



## **Mathematical Concepts In Linguistic Thought At Dr. Abd Al-Rahman Al-Haj Saleh**

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### Abstract

Linguistic scholars seek to revitalize Arabic grammar by grounding it in the heritage of linguistic thought. This is what prompted Abdulrahman Al-Haj Saleh to assert the lack of any logical basis for Arabic grammar and that the perspective of ancient Arab grammarians was purely concerned with the reality of linguistic discourse. This research sheds light on some of the grammatical issues addressed by Al-Haj Saleh in his book "Mantiq Al-Arab fi 'Ulum Al-Lisan" (Logic of the Arabs in the Sciences of Language), particularly his analysis and mathematical justifications of these issues, even though they may initially appear to be conventional, such as linguistic perception, for example.

**Keywords:** mathematical concepts, grammar, linguistics, revitalize.

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### Introduction:

Linguistics is an interdisciplinary field that encompasses various domains, including humanities, social sciences, and mathematics, they all serve the language especially in this era marked by significant interactions between different branches and sources of knowledge. There has been an increased interest in the intersection of language and mathematics, as well as a growing interest among mathematicians in language itself. This has led to the emergence of what is now known as mathematical linguistics, which is taught in major universities in Europe. Researchers in this field have studied language from a mathematical perspective, focusing on the mathematical methods that govern symbol manipulation, information storage, data processing in computers, machine translation, and other branches of computational linguistics.

Indeed, this is not limited to Western researchers. We find among our Arab scholars those who have adopted mathematical logic as a means to analyze traditional statements and employ them within a computerized database. One notable example is the Algerian linguist, Dr. Abdulrahman Al-Haj Saleh, who was a pioneer in utilizing mathematical principles in analyzing the logic of the Arabic language. He was at the forefront of incorporating mathematical insights into linguistic analysis and made significant contributions in this field.

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**Research Problem:**

Based on these premises, several questions have arisen, the most important of which are:

1. What is Dr. Abdulrahman Al-Haj Saleh's perspective on Arabic grammar?
2. Are its foundations merely based on transmission, similar to oral tradition?
3. Where does the mathematical thought manifest in Al-Haj Saleh's work?

**Methodology:**

In this research, we have adopted a descriptive-analytical methodology to present the mathematical terms used by Dr. Abdulrahman Al-Haj Saleh and to examine their concepts and analysis.

**Previous Studies:**

There have been numerous studies, particularly scientific articles, that have addressed the research on the ideas of Abdulrahman Al-Haj Saleh. We mention some of them as examples, without limitation.

1. Muhammad Al-Sawi, "Al-Mafahim al-Asasiyyah lil-Nazariyyah al-Khaliliyyah al-Hadithah" (The Fundamental Concepts of Modern Khalili Theory), Department of Arabic Language, University of Annaba, Forum of the Arabic Language Academy on the World Wide Web, Linguistic Studies and Research, Vol. A and B.
2. Al-Sharif Bouchhadane, "Al-Ustadh Abdulrahman Al-Haj Saleh wa Juhooduhu al-Ilmiyyah fi Tarqiyat al-Lughah al-Arabiyyah" (Professor Abdulrahman Al-Haj Saleh and His Scientific Efforts in the Advancement of the Arabic Language), Issue 7, Journal of the Faculty of Arts, Social Sciences, and Humanities, Faculty of Arts and Languages.

1- Dr. Abdulrahman Al-Haj Saleh

is an Algerian scholar born in 1927 in the city of Oran. He initially studied medicine and specialized in neurology in Egypt. After that, he devoted himself to studying and researching linguistics. In 1980, he defended his master's thesis in Linguistic. He was later appointed as a correspondent member of the Arabic Language Academy in Cairo and then elected as a regular member in 2003. He held several scientific positions, most notably as the President of the Algerian Academy of the Arabic Language. He is credited with advocating for the revival of Arabic grammatical heritage. He is known as a moderate linguist who emphasizes grounding in linguistic studies and rejects blind adherence to tradition. He is the proponent of the modern Khalili theory and was one of the first to advocate for the computational treatment of the Arabic language within the framework of the Arabic Linguistic Arsenal or the Arabic Language Bank project.

Dr. Abdulrahman Al-Haj Saleh has authored numerous scientific works in the field of linguistics, including:

1. "Mu'jam 'Ulum al-Lisan" (Dictionary of Linguistic).
2. "Bahooth wa Dirasat fi 'Ulum al-Lisan" (Research and Studies in Linguistic).
3. "Al-Sama' al-Lughawi 'Inda al-Arab wa Mafhum al-Fasaha" (Linguistic Audition among the Arabs and the Concept of Eloquence).
4. "Al-Nazariyyah al-Khaliliyyah al-Hadithah, Mafahimha al-Asasiyyah, wa Mantiq al-Arab fi 'Ulum al-Lisan" (The Modern Khalili Theory, Its Fundamental Concepts, and Arab Logic in Linguistic Sciences).

He passed away in the capital city of Algeria in 2017.

**2- The authenticity of Arabic grammar:**

Arabic grammar originated purely and without any blemish, absolved from all accusations and claims directed towards its construction, particularly in its early stages. These false declarations have spread regarding the Arabic language and its scholars among researchers, accusing ancient Arabic linguists of appropriating the

ideas of other nations, in various aspects such as the trilateral division of words, diacritical marks, and the Aristotelian notions of cause and agent. Their aim was to tarnish the Arab intellect and describe it as incapable and inefficient in research, theorization, and deducing judgments, oblivious to the fact that this intellect is the heir to the Aramaic and Canaanite civilizations, which taught nations writing and alphabets. It is not surprising that their descendants excelled in grammar and other disciplines.

The early Arab grammarians relied on analytical methods in their specific research on the Arabic language, which necessarily depended on reason. However, the intervention of reason can take various forms, although all scholars, especially, agree on the reliance on fundamental intellectual principles. The method of acquiring knowledge differs from one people to another and from one era to another, and each people and era have their own perceptions and perspectives, sometimes more than one perspective. (Al-Haj Saleh, Abdulrahman, 2012, p 07).

As for the presumed aspects of the influence of other regions, particularly the Indian and Greek, on Arabic grammar, it can be attributed to shared human thinking and the concept of justification based on the innate human tendency to seek explanations for things. The concept of analogy does not deviate from the principle of analogizing based on nature and reason. (Felfel, Mohamed Abdo, 2018, p. 19).

### **3- Auditory Perception:**

Dr. Al-Haj Saleh convincingly acknowledges the scientific nature of the work of the early grammarians and passionately defends this notion. He substantiates his claim with strong evidence, particularly through his description of the process of linguistic logical perception (auditory perception) adopted by the early grammarians as a means of gathering material and constructing linguistic rules. He concludes that "this extensive auditory perception, unprecedented in history in terms of its greatness and objectivity, is given tremendous importance by its adherents, who grant it absolute priority as a fundamental source of linguistic scientific knowledge, surpassing the other source, which is rational inference." He further explains the initial misconception that may arise for the reader, represented by the encounter between the concept of "auditory perception" as a seemingly illogical action and the concept of "rational inference." He states, "This observation may initially lead us to judge that Arabic grammar is almost entirely based on perception rather than being the result of intellectual thought and the use of mental faculties." (Al-Haj Saleh, Abdulrahman. (2012). "Al-Nahw Al-Arabi: Dirasah Fi Ulum Al-Lisan" (Arabic Grammar: A Study in Linguistic Sciences). p. 93).

The dilemma that stands as a barrier before us while contemplating the ideas of Al-Haj Saleh is: Why did our early scholars prioritize auditory perception over inference, considering that both are based on logical and mathematical reasoning? Ibn Jinni addressed this issue in his discussion on the conflict between auditory perception and inference, stating: "If they conflict, one should rely on what is heard without resorting to inference. This is exemplified in the saying of Allah: 'Satan has gained mastery over them' [Al-Mujadila, 58:19]. This is not inference, but it must be accepted" (Ibn Jinni, Abu Al-Fath Uthman, 1st edition, p. 117).

Al-Haj Saleh addresses this dilemma, stating: "The reason behind their emphasis on absolute reliance on auditory perception, in the view of most of them, can be attributed to two interrelated factors, as we will see. The first factor pertains to language, while the second relates to scientific methodology. Regarding the essence of language, it is a system based on evidence that is confirmed by its users. The existence of a social reference (the community of speakers), a textual reference, or both is necessary for the existence of a language among the languages. It is inconceivable for someone to claim that they speak a language without adhering to what the speakers of that language have agreed upon... Therefore, there can be no scientific study except by prior reliance on the written words of trustworthy speakers of the language. As for scientific methodology, auditory perception is observation or transmission of data, and every observation enters the initial stage of any scientific research." This characteristic is fundamental to modern scientific research, encompassing all fields of science. Thus, linguistic and mathematical work does not deviate from observation and analysis, which are essential features relied upon in scientific research. (Al-Haj Saleh, Abdulrahman, 2012, p. 104).

#### 4- Abdulrahman's Mathematical Thinking:

Al-Haj Saleh was able to demonstrate to readers and enthusiasts of linguistics and Arab heritage that the majority of concepts reached by ancient Arab grammarians and the methods they employed in examining the Arabic language, whether in terms of morphology, classification, or even linguistic analysis, are rooted in the essence of mathematics. This indicates their logical and mathematical thinking and the scientific nature of their work. It is not surprising for those engaged in the study of language, as "the linguist's need to deal with mathematical logic and utilize its established tools primarily relates to specific issues, with mathematical logic, represented by the concept of structure, being at the forefront" (Ghanem, Mohammed, 1st edition, p. 53).

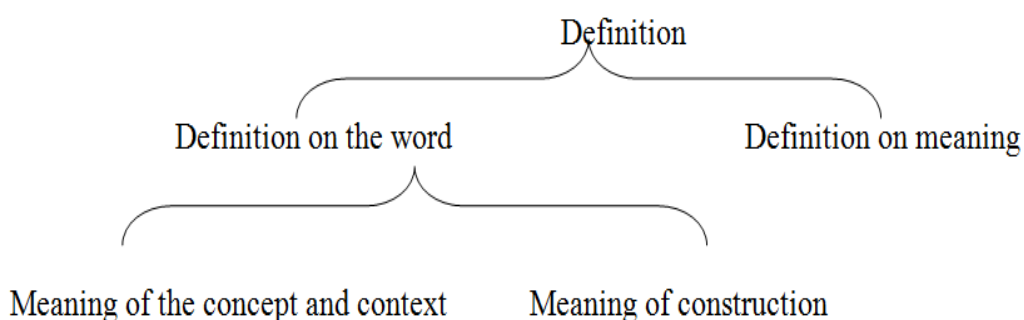
Contemplating the thoughts of Dr. Al-Haj Saleh, one can find certain descriptive and analytical linguistic issues that he focused on. These pivotal issues emphasize the tools of observation and the intellectual and mathematical methods adopted by grammarians in their work while documenting the grammatical rules. This was achieved by thoroughly examining the books of early grammarians and the statements of scholars of the principles of grammar in their authentic sources. Particularly noteworthy is the matter of "linguistic perception," which is unanimously recognized as a scientific endeavor undertaken by grammarians. It is a meticulous task comparable to the work of modern linguists, accompanied by a documented record of their research.

#### 4-1- Classification:

The discussion of linguistic perception inevitably leads us to the discussion of classification, which is considered one of the intellectual methods relied upon by grammarians. Therefore, classification is an exploratory and deductive process. Dr. Al-Haj Saleh did not overlook this process; he addressed it in his book "The Logic of Arabs in Linguistic Sciences."

Al-Haj Saleh drew inspiration from the statement of Al-Kisā'ī: "Grammar is derived from what is transmitted." This statement was made by a grammarian who considered auditory perception as the primary source for establishing grammar, without any conditions on what is heard, as he was one of the scholars of Kufa and one of its early founders (Ibrahim, Sabri, 1st edition, 2011, pp. 42-43). This introduction reveals the consequence of the statement in recognizing the logical and mathematical nature of the grammarians' work. Consequently, classification necessarily relies on definition, as Al-Haj Saleh perceives it.

He divided this definition into two distinct aspects: the aspect of meaning and the aspect of expression. The subsequent form summarizes what has been mentioned in this division.



#### Firstly, Definition based on Meaning:

By the term definition based on meaning Al-Haj Saleh means "the set of attributes by which [the concept] distinguishes itself from others. Therefore, these attributes must be taken into account in its definition" (Al-Haj Saleh, Abdulrahman, 1st edition, 2012, p. 115). Examples of such definitions can be found in the classification of words by grammarians into nouns, verbs, and particles. They defined each of these categories based on a definition rooted in meaning and assigned distinctive markers to each category, distinguishing it from others. These markers are primarily semantic rather than purely linguistic.

#### Secondly, Definition based on Expression:

Within this definition, three terms are included: structure, limit, and flow. Al-Haj Saleh considers these terms to be among the most commonly used in the books of early grammarians, especially Sibawayh. They hold the same significance as many other important terms and concepts, such as the term "chapter" (bab), counterpart (nazir), root (asl), branch (fara'), and analogy (qiyas) (Al-Haj Saleh, Abdulrahman, 1st edition, 2012, p. 121).

### **Meaning of Structure :**

The term "structure" refers to the "structure of the word or speech itself" (Al-Haj Saleh, Abdulrahman, 1st edition, 2012, p. 104). When dealing with abstract concepts, the analysis is carried out through comparison and analogy.

### **Meaning of Limit and**

The term "limit" (al-hadd) has been given the meaning of "concept" by many researchers. For example, Saber al-Habasha quotes some scholars as saying: "Limit, in general, is a mental process that involves defining the specific concept of a particular representation. It is the statement that indicates the nature of a thing. It is usually derived from the genus (jins) and differentia (fasl), such as defining a human being as a rational animal. The difference between limit and definition can be explained as follows: The former indicates the essence of a thing and is composed of the proximate genus and specific differentia, while the latter is intended to form a mental image of a thing and clarify it. Every limit is a definition, but not every definition is a complete limit; it may be an incomplete limit" (Saber al-Habasha, 1st edition, 2010, p. 13).

If we consider the statement of Ibn Jani regarding the definition of language, where he says, "The chapter on language and what it is. As for its limit, it is the sounds by which every people express their purposes. This is its limit" (Abu al-Fath Uthman, Ibn Jani, Vol. 1, p. 33), it encompasses all the meanings and various definitions, and it eliminates the differences people may have regarding it. Does it serve as an inspiration or a revelation? If we find that it overlaps with the concept we mentioned in distinguishing between limit and definition, it is because sound is part of the essence of language, and therefore, it is a limit. However, the differences among people regarding language are not part of its essence but rather a comprehension and clarification of it alone.

If we return to Dr. Al-Haj Saleh's perspective on defining the concept of "limit," we find that he relies on a set of texts from Sibawayh that mention the term "limit." These texts are as follows:

**First Text:** Sibawayh says, "Don't you see that the limit of speech is to delay the verb and say, 'Which one did you see?'" (Sibawayh, Vol. 1, 3rd edition, 1988, p. 126).

**Second Text:** Sibawayh says, "The case of speech and its limit is the preposition, as it is not a place for tanween (nunation)" (Sibawayh, Vol. 1, 3rd edition, 1988, p. 171).

**Third Text:** Sibawayh says, "He is not capable in that limit, but in this case, he is capable" (Sibawayh, Vol. 1, 3rd edition, 1988, p. 226).

**Fourth Text:** Sibawayh says, "And it does not have a method that can be applied to speech" (Sibawayh, Vol. 2, 3rd edition, 1988, p. 217).

He arrives at a conclusion that the "limit" (al-hadd) is the "aspect, state, and method," and in all of these, it pertains to speech in terms of expression. It becomes clear from this that the limit is the aspect of speech and a state as well, not just any aspect or any state, but rather that which is produced by a specific method or specific manipulation. It is the pattern of actions that lead to a result, which is grammar or a particular form of speech that is bounded by the limit, while at the same time, it is the pattern of that specific speech itself. Therefore, the concept of the limit, according to Al-Haj Saleh, differs from the previous definition that stated it is part of the essence of a thing. Here, the limit is not meant to define a concept but rather to define the necessary actions that lead to the formation of a particular form of speech. (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 121).

Dr. Al-Haj Saleh adds that the term "limit" (hadd) lost its original linguistic meaning after Sibawayh, especially with the translation of the Greek term "ORISMOS," which refers to the definition in logic. For most grammarians after Sibawayh, it came to signify defining a concept, essence, or noun. Gradually, the original linguistic meaning, which is the process of formation, disappeared. (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 128). He emphasizes that "the confusion and the failure to grasp the purposes of the early grammarians have led to the differences among grammarians of the fourth century, especially in defining the noun." (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 131).

#### 4-1- Statistics

The majority of researchers in the field of linguistics agree on the distinctiveness of the latter, especially in the second half of the twentieth century, in utilizing methodological procedures derived from the mathematical sciences. With the onset of the twentieth century, statistical methods permeated all branches of science, including linguistics. (Milka, Eviath, 2nd edition, 2000, p. 397). Such a practice is not unfamiliar to the procedures adopted by the early Arab grammarians, which they followed in deducing the linguistic principles. This carefully delimited approach is among the most distinguishing features of scientific research in language in terms of objectivity. Objective knowledge can only be obtained through statistical analysis. Arab scholars needed to verify the frequency of usage, whether it was common or rare, by conducting comprehensive statistical surveys that covered everyone they heard speaking, thereby determining prevalence. (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 361). This is an initial form of statistical analysis. "Then there is another form of statistical analysis that focuses on linguistic units through written texts, by compiling them in notebooks along with their various meanings." (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 361).

Abdul Rahman Al-Haj Saleh expresses astonishment at the awareness and utilization of statistics by the ancient grammarians in their linguistic studies, despite the lack of modern tools that expedite linguistic processes. He remarks, "We wonder today how the Arab grammarians managed to statistically analyze everything they encountered in the vast body of oral tradition. It is truly a miraculous feat considering their lack of access to the electronic devices we use today for statistical analysis. As for the complete enumeration of a set of linguistic elements and determining the frequency of each one, as Al-Jahiz pointed out, this was achieved by statistically analyzing them in a limited number of texts, and it did not pose significant difficulty." (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 121).

Indeed, the Arabs were familiar with and employed statistics in their linguistic studies since ancient times, while the West only came to know it recently with the advancement of sciences, including linguistics. Al-Khalil, for example, relied on a descriptive statistical approach in the classification of his dictionary, *Al-Ayn*. This enabled him to gather extensive material, encompassing all the vocabulary of the Arabic language, whether commonly used or neglected. An example of statistical analysis by Al-Khalil ibn Ahmad Al-Farahidi is his classification of linguistic roots, categorizing them into trilateral, quadrilateral, and quintessential roots. He employed the system of pattern matching (*tawfiqat*) to categorize the roots.

Hamza al-Asbahani mentioned in his book "*Al-Mawazin*" as reported by historians: Al-Khalil mentioned in his book "*Al-Ayn*" that the total number of word structures in the Arabic language, including both commonly used and neglected ones, can be categorized into four levels (bi-, tri-, quadri-, and quintessential roots) without repetition. The total count is twelve million, three hundred and five thousand, four hundred and twelve (12,305,412). This can be broken down as follows: (Al-Jilali, Halim, 1997, p. 44).

- Number of bi-root word structures: Seven hundred and fifty-six.
- Number of tri-root word structures: Nine hundred and sixty-one thousand, six hundred and fifty.
- Number of quadri-root word structures: Four hundred and one thousand, ninety-one.
- Number of quintessential root word structures: Eleven million, seven hundred thousand, three hundred and ninety-six hundred.

Al-Khalil was able to enumerate this number of roots in the Arabic language by adopting the system of mathematical pattern analysis, which provides a set of possibilities for word structures resulting from the forms (bi-, tri-, quadri-, and quintessential) in the Arabic language.

Indeed, this system bears a resemblance, to some extent, to the concept of sets in algebra, which involves enumerating numbers with similar mathematical properties or belonging to a specific type of numbers. It has also been demonstrated how all tri-root structures can be categorized using what is now known as Cartesian multiplication. (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 363). Indeed, the author Abdul Rahman Al-Haj Saleh praised Al-Khalil's understanding of the division of structures, distinguishing between the commonly used and neglected ones. Al-Khalil's knowledge of mathematical division is profound, as it allows him to differentiate between what is required by reason and calculation in terms of structures and what actually exists in the Arabic language. (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 363). The work of Al-Khalil ibn Ahmad extended beyond him to numerous linguists in the field, as mentioned by Al-Haj Saleh. He also mentioned their statistical approach in dealing with language in his book, stating that: "Among the best things they have done in terms of enumeration, with deliberate classification based on specific meanings, is the classification of vocabulary according to conceptual domains... such as the Book of Camels, the Book of Horses, the Book of Plants and Trees... and others. They named this collection 'Al-Musannaf' and explained its vocabulary, calling these explanations 'Ghareeb Al-Musannaf,' following the model they used for 'Ghareeb Al-Quran' and 'Ghareeb Al-Hadeeth.' This is a work that the Arab linguists pioneered." (Abdul Rahman, Al-Haj Saleh, 1st edition, 2012, p. 363).

The concept of "classification" emphasized by Al-Haj Saleh aligns with the well-known mathematical concept in the field of algebra, which pertains to the laws of sets. This indicates Al-Haj Saleh's reliance on mathematics in analyzing linguistic issues. It also highlights the understanding of the methodology followed by grammarians and linguists in their classifications, even though they may not have intentionally used mathematical terminology or its mathematical concepts.

## **5-Areas of influence of Abd al-Rahman al-Hajj Saleh by mathematical thought:**

### **5-1 -School modern d'Elkhlil:**

Dr. Abdul Rahman Al-Haj Saleh invested mathematical thinking in analyzing many ancient linguistic issues, relying on the mathematical technique that characterizes the Arabic language.( Abdul Rahman, Al-Haj Saleh,1986,p.59).

Al-Khalil bin Ahmed Al-Farahidi was aware of mathematical laws, and he invested them in his linguistic research. He says in the introduction to the Al-Ayn dictionary: "Know that a word consisting of two letters results in two words..., a word consisting of three letters results in six words..., and one word... The quatrain produces twenty-four words, because its four letters are multiplied by the correct words consisting of three letters, resulting in twenty-four words, the user takes them and we leave the unused ones..."( Al-Khalil,section1,p.56).

Dr. Abdul Rahman Al-Haj Saleh linked the idea of linguistic morphology to the idea of the mathematical factor, which is what is known as the mathematical probability system, as follows:( Abdul Rahman, Al-Haj Saleh,1986,p. 70).

$$2!=1\times 2=2$$

$$3!=1\times 2\times 3=2!\times 3=6$$

$$4!=1\times 2\times 3\times 4=24$$

$$5!=1\times 2\times 3\times 4\times 5=120$$

He relied on the idea of permutation in determining morphological forms, and he collected all used and unused forms. He also adopted this technique in describing the structure of Arabic poetry.

### **5-2- Linguistic repertoire:**

Dr. Abdul Rahman Al-Haj Saleh focused his attention on the computerization of the Arabic language and its automated processing according to artificial intelligence, and this is what he called the Arab Linguistic Bank project or Arabic language technology. To achieve this topic, he used "computers, the necessary reading tools,

and appropriate computer software." ( Abdul Rahman, Al-Haj Saleh,1986,p122). Abd al-Rahman al-Haj Saleh believes that "the logical-mathematical concepts of Arabic grammar have advantages..., such as their advantage in computer language processing because they are characterized by the special qualities it requires."

It is compatible with automated processing, and this is due to its vowels and morphological structures, likewise for the grammatical aspect. ( Abdul Rahman, Al-Haj Saleh,2009,p358.)

### **Conclusion:**

Al-Haj Saleh employs mathematical thinking in dealing with linguistic issues, both in reception, interpretation, and analysis. Through our brief examination of his scientific book "The Logic of Arabs in Language Sciences," we have arrived at the following conclusions:

- 1- Abdul Rahman Al-Haj Saleh is among the moderate researchers who have attempted to revive the legacy of Al-Khalil's grammatical works and establish the authenticity and scholarly nature of Arabic grammatical research in the first three centuries. He has done so through presenting logical and rational arguments, as well as authentic narrations and evidence.
- 2- Al-Haj Saleh indeed emphasizes the principle of classification, which is a well-known mathematical concept in the field of algebra, specifically referring to the laws of sets. This signifies Al-Haj Saleh's reliance on mathematics in analyzing linguistic issues.
- 3- Al-Haj Saleh mentions numerous scholars in the field of language and highlights their statistical approach in dealing with language, such as Khalil ibn Ahmad. Khalil distinguished between the unused and used elements, thereby differentiating between the structures required by logic and calculation and those that actually exist in the Arabic language.
- 4- The grammarians and linguists, although unaware of the mathematical concepts behind their classifications, followed a methodology in their categorizations. While they may not have intentionally used mathematical terminology, their classifications exhibit mathematical concepts.
- 5- Abdul Rahman Al-Haj Saleh's research, in which he revealed the distinctiveness of Arabs in the field of linguistic research and presented explicit evidence, debunks the accusations leveled against the foundations of Arabic grammar. His research calls for the adoption of a scientific methodology in understanding issues related to Arabic grammatical thinking.
- 6- Mathematical thought allowed Dr. Abdul Rahman Al-Haj Saleh to analyze grammatical rules that modern scholars could not accurately understand, and he was helped in this by the relationship that exists between linguistics and mathematics.

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