


<div> International Meetings and Journals Research Association ISSN p (e): 27900169; 27900177 Established: 2022 </div> <div> Science, Education and Innovations in the Context of Modern Problems </div> <div> Editor-in-Chief: Chair of the Editorial Board: Dr. Habbaddine Monthly Regular Open Access October 2025 Issue 20, Vol. 9 imcra-az.org </div>	Science, Education and Innovations in the Context of Modern Problems
	Issue 1, Vol. 9, 2026
	<div> RESEARCH ARTICLE  </div>
	<div> <h1>The Encyclopedic Mindset in Classical Arabic Dictionaries: Kitāb al-‘Ayn of al-Khalīl ibn Aḥmad as a Model</h1> </div>
Islam Habbeddine	<div> Dr. Mohamed El Bachir El Ibrahimi University of Bordj Bou Arreridj Algeria E-mail: islam05habbeddine@gmail.com </div>
Dirar Adjoudje	<div> Dr. Mohamed Lamine Debaghine University of Sétif 2 Algeria E-mail: dirar05dirar@gmail.com </div>
Issue web link	https://imcra-az.org/archive/389-science-education-and-innovations-in-the-context-of-modern-problems-issue-1-vol-9-2026.html
Keywords	Arabic lexicography; encyclopedic knowledge; epistemic integration; Kitāb al-‘Ayn; al-Khalīl ibn Aḥmad; phonetic theory.
<div> Abstract Classical Arabic lexicography stands among the most sophisticated intellectual achievements in the history of human knowledge. It functioned not merely as a linguistic enterprise concerned with the collection of vocabulary, but as a comprehensive encyclopedic system that integrated a wide range of scientific, cultural, and epistemological domains. Early Arabic dictionaries embodied a holistic vision of knowledge, reflecting the principle of epistemic unity that characterized Islamic civilization. This study examines the encyclopedic mindset underlying classical Arabic lexicographical works, with particular emphasis on Kitāb al-‘Ayn by al-Khalīl ibn Aḥmad al-Farāhīdī (d. 175 AH / 791 CE), widely recognized as the earliest systematically organized Arabic dictionary. The paper argues that al-‘Ayn constitutes an intellectual encyclopedia in which phonetics, morphology, syntax, semantics, Qur’ānic sciences, medicine, anatomy, zoology, botany, mathematics, and logic are integrated within a unified and coherent methodological framework. Through its innovative phonetic ordering, mathematically grounded system of lexical permutations, and extensive interdisciplinary references, Kitāb al-‘Ayn exemplifies epistemic integration (takamul ma‘rifī) centuries before the emergence of modern encyclopedic traditions. By highlighting the civilizational and scientific significance of al-Khalīl’s lexicographical project, this study challenges contemporary narratives that marginalize Arab-Islamic intellectual heritage in favor of exclusively Western epistemological models, and underscores the enduring relevance of classical Arabic lexicography to modern interdisciplinary scholarship. </div>	
<div> Citation Islam H.; Dirar A. (2026). The Encyclopedic Mindset in Classical Arabic Dictionaries: Kitāb al-‘Ayn of al-Khalīl ibn Aḥmad as a Model. <i>Science, Education and Innovations in the Context of Modern Problems</i>, 9(1), 966-973. https://doi.org/10.56334/sci/9.1.89 </div>	
<div> Licensed © 2026 The Author(s). Published by Science, Education and Innovations in the context of modern problems (SEI) by IMCRA - International Meetings and Journals Research Association (Azerbaijan). This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/). </div>	
Received: 25.07.2025	Accepted: 10.12.2025
Published: 10.01.2026 (available online)	

1. Introduction

The contemporary Arab researcher often experiences a profound sense of cultural dislocation, manifested in the perception of Arab-Islamic heritage as a static relic—mere ruins unworthy of sustained intellectual engagement—while the dominant Western paradigm is elevated to the status of an exclusive epistemological refuge. This perception has

contributed to a partial rupture between modern scholarship and the foundational texts of Arab intellectual history, particularly in the fields of language and the humanities (al-Jābirī, 1991; Arkoun, 2002).

However, Arabic linguistic heritage constitutes a vast epistemic treasury whose depth and methodological sophistication cannot be overlooked. A careful, critical rereading of classical linguistic texts reveals unmistakable evidence of an encyclopedic mindset that governed early Arab scholarship. Among all linguistic disciplines, lexicography occupies a central position in this encyclopedic vision, as dictionary compilation inherently requires the integration of multiple sciences—phonetics, morphology, syntax, semantics, rhetoric, theology, jurisprudence, and natural sciences—in order to establish meaning on rigorous methodological grounds (Versteegh, 1997).

Within this intellectual context, *Kitāb al-ʿAyn* by al-Khalīl ibn Aḥmad al-Farāhīdī emerges as a paradigmatic example of encyclopedic lexicography. It is not merely the first Arabic dictionary in chronological terms, but also one of the most intellectually ambitious projects in the history of lexicographical thought. Al-Khalīl distilled his vast knowledge into a systematic framework based on phonetic principles and mathematical logic, thereby laying the foundations for Arabic linguistic sciences and influencing generations of scholars across disciplines (Baʿalbaki, 2014).

2. *Kitāb al-ʿAyn* as an Intellectual Encyclopedia

Kitāb al-ʿAyn represents a comprehensive intellectual encyclopedia in which al-Khalīl integrates linguistic and non-linguistic sciences within a unified epistemological structure. His lexicographical endeavor transcends the mere recording of lexical items and instead reflects a vision of language as a gateway to understanding the natural world, human anatomy, social practices, and religious knowledge.

Al-Khalīl's dictionary contains extensive references to:

- **Morphology and syntax**, through detailed discussions of word patterns, derivations, and grammatical functions;
- **Semantics and rhetoric**, by contextualizing meanings within poetic, Qurʾānic, and cultural usage;
- **Medicine and anatomy**, evident in precise descriptions of bodily organs and physiological processes;
- **Zoology and botany**, through the classification and naming of animals and plants;
- **Mathematics and logic**, particularly in the systematic use of phonetic permutations (*taqlībāt*), which reflect combinatorial reasoning (Ibn Jinnī, 1952).

This multidimensional structure demonstrates that *al-ʿAyn* was conceived as a repository of integrated knowledge, reflecting what modern epistemology would describe as an interdisciplinary or transdisciplinary approach (Foucault, 1970).

3. Phonetics as the Epistemic Core of *al-ʿAyn*

Al-Khalīl opens *Kitāb al-ʿAyn* with an extensive introduction to phonetics, a decision that reflects his deep awareness of the foundational role of sound in linguistic and epistemic systems. He organizes the Arabic lexicon according to the place of articulation (*makhārīj al-ḥurūf*), beginning with the deepest sounds produced in the throat and proceeding outward toward the lips.

This phonetic organization is not arbitrary. Rather, it demonstrates al-Khalīl's recognition of the intimate relationship between phonetics and:

- **Anatomy**, through the study of speech organs;
- **Medicine**, in understanding physiological sound production;
- **Physics**, in the transmission and resonance of sound;
- **Mathematics**, via the principle of permutation and systematic enumeration of phoneme combinations (al-Suyūṭī, 1998).

The principle of phonetic permutations (*al-taqlīb al-ṣawwī*) represents one of al-Khalīl's most innovative contributions. By calculating all possible root combinations, he establishes a mathematically grounded framework for lexical completeness, ensuring that the dictionary accounts for both actual and potential lexical forms (Versteegh, 1997).

4. Lexicography, Qurʾānic Sciences, and Epistemic Integration

One of the most profound dimensions of *Kitāb al-ʿAyn* is its close relationship with Qurʾānic sciences. Al-Khalīl's lexicographical methodology reflects a deep engagement with:

- **Qurʾānic recitation (tajwīd)**, grounded in phonetic precision;
- **Qurʾānic readings (qirāʾāt)**, which require a nuanced understanding of phonological variation;
- **Semantic exegesis (tafsīr)**, dependent on accurate lexical interpretation (al-Zarkashī, 1988).

This interdependence underscores the role of lexicography as a foundational science within Islamic knowledge systems, bridging linguistic analysis with theological and legal interpretation.

5. Foundations of Dictionary Construction in Classical Arabic Thought

A classical Arabic dictionary is constructed upon multiple interrelated foundations, including:

1. **Phonetic foundations:** classification of sounds by articulation and acoustic properties.
2. **Morphological foundations:** analysis of roots, patterns, and derivational systems.
3. **Syntactic foundations:** identification of grammatical functions and contextual usage.
4. **Semantic foundations:** tracing meaning through usage, metaphor, and contextual shifts.
5. **Cultural and civilizational foundations:** incorporating poetry, proverbs, customs, and scientific knowledge.

Al-Khalil's *al-'Ayn* exemplifies the harmonious integration of these foundations, establishing a model of lexicography that is simultaneously linguistic, scientific, and cultural.

4. Epistemic Cross-Fertilization and the Mathematical-Phonological Framework in *Kitāb al-'Ayn* (Continued)

4.1. Phonetic and Phonological Markers as Systemic Laws

The phonetic observations scattered throughout *Kitāb al-'Ayn* do not represent isolated remarks or anecdotal linguistic intuitions. Rather, they form a coherent system of **phonological constraints** (*qawānīn ṣawṭiyya*) that regulate permissible and impermissible sound combinations in Arabic. These constraints reveal al-Khalil's awareness of what modern linguistics terms *phonotactics*, long before the emergence of structural phonology.

Al-Khalil's insistence on incompatibility between certain consonants (e.g., *tā'* and *ā'*, *dād* and *ṣād*, *qāf* and *kāf*) reflects a deep understanding of articulatory proximity, acoustic similarity, and cognitive ease of pronunciation. Such observations implicitly acknowledge physiological, anatomical, and acoustic factors governing speech production, thereby linking phonetics to **medicine and anatomy**, while simultaneously grounding lexical validity in **mathematical regularity** through permutation and exclusion principles.

The example involving *ḥisāb al-jummal* is particularly revealing. Al-Khalil explicitly connects lexical formation with **numerical calculation**, demonstrating that linguistic acceptability is not merely semantic but also governed by **phonetic harmony and cognitive plausibility**. When the constructed example *ṣa'faḍ* proved phonetically displeasing, it was modified to *ṣa'fa's*, illustrating that mathematical legitimacy alone is insufficient without phonological harmony. This principle anticipates modern notions of *markedness* and *phonological well-formedness* (Jakobson, 1968; Versteegh, 1997).

Thus, phonetics in *al-'Ayn* functions as a mediating discipline that unites sound physiology, mathematical logic, and linguistic structure within a single epistemic system.

4.2. Foreign and Non-Arabic Words (*al-dakḥīl*) and the Logic of Linguistic Filtering

Al-Khalil's treatment of foreign and loanwords (*al-dakḥīl*) constitutes one of the earliest systematic attempts at **linguistic discrimination based on structural criteria rather than ethnic or cultural prejudice**. His approach is governed by phonological, morphological, and combinatorial rules, not by subjective judgments.

The criteria he employs include:

1. **Absence of dhalaq or labial letters** in quadriliteral or quinqueliteral forms, indicating non-native origin.
2. **Violation of Arabic phonotactic constraints**, such as impermissible vowel patterns or consonantal sequences.
3. **Morphological irregularity**, including deviation from established Arabic patterns (*awzān*).
4. **Phonetic disharmony**, which contradicts the natural sound flow of Arabic speech.

For instance, al-Khalil's classification of *al-saqraq'* as Ethiopian in origin is based on a precise phonological observation: authentic Arabic words do not naturally begin with a *ḍammah* and terminate with a *faḥah* unless governed by exceptional structural principles. Similarly, the term *al-muhandis* is identified as Persian due to the inadmissibility of a *zāy* following a *dāl* in genuine Arabic words.

This analytical rigor demonstrates that al-Khalil viewed Arabic as a **self-regulating linguistic system**, governed by internal laws analogous to those found in natural sciences. His methodology reflects an early form of **linguistic system theory**, wherein the integrity of the system is preserved through identifiable constraints (Ba'albaki, 2014).

4.3. Arabization (*Ta'rib*) as Controlled Epistemic Adaptation

Al-Khalil does not reject foreign terms outright. Rather, he acknowledges processes of **Arabization**, whereby foreign lexemes are adapted to conform to Arabic phonological and morphological norms. This demonstrates a nuanced understanding of language contact and cultural exchange.

Terms such as *dahliz*, *al-khurnaq*, and *farand* illustrate how foreign elements are assimilated into Arabic through phonetic modification and morphological alignment. Arabization thus appears as a **regulated epistemic adaptation**, not a chaotic borrowing process.

This perspective situates Arabic lexicography within a broader civilizational framework that recognizes interaction, exchange, and transformation, while preserving systemic coherence. In this sense, *Kitāb al-'Ayn* functions not only as a linguistic record but also as a historical archive of intercultural knowledge transfer.

4.4. Defects of Pronunciation and the Intersection of Linguistics and Medicine

One of the most striking aspects of *Kitāb al-ʿAyn* is al-Khalīl’s systematic treatment of speech defects (*ʿuyūb al-nuṭq*). These entries reflect a profound awareness of speech pathology, long before the emergence of modern speech therapy or phonetic medicine.

Terms such as *al-thaghthaghah*, *al-naʿnaʿah*, *al-hathathah*, and *al-ghatmah* demonstrate a refined descriptive vocabulary for articulatory disorders, including lisping, nasalization, stammering, and articulatory blockage. Al-Khalīl’s descriptions indicate sensitivity to:

- **Articulatory mechanics** (tongue position, airflow),
- **Neuromuscular coordination**,
- **Auditory perception of speech clarity**.

This dimension of *al-ʿAyn* reveals an implicit integration of linguistics with **medicine, physiology, and psychology**. Speech is treated not merely as a linguistic phenomenon but as a bodily function subject to impairment, variation, and correction. Such insights reinforce the encyclopedic nature of the dictionary and underscore its role as a multidisciplinary reference work.

4.5. The Encyclopedic Diagram: Linguistics at the Center of Knowledge Integration

The phonetic, mathematical, medical, and cultural elements identified above converge into a single epistemic structure, which may be schematically represented as follows:

- **Mathematics** → permutation, enumeration, exclusion
- **Phonetics / Phonology** → articulation, harmony, compatibility
- **Morphology** → root patterns, derivation
- **Semantics** → meaning, usage, context
- **Medicine & Anatomy** → speech organs, defects
- **Cultural Sciences** → poetry, customs, loanwords
- **Qurʾānic Sciences** → recitation, readings, semantic precision

At the center of this network stands **lexicography**, functioning as the nexus through which all these disciplines interact. This configuration confirms that *Kitāb al-ʿAyn* is not a mere linguistic tool but a **civilizational epistemic project**, reflecting a worldview in which knowledge is unified, coherent, and mutually reinforcing.

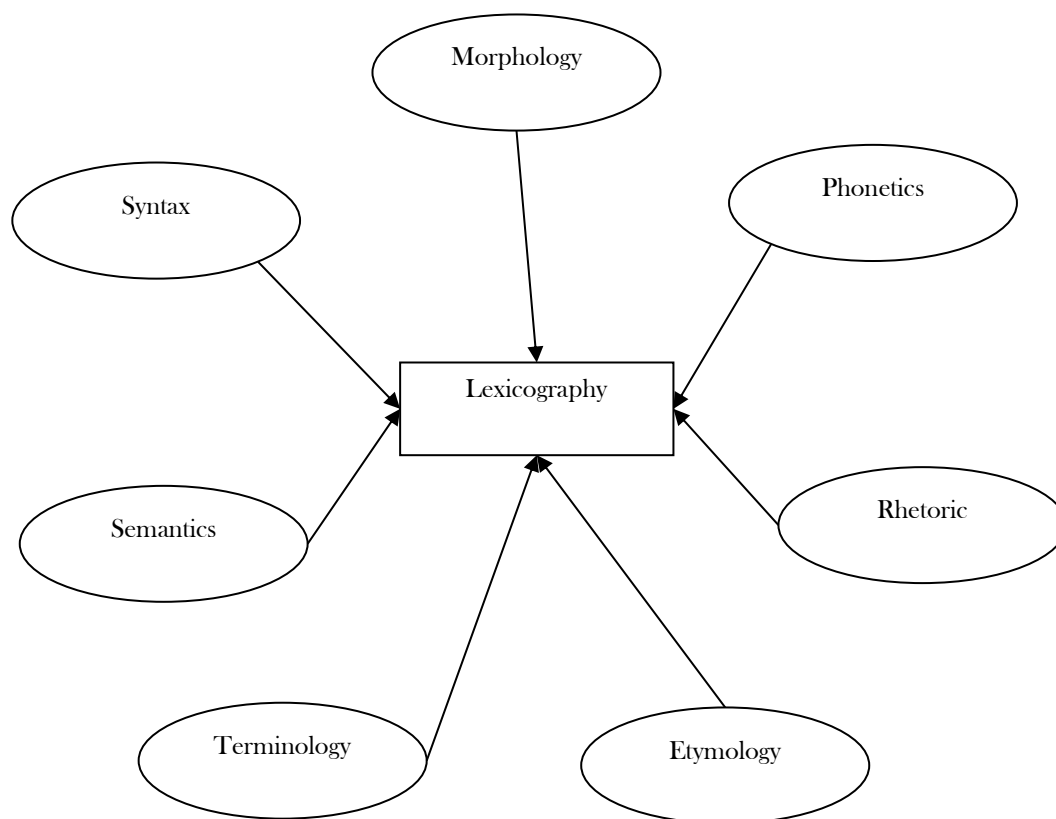
4.6. Interim

The analysis above confirms that *Kitāb al-ʿAyn* embodies a sophisticated form of epistemic cross-fertilization rooted in mathematical logic and phonological systematization. Al-Khalīl’s dictionary demonstrates that early Arabic scholarship achieved a level of interdisciplinarity that rivals, and in some respects anticipates, modern scientific paradigms.

By integrating phonetics, mathematics, medicine, and cultural analysis into a single lexicographical framework, al-Khalīl established a model of encyclopedic thinking that remains profoundly relevant for contemporary discussions on knowledge integration and the philosophy of language.

Table 1. Epistemic Cross-Fertilization in *Kitāb al-ʿAyn*

Domain of Knowledge	Manifestation in <i>Kitāb al-ʿAyn</i>	Epistemic Function
Mathematics	Phonetic permutations (<i>taqīl bāṭ</i>), exclusion rules, <i>ḥisāb al-jummal</i>	Guarantees structural completeness and logical consistency
Phonetics / Phonology	Articulation points, sound harmony, incompatibility rules	Regulates word formation and phonotactic acceptability
Morphology	Root analysis, triliteral–quineliteral patterns	Ensures derivational productivity
Semantics	Contextual meaning, usage in poetry and speech	Anchors lexical meaning in authentic usage
Medicine & Anatomy	Description of speech organs and defects	Connects language to physiology
Cultural Sciences	Loanwords, customs, occupations	Documents civilizational interaction
Qurʾānic Sciences	Tajwīd, qirāʾāt, semantic precision	Supports accurate religious interpretation

Table 2. Phonetic / Phonological Constraints in *Kitāb al-'Ayn*

Volume & Page	Phonetic Rule Identified by al-Khalīl	Linguistic Principle
Vol. 1, p. 129	<i>Ṣād</i> may alternate with <i>sīn</i> before <i>qāf</i>	Context-dependent phonetic substitution
Vol. 1, p. 96	' <i>Ayn</i> , <i>ḥā</i> ', <i>khā</i> ' do not combine with many letters	Articulatory incompatibility
Vol. 1, p. 52	Words lacking <i>dhalaq</i> or labials are innovated	Phonological authenticity criterion
Vol. 5, p. 32	<i>Qāf</i> and <i>kāf</i> do not co-occur	Articulatory proximity constraint
Vol. 2, p. 182	<i>Ṭā</i> ' and <i>tā</i> ' do not combine	Redundancy avoidance
Vol. 7, p. 5	<i>Ḍād</i> and <i>ṣād</i> incompatible except numerological example	Phonological harmony over mathematical construction
Vol. 4, p. 103	<i>Hā</i> ' before <i>hamza</i> is disfavored	Euphonic regulation

Table 3. Mathematical-Phonological Logic in Lexical Validation

Principle	Description	Example from <i>Kitāb al-'Ayn</i>
Permutation (<i>taqlīb</i>)	Enumeration of all root combinations	Exhaustive lexical mapping
Exclusion	Elimination of phonetically impossible forms	<i>qāf</i> + <i>kāf</i>
Numerical validation	Use of <i>ḥisāb al-jummal</i>	<i>ṣa'faḍ</i> → <i>ṣa'fa's</i>
Phonetic correction	Preference for euphony over calculation	Replacement of <i>ḍād</i>

Table 4. Criteria for Identifying Foreign (Dakhīl) Words

Criterion	Explanation	Example
-----------	-------------	---------

Absence of labials	Non-Arabic phonological profile	<i>al-da‘shūqah</i>
Irregular vowel pattern	Violates Arabic phonotactics	<i>al-saqraq‘</i>
Impermissible consonant sequence	Structural incompatibility	<i>al-muhandis</i>
Non-Arabic morphological pattern	No Arabic analog	<i>al-kashkhān</i>
Known foreign origin	Historical borrowing	<i>dahlīz, farand</i>

Table 5. Arabization (*Ta‘rīb*) Mechanisms in *Kitāb al-‘Ayn*

Foreign Term	Original Language	Arabized Form	Adaptation Mechanism
<i>Dālīj</i>	Persian	<i>Dahlīz</i>	Phonetic substitution
<i>Harnakāh</i>	Persian	<i>Al-khurnaḡ</i>	Morphological alignment
<i>Hindazah</i>	Persian	<i>Muhandis</i>	Consonantal adaptation
<i>Farand</i>	Persian	<i>Farand</i>	Minimal phonetic adjustment

Table 6. Defects of Pronunciation in *Kitāb al-‘Ayn*

Term	Volume & Page	Description	Related Discipline
<i>Al-thaghthaghhah</i>	Vol. 1, p. 84	Lisp dominated by <i>thā’</i> and <i>‘ayn</i>	Speech pathology
<i>Al-na‘na‘ah</i>	Vol. 1, p. 91	Nasal vibration replacing intended sound	Phonetics
<i>Al-‘aft</i>	Vol. 2, p. 74	Softening or breaking of sound	Accentology
<i>Al-hathathah</i>	Vol. 3, p. 349	Tongue twisting or stammering	Neuromuscular speech
<i>Al-hathhah</i>	Vol. 3, p. 350	Lisp-related articulation	Phonology
<i>Al-ghatmah</i>	Vol. 4, p. 398	Inarticulate speech	Medical linguistics

Table 7. Encyclopedic Role of Lexicography in *Kitāb al-‘Ayn*

Central Discipline	Connected Fields	Outcome
Lexicography	Mathematics, phonetics, medicine, theology	Unified epistemic system
Phonetics	Anatomy, tajwīd, physics	Accurate sound modeling
Morphology	Logic, derivation theory	Systematic word formation
Semantics	Tafsīr, rhetoric	Meaning precision

6. Conclusion

This study has demonstrated that *Kitāb al-‘Ayn* is not merely an early Arabic dictionary but a fully developed intellectual encyclopedia that embodies an advanced epistemological vision. Al-Khalīl ibn Aḥmad’s lexicographical project reflects a deep commitment to epistemic integration, uniting linguistic sciences with natural sciences, mathematics, medicine, and religious knowledge.

Reexamining such works is not an exercise in nostalgia but a necessary step toward reclaiming the intellectual continuity of Arab-Islamic civilization and challenging reductive narratives that marginalize its scientific heritage. *Kitāb al-‘Ayn* stands as enduring evidence that encyclopedic thinking is deeply rooted in classical Arabic scholarship and remains relevant to contemporary debates on interdisciplinarity and knowledge integration.

5. Grammatical Indicators in *Kitāb al-‘Ayn*: Lexicography as a Syntactic Science

In *Kitāb al-‘Ayn*, lexicography is inseparable from grammatical analysis. Al-Khalīl ibn Aḥmad does not treat words as isolated lexical units; rather, he situates them within their **syntactic environments**, explicating their grammatical states (*aḥwāl i‘rābiyyah*), functions, and positional meanings. This approach demonstrates that early Arabic lexicography functioned simultaneously as a **descriptive grammar**.

For example, in his discussion of the term **ḥall** (Vol. 3, p. 26), al-Khalīl defines it as denoting *position or state*, explicitly contrasting it with *murtahīl* (one who is traveling). He supports this semantic distinction through poetic evidence cited from al-A‘shā, thereby grounding grammatical explanation in authentic literary usage. When questioned about syntactic ordering—specifically the permissibility of beginning a clause with an indefinite noun—al-Khalīl clarifies that such constructions fall outside standard Arabic usage and should be understood as isolated reports rather than normative grammatical patterns. This reflects an early awareness of **linguistic normativity versus attested deviation**, a distinction central to modern linguistic theory (Versteegh, 1997).

Similarly, al-Khalīl’s treatment of **‘inda** (Vol. 2, p. 52) exemplifies his syntactic precision. He classifies it as a *ḥarf ṣilāḥ* functioning adverbially, normally marked by the accusative (*naṣb*) due to its role as a circumstantial qualifier. However, he acknowledges exceptional contexts in which it assumes nominative case (*raf‘*), illustrating a rule-based yet flexible grammatical system sensitive to discourse context.

The analysis of **ba‘da** further reveals al-Khalīl’s syntactic depth. He explains its behavior across multiple constructions—absolute usage without tanwīn, accusative qualification, and nominal subordination when preceded by *mim*. His justification

rests on a logical grammatical principle: two qualifiers cannot occupy the same syntactic position, and thus hierarchical dominance determines grammatical function. Such reasoning anticipates modern dependency-based syntactic analysis.

6. Semantic–Grammatical Interface and Qur’ānic Evidence

Al-Khalīl’s lexicographical method reaches its highest level of sophistication when lexical meaning intersects with Qur’ānic interpretation. In his discussion of **al-bid‘ah** (Vol. 1, pp. 54–55), he explains the accusative reading (*naṣb*) in the verse “*Badī‘a al-samāwāti wa al-arḍ*” as expressing amazement or admiration, reflecting the semantic nuance of wonder attributed to human speech. Conversely, when the term functions as a divine attribute (*al-Badī‘*), the nominative reading (*raf‘*) is preferred, indicating permanence and absolute attribution.

This distinction demonstrates al-Khalīl’s sensitivity to **semantic case-marking**, where grammatical form is determined by meaning, discourse role, and theological implication. Such analysis positions lexicography as a foundational discipline for **Qur’ānic sciences**, particularly tafsīr and qirā’āt (al-Zarkashī, 1988).

7. Grammatical Gender and Morphological Reasoning

In addressing the markers of femininity (*ta’nīth*), al-Khalīl identifies three primary indicators: the feminine *hā’*, the extended vowel (*madḍa*), and the *yā’* (Vol. 1, p. 312). Beyond formal markers, he introduces a **semantic–cognitive explanation**, asserting that femininity extends to entities characterized by openness or separation, such as fingers or nostrils. This reasoning reveals an early form of **conceptual morphology**, in which grammatical gender is informed by perceptual and functional properties rather than arbitrary classification.

Such insights demonstrate that al-Khalīl’s grammatical thought was not merely formalistic but deeply cognitive, anticipating modern approaches in cognitive linguistics (Langacker, 1987).

8. Terminology (*Muṣṭalah*) and the Foundations of Linguistic Sciences

Al-Khalīl’s encyclopedic genius is further evident in his systematic development of technical terminology. Recognizing that every science requires conceptual tools, he established a terminological framework that became foundational for phonetics, grammar, lexicography, and prosody. Terms such as *al-jahr* (voicing), *al-hamz* (glottalization), *al-makhrāj* (point of articulation), and *al-ḥayz* (phonetic space) remain integral to linguistic discourse.

Notably, modern phonetic terminology aligns closely with al-Khalīl’s system:

- *Al-majhūr* → voiced
- *Al-mahmūs* → voiceless
- *Al-rakhw* → fricative

This continuity confirms that classical Arabic phonetics achieved a level of conceptual precision comparable to modern scientific standards (Ba’albaki, 2014).

9. Mathematics as the Structural Core of *Kitāb al-‘Ayn*

At the heart of *Kitāb al-‘Ayn* lies a **mathematical lexical theory** based on combinatorics and permutation. Al-Khalīl systematically enumerated the possible arrangements of Arabic letters, recognizing that words may be biliteral, trilateral, quadrilateral, or quinqueliteral. By generating all theoretical permutations and subsequently distinguishing between *used* and *unused* forms, he established a comprehensive model of lexical potential.

This approach mirrors what modern mathematics describes as **factorial analysis** and **set theory**. The use of permutation trees—illustrated through simple combinatorial examples (e.g., arranging A, B, and C)—demonstrates that al-Khalīl employed abstract mathematical reasoning to solve linguistic problems. His method anticipates modern computational linguistics, corpus modeling, and algorithmic lexicography (al-Naṣrāwī, 2012).

10. Phonetics and Physics: Sound as a Natural Phenomenon

Al-Khalīl’s phonetic theory is deeply rooted in physical reality. He implicitly understood sound as a vibrational phenomenon transmitted through air and processed by the auditory system. His classification of sounds into strong, weak, and intermediate categories reflects an awareness of airflow control, resistance, and acoustic energy.

Modern phonetics, which draws heavily on physics—particularly acoustics and wave theory—confirms the validity of these early insights. The Arab classification of sounds based on voicing, intensity, and airflow corresponds closely with contemporary acoustic phonetics (Jakobson, 1968). This confirms that Arabic phonetic thought did not merely precede modern physics-inspired linguistics but actively anticipated it.

11. Conclusion

The intellectual legacy of al-Khalīl ibn Aḥmad al-Farāhīdī represents a landmark in the history of human knowledge. Through *Kitāb al-‘Ayn*, he established a **phonetic–mathematical lexical theory** that integrated grammar, semantics, physics,

mathematics, and theology into a unified epistemic system. His work exemplifies the encyclopedic mindset of classical Arab scholarship and challenges contemporary narratives that marginalize non-Western scientific traditions.

12. Findings and Recommendations

A. Findings

- Classical Arabic manuscripts embody a deeply rooted encyclopedic epistemology.
- *Kitāb al-ʿAyn* represents a uniquely Arab scientific achievement grounded in mathematical reasoning.
- Integrated knowledge across disciplines yields profound methodological innovation.
- Phonetics emerges as an interdisciplinary science drawing on anatomy and physics.
- Lexicography requires exceptional encyclopedic competence.

B. Recommendations

1. Establish advanced phonetics laboratories equipped with digital analyzers and oscillographic tools.
2. Provide continuous training in modern phonetic theory.
3. Integrate physics into linguistics and lexicography curricula.
4. Emphasize mathematical modeling to support digital lexicography and automated phonetic systems.

Ethical Considerations

This study is based exclusively on the analysis of classical texts, published sources, and historical manuscripts related to Arabic lexicography and linguistic theory. It does not involve human participants, personal data, interviews, experiments, or animal subjects. Consequently, ethical approval from an institutional review board was not required. The authors affirm that all sources have been cited accurately and responsibly, in accordance with academic integrity and international publication ethics standards.

Acknowledgements

The authors would like to express their sincere appreciation to their respective academic institutions—Mohamed El Bachir El Ibrahim University of Bordj Bou Arreridj and Mohamed Lamine Debaghine University of Sétif 2—for providing an intellectually supportive research environment. Special thanks are extended to scholars of Arabic linguistics and lexicography whose foundational works have contributed significantly to the development of this study.

Funding

This research received no specific grant from any funding agency in the public, commercial, or non-profit sectors. The study was conducted independently by the authors as part of their academic research activities.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. The research was carried out without any financial or personal relationships that could inappropriately influence or bias the content of the study.

References

1. al-Khalīl ibn Aḥmad al-Farāhīdī. *Kitāb al-ʿAyn*. Ed. Maḥdī al-Maḥzūmī & Ibrāhīm al-Sāmīrāʾī.
2. Baʿalbaki, R. (2014). *Arabic Lexicography*. Brill.
3. Jakobson, R. (1968). *Child Language, Aphasia and Phonological Universals*.
4. Langacker, R. (1987). *Foundations of Cognitive Grammar*.
5. al-Naṣrāwī, ʿĀ. ʿA. (2012). *The Mathematical Method in Phonetic Studies*.
6. Versteegh, K. (1997). *The Arabic Language*. Edinburgh University Press.
7. Arkoun, M. (2002). *The Unthought in Contemporary Islamic Thought*. London: Saqi Books.
8. Baʿalbaki, R. (2014). *Arabic Lexicography: Its History and Development*. Leiden: Brill.
9. Foucault, M. (1970). *The Order of Things*. New York: Vintage Books.
10. Ibn Jinnī, A. (1952). *Al-Khaṣāʾiṣ*. Cairo: Dār al-Kutub al-Miṣriyya.
11. al-Jābirī, M. ʿĀ. (1991). *Naqd al-ʿAql al-ʿArabī*. Beirut: Markaz Dirāsāt al-Waḥda al-ʿArabiyya.
12. al-Suyūṭī, J. (1998). *Al-Muḥḥir fī ʿUlūm al-Lughā*. Beirut: Dār al-Kutub al-ʿIlmiyya.
13. al-Zarkashī, B. (1988). *Al-Burhān fī ʿUlūm al-Qurʾān*. Cairo: Dār al-Turāth.
14. Versteegh, K. (1997). *The Arabic Language*. Edinburgh: Edinburgh University Press.