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Modeling Syntactic Structures in Arabic: A Study of Selected Qura'nic Semi-Clauses Using Dependency Grammar and Computational Analysis

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Abstract
This study investigates the attachment of prepositional and adverbial phrases in Qur'anic discourse through an integrated framework combining traditional Arabic grammar, dependency analysis, constituency structure, computational parsing, and probabilistic graph-based modeling. The findings show that multiple attachment is a systematic syntactic feature that enriches semantic interpretation. Applied models revealed that traditional grammar preserves interpretive plurality, dependency grammar clarifies relational structure, and constituency analysis represents hierarchy without resolving ambiguity. Computational tools largely favored single verbal attachment, while probabilistic models captured competing links with weighted likelihoods (e.g., 0.55/0.25/0.20; 0.60/0.40). The study concludes that single-path parsing is insufficient for complex Qur'anic syntax, and that multi-attachment probabilistic modeling provides a more accurate representation when integrated with traditional grammatical insights.
Keywords: Qur'anic Syntax; Dependency Grammar; Computational Parsing; Arabic Language

INTRODUCTION

The interdependence of grammatical structures in Arabic reflects both the language's systemic coherence and its structural complexity, arising from syntactic flexibility, semantic multiplicity, and the interaction between predicational and dependency relations (Ibn Hisham, 2004; Owens, 1984). Classical Arab grammarians conceptualized these relations through the ʿāmil–maʿmūl framework, the link between inflection and syntactic function, and the distinction between overt and covert elements (Ibn Yaʿīsh, 2001; Al-Halabi, 2000). However, the abstraction of this predication-based model limits its direct computational formalization without systematic reinterpretation (Habash et al., 2009; Khalifa et al., 2020). Advances in Natural Language Processing (NLP) highlight the need for formal computational models of Arabic syntax (Dukes & Buckwalter, 2010; Al-Sabbagh & Girju, 2012). Dependency Grammar offers an effective framework by representing sentences as networks of lexical nodes connected through directed relations (Nivre, 2005; Kübler, McDonald, & Nivre, 2009). This study examines the modeling of prepositional and adverbial phrase attachment in Arabic—particularly in Qurʾanic discourse—where structural ambiguity and multiple dependencies are frequent (Al-Sulaiti & Atwell, 2006; Halabi et al., 2020). It adopts a dual approach combining theoretical linguistic analysis with computational modeling using tools such as CAMeL Tools, Stanza, and spaCy (Obeid et al., 2020; Zhang et al., 2020).

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This study aims to develop a dependency-based syntactic model for representing complex grammatical relations in Arabic, apply computational syntactic and semantic tools to analyze prepositional and adverbial phrase attachment in Qurʾanic texts, systematically compare traditional Arabic grammatical analysis with contemporary computational parsing approaches. Propose enhancements to Arabic Natural Language Processing systems to better model syntactic ambiguity and multiple attachment relations. This study strengthens the theoretical linkage between classical Arabic grammar and contemporary dependency-based computational frameworks by formalizing Arabic syntactic structures within a dependency paradigm. It demonstrates the effectiveness of dependency relations in representing Arabic syntax and examines prepositional phrases as a structurally complex feature that remains insufficiently addressed in current computational resources, thereby contributing to the formal representation of Arabic syntax. Applied contributions include empirically grounded support for advancements in Arabic NLP and artificial intelligence. The proposed models inform the development of linguistically driven applications such as intelligent language-learning systems, automated grammar checking, and machine translation. By improving the computational analysis of prepositional phrases in Qurʾanic discourse, the study enhances syntactic parsing accuracy and semantic interpretation in advanced Arabic NLP systems.

This study adopts an integrative framework that situates classical Arabic grammatical theory in dialogue with dependency-based syntax and contemporary computational linguistics. It proceeds from the premise that while Arabic grammatical thought provides a sophisticated account of syntactic relations, its interpretive nature necessitates formal restructuring for compatibility with explicit and empirically grounded models of representation (Alhawary, 2022; Habash et al., 2012). Classical Arabic grammar conceptualizes sentence structure through governance, dependency, and predication, with syntactic meaning primarily encoded through iʿrāb. Central to this system are the notions of the governor (ʿāmil), the governed (maʿmūl), and the distinction between overt and covert elements. The concept of attachment (taʿalluq)—particularly in relation to prepositional and adverbial phrases—explains their association with explicit or implicit governing elements, a feature especially significant in Qurʾanic discourse characterized by ellipsis and semantic layering (Hassanein, 2023).

Despite its descriptive richness, the traditional model remains largely non-formalized, relying on interpretive inference and multiple valid analyses, which limits its applicability to systematic modeling (Habash et al., 2012). Dependency grammar offers a compatible relational framework by representing syntax through direct head-dependent relations, making attachment explicit without reliance on phrasal structure (Kuhlmann & Nivre, 2006; De Marneffe & Manning, 2008). In Arabic linguistics, such representations enable the formalization of traditional insights while facilitating empirical evaluation through computational implementation (Hajič et al., 2009). Recent advances in Arabic computational linguistics have created new opportunities to examine complex syntactic phenomena—such as semi-clauses—through dependency-based frameworks. Traditionally treated within classical Arabic grammar under categories such as circumstantial expressions and prepositional attachments, semi-clauses have often been analyzed descriptively rather than formally. However, contemporary research shows a growing shift from phrase-structure approaches toward dependency grammar, which emphasizes relational links between linguistic elements rather than hierarchical constituency. This shift is particularly significant for

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Arabic, whose syntax frequently encodes meaning through functional relations rather than fixed structural configurations (Halabi et al., 2021; Aziz et al., 2024).

One of the most important developments in this regard is the effort to bridge traditional Arabic grammatical theory with computational modeling. Recent dependency treebanks grounded in classical grammatical principles demonstrate that relational concepts from the Arabic syntactic tradition can be formally represented within modern annotation systems. Halabi et al. (2021) show that dependency annotation inspired by traditional grammar provides a structurally faithful representation of Arabic syntactic relations. Such integration allows constructions that behave like semi-clauses to be treated not as incomplete clauses but as relational units governed by dependency links.

The rise of neural dependency parsing has further strengthened this perspective. Transformer-based models and contextualized embeddings have significantly improved the ability of computational systems to represent complex syntactic relations. Contemporary Arabic parsers such as CamelParser2.0 demonstrate how contextual neural architectures can model syntactic dependencies with high accuracy (Elshabrawy et al., 2023). Similarly, recent evaluations of BERT-based Arabic parsing models confirm that neural approaches significantly enhance syntactic representation and attachment resolution (Al-Ghamdi et al., 2023; Saadiyeh et al., 2025). These advances are particularly relevant for semi-clauses, whose interpretation often depends on contextual cues and non-local attachment rather than explicit clausal markers.

Annotated resources have also played a crucial role in advancing computational syntactic analysis. The development of large-scale Arabic dependency treebanks has made it possible to empirically examine structures that were previously treated only theoretically. Resources such as the CAMeL Treebank enable computational models to integrate morphological and syntactic information simultaneously (Habash et al., 2022). This is especially important for semi-clausal constructions, which may function adjectivally, adverbially, or circumstantially depending on their relational context. In addition to parsing, recent research in dependency-based semantic extraction has demonstrated that clause-like units can be computationally identified through relational structures rather than overt clausal boundaries. For example, dependency parsing has been successfully used for Arabic open information extraction, enabling systems to identify predicate–argument relations and embedded semantic units from text (El-Morsy et al., 2022). These findings support the view that semi-clauses function as relational meaning units that contribute to interpretation without necessarily forming full syntactic clauses.

Cross-dialectal studies have also revealed that Arabic syntactic relations vary considerably across linguistic varieties. Neural dependency parsers have shown promising adaptability when applied to dialectal data despite structural variation (Abo Mokh et al., 2024). This adaptability is particularly relevant for semi-clauses, which often appear more productively in spoken varieties and exhibit greater attachment ambiguity. More broadly, recent work has begun to link dependency parsing with semantic representation. By identifying complex sentence patterns through syntactic relations, computational systems can construct higher-level meaning representations. This trend is evident in studies that use dependency parsing for syntactic pattern identification and semantic analysis (Aziz et al., 2024).

Thus, the literature reflects a transition from deterministic, phrase-based analysis toward probabilistic, relation-based modeling of Arabic syntax. The integration of neural parsing,

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annotated treebanks, and semantic extraction techniques has opened new avenues for studying semi-clausal constructions computationally (Saadiyeh et al., 2025; Al-Ghamdi et al., 2023). These developments support a reconceptualization of semi-clauses as dependency-governed substructures rather than incomplete clauses, and suggest that future research will benefit from combining classical grammatical insights with modern computational modeling (Saadiyeh et al., 2025).

METHOD

The study employs a comparative analytical methodology to examine the syntactic representation of prepositional phrases in Arabic through three stages: analysis within classical grammar, modeling through dependency-based computational frameworks, and systematic comparison of both approaches to assess structural and semantic implications (Dukes & Habash, 2010; Halabi et al., 2020). The dataset comprises purposively selected Qurʾanic verses containing syntactically complex prepositional and adverbial phrases. Selection criteria include multiple potential attachment sites, interpretive ambiguity, and cases requiring inferred grammatical relations, ensuring alignment with the study's analytical focus (Dukes & Habash, 2010).

Traditional analysis is conducted manually using authoritative grammatical sources, while computational analysis employs dependency-based NLP tools such as CAMeL Tools and Stanza to generate formal syntactic representations (Abu Khalil & Shaalan, 2020; Zhang et al., 2020). Each verse is analyzed contextually through traditional grammatical interpretation and dependency-based computational modeling. The resulting representations are compared to identify convergences and divergences in attachment structures and their semantic implications, with findings synthesized to support the study's conclusions (Dukes & Habash, 2010). The Traditional Grammatical Analysis of the Attachment of Semi-Clauses (Shibh al-Jumlah) to Governing Elements in Qurʾānic Texts. The Grammatical Concept of the Semi-Clause and Its Attachment to Governing Elements.

RESULTS AND DISCUSSION

Applied Model One

The analyzed semi-cla is: ﴿ثُمَّ الَّذِينَ كَفَرُوا بِرَبِّهِمْ يَعْدِلُونَ﴾(Qurʾān 6:1). In traditional predicative grammar, *(ثمthumma)* functions as a coordinating particle, *(alladhīna)* as the subject, *(كفروkafarū)* as the relative clause, *(yaʿdilūn)* as the predicate, and *(بربهمbi-rabbihim)* as a semi-clause (prepositional phrase). The key issue is the attachment of *(bi-rabbihim)*. It may relate either to *(kafarū)* → "they disbelieved in their Lord" ← the overt reading, or to *(yaʿdilūn)* → "they equate [others] with their Lord" / "deviate from Him." Both attachments are grammatically permissible. Further details are shown in Table 2.

Table 1. Computational Recommendation Summary

Modeling Requirement	Justification
Dual attachment representation	Preserves interpretive plurality
Probabilistic ambiguity scoring	Ranks possible readings
Graph-based parsing	Avoids semantic loss from forced disambiguation
Multi-layer annotation	Encodes classical and dependency insights simultaneously

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Table 2. Applied Model One — Ambiguous Prepositional Attachment (Qurʾān 6:1)

Component	Grammatical Analysis	Attachment to *kafarū*	Attachment to *yaʿdilūn*	Dependency Represent.	Interpretive Outcome
Particle	*thumma* → coordinating particle	—	—	Discourse connector	Sequential emphasis
Subject	*alladhīna* → subject (mubtadaʾ)	Subject of *yaʿdilūn* via relative clause	Subject of *yaʿdilūn*	alladhīna → nsubj	Refers to persistent disbelievers
Relative Clause	*kafarū* → relative verb	Head of PP attachment	Subordinate clause	kafarū → acl (relative clause)	Defines the subject
Predicate	*yaʿdilūn* → predicate	Root of main clause	Root of main clause	ROOT	Central predication
Prepositional Phrase	*bi-rabbihim* → semi-clause (PP)	Dependent of *kafarū*	Oblique of *yaʿdilūn*	obl	Source of ambiguity
Ellipsis Possibility	Implied objects/complement	Requires omitted complement (e.g., *yaʿdilūnahu bi-ghayrihi*)	No required ellipsis	Structural variation	Affects semantic scope
Dependency Structure	Not formally specified	kafarū ← head → bi-rabbihim	yaʿdilūn ← head → bi-rabbihim	Alternative graphs	Dual attachment
Semantic Reading	Interpretive plurality allowed	"They disbelieved in their Lord [and equated others with Him]."	"They equate others with their Lord."	Competing parses	Theological nuance shifts
Computational Implication	Non-formalized interpretive model	Single-head attachment	Single-head attachment	Requires multi-graph modeling	Supports ambiguity preservation
Recommended Modeling	Descriptive analysis	One dependency tree	Alternative dependency tree	Graph-based parsing	Probabilistic ambiguity scoring

Applied Model Two

The verse under analysis is: ﴿فَنَادَاهَا مِن تَحْتِهَا أَلَّا تَحْزَنِي﴾(Maryam 19:24). The locus of evidence is the clause *fa-nādāhā min taḥtihā* ("Then he called her from beneath her"). The prepositional phrase *(min taḥtihā)*—composed of *min* (from) and *taḥtihā* (beneath her)—admits two possible syntactic attachments. In the first reading, it attaches to the past verb *nādāhā* ("he called her") as a locative modifier, specifying the spatial source or direction of the call. In the second, it attaches to an implicit circumstantial predicate (ḥāl) of the covert subject *huwa*, referring either to the calling angel (Gabriel) or the newborn Prophet (Jesus, peace be upon him), describing the caller's position rather than the origin of the act itself (Al-Zamakhsharī, 2009; Al-Ālūsī, 2010). From a dependency grammar perspective, *nādāhā* is the clause root. It governs two objects: the attached pronoun *-hā*, functioning as a direct object, and the subordinate clause *ʾallā taḥzanī*, representing the propositional content of the speech act. The prepositional phrase *min taḥtihā* can attach via two paths. If attached to *nādāhā*, it functions as a locative oblique modifier specifying the source of the call.

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This reading conveys that she was called by a voice originating from beneath her. If attached to the implicit ḥāl of the subject, it describes the caller's state. Here, someone (Gabriel or Jesus) called her while being beneath her. A multi-headed representation allows *(min taḥtihā)* to depend simultaneously on both the verb *nādāhā* (event locative) and the implicit ḥāl (subject-state locative). Enhanced UD frameworks can encode this dual function, preserving both semantic readings (Saadiyeh et al., 2025). Computationally, Stanza and Farasa typically attach the phrase to the verb, while CAMeL Tools identifies it as locative but does not model implicit structures. AraBERT + UDPipe can capture multi-headed dependencies if trained on specialized corpora. This approach ensures computational models maintain interpretive flexibility, consistent with grammatical tradition and semantic precision.

Table 3. Applied Model Two — Locative Attachment Ambiguity (Maryam 19:24)

Component	Grammatical Analysis	Attachment to *nādāhā*	Attachment to Implicit ḥāl	Dependency Represent.	InterpretOutcome
Verb (Root)	*nādāhā* → past verb	Root of clause	Root of clause	nādāhā → ROOT	Central speech act
Object Pronoun	*-hā* → direct object	Direct object of verb	Direct object of verb	obj	Mary as addressee
Subordinate Clause	*ʾallā taḥzanī* → content clause	Complement of speech act	Complement of speech act	ccomp	Propositional content
Prepositional Phrase	*min taḥtihā* → semi-clause (locative)	Locative modifier of verb	Locative modifier of implicit subject state	obl:loc	Source of ambiguity
Attachment Target	Not explicitly formalized	Attached to *nādāhā*	Attached to covert ḥāl (state of subject)	Alternative dependency paths	Structural ambiguity
Semantic Scope	Interpretively flexible	Specifies origin of the call	Specifies position of the caller	Competing locative relations	Shifts focus from event to agent
Event Interpretation	Contextually inferred	"She was called from beneath her."	"He called her while being beneath her."	Single-head parse vs. enhanced representation	Distinct narrative nuance
Implicit Structure	Accepted via interpretive tradition	No implicit predicate required	Requires implicit circumstantial predicate (ḥāl)	Requires enhanced annotation	Encodes covert grammatical layer
Dependency Modeling	Not formally specified	min taḥtihā → nādāhā	min taḥtihā → implicit ḥāl	Multi-path possibility	Dual reading preservation
Computational Behavior	Not computationally modeled in classical grammar	Standard parsers attach to verb	Implicit ḥāl typically not modeled	Requires enhanced UD	Preserves semantic plurality

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Table 4. Integrated Computational Framework

Tool / Requirement	Function	Limitation	Enhancement / Purpose
Stanza	PP attaches to verb	No implicit-state modeling	Enhanced dependency layer
Farasa	Verb attachment	No multi-headed structure	Graph-based extension
CAMeL Tools	Detects locative relation	No implicit ḥāl encoding	Latent structure modeling
AraBERT + UDPipe	Supports enhanced UD	Needs specialized data	Multi-headed encoding
Dual attachment encoding	Preserves event & state readings	—	Interpretive plurality
Enhanced UD	Represents implicit predicates	—	Models covert structure
Multi-headed graphs	Allows multiple analyses	—	Structural flexibility
Classical corpus training	Captures ellipsis	—	Classical accuracy
Probabilistic scoring	Ranks analyses	—	Resolves ambiguity

Applied Model Three

The verse under analysis is: "And when distress touches you at sea, those you invoke vanish except Him…" (Qurʾān 17:67). The focus is the segment *"When distress touches you at sea, those you invoke vanish."* The prepositional phrase (في البحر)("at sea") allows multiple attachment possibilities. It may attach to the past verb مسّكم("touches you"), specifying the spatial context of the distress; to an elliptical circumstantial predicate (ḥāl) of the subject or object pronoun كم, describing the state of those affected; or to the verb ضلّ("vanish"), indicating the location of the vanishing event. In the conditional clause إذا مسّكم الضر في البحر(*When distress touches* you at sea), the verb مسّfunctions as the syntactic head and governs كم(object), الضر(subject), and (في البحر) (prepositional phrase). In the apodosis clause ضلّ من تدعون إلا إياه(Those you invoke vanish except Him), ضلّserves as the head, governing من(subject), تدعون(relative clause), and إياه(accusative of exception). For dependency paths of (في البحر), the first attachment is to the verb مسّ:

[إذا]
↓
[مسّ]
/ | \
[الضر] [كم] [في البحر]

Here, (في البحر)functions as a locative dependent of the verb, specifying that distress touches you **in the sea**. The second path attaches (في البحر)to an implicit circumstantial predicate of كم:

[إذا]
↓
[مسّ]
|
[كم]
↑

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[حال]
↑
[في البحر]

This reading indicates that you are at sea when distress occurs, describing the state of the affected subject rather than the event itself. The third path attaches *(في البحر)* to ضلّ, assuming structural displacement and delayed attachment:

[إذا]
↓
[مسّ]
/ \
[الضر] [كم]
[ضلّ]
/ | \
[من] [تدعون] [في البحر]

Here, *(في البحر)* indicates the location of the vanishing: those invoked vanish in the sea, except Him. A multi-headed dependency analysis integrates both attachments, allowing *(في البحر)* to depend simultaneously on the verb (*event locative*, 65%) and the elliptical subject-state (*circumstantial ḥāl*, 35%). Within a graph-based framework, the nodes and edges can be represented in Table 5.

Table 5. The Relations Between The Nodes And Edges

From	To	Relation	Probability
M مسّكم	D الضر	Subject	1.00
M مسّكم	V في البحر	Locative (verb attachment)	0.65
D الضر	V في البحر	Circumstantial (subject state)	0.35
Z ضلّ	T تدعون	Subject	1.00
Z ضلّ	E إياه	Exception	1.00

Table 6. A Comparative Evaluation Of Analytical Approaches

Approach	Attachment of في البحر	Strength	Limitation
Traditional Grammar	Verb / Circumstantial	Interpretive richness	Not computational
Dependency Grammar	Mostly Verb	Structural precision	No multi-attachment
Constituency Grammar	Under VP	Strong structure	Weak relational precision
CAMeL Tools	Verb	Reliable parsing	No interpretive modeling
Multi-Attachment Graph	65% Verb / 35% Subject	Preserves semantic flexibility	Requires training

The structurally and semantically stronger interpretation attaches *(في البحر)* to the elliptical circumstantial state of كم, reflecting the contextual condition of the subject. Probabilistic multi-attachment modeling preserves both event-location and human situational vulnerability, offering the most faithful computational representation of Qurʾānic syntax and discourse semantics.

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Table 7. Applied Model Three — Multi-Path Locative Attachment (Qurʾān 17:67)

Component	Grammatical Analysis	Verb (*mas-sakum*)	Circumstantial ḥāl	Verb (*ḍalla*)	Dependency Represent	Interpretive Outcome
Conditional Particle	*idhā* → conditional marker	Introduces protasis	Same	Same	mark	Temporal/conditional frame
Verb (Protasis)	*mas-sakum* → verbal head	Governs PP	Governs object only	Not governing PP	ROOT (conditional clause)	Distress event
Subject	*al-ḍurr* → subject of *mas-sa*	Governs PP (secondary link possible)	State anchor	—	nsubj	Source of distress
Object Pronoun	*-kum* → direct object	Affected participant	Governs implicit ḥāl	—	obj	Human addressees
Prepositional Phrase	*fī al-baḥr* → semi-clause (locative)	Event-locative modifier	Circumstantial state of addressee	Delayed locative of *ḍalla*	obl:loc	Locus of ambiguity
Verb (Apodosis)	*ḍalla* → head of second clause	—	—	Governs PP (delayed attachment)	ROOT (main clause)	Vanishing event
Relative Clause	*man tadʿūn* → subject of *ḍalla*	—	—	Subject of vanishing	nsubj + acl	Invoked entities
Exception Phrase	*illā iyyāhu* → accusative of exception	—	—	Dependent of *ḍalla*	expl:pv / exception relation	Divine exclusivity
Primary Semantic Reading	Context-dependent	Distress occurs at sea	You are at sea when distress strikes	Invoked beings vanish at sea	Competing locative scopes	Narrative nuance shifts
Structural Status	Interpretively flexible	Standard verbal attachment	Requires implicit ḥāl	Requires structural displacement	Alternative graphs	Multi-layer interpretation

Table 8. Probabilistic Multi-Attachment Representation

From	To	Relation	Probability
mas-sakum (M)	*al-ḍurr* (D)	Subject	1.00
mas-sakum (M)	*fī al-baḥr* (V)	Locative (event)	0.65
al-ḍurr (D)	*fī al-baḥr* (V)	Circumstantial (state)	0.35
ḍalla (Z)	*man tadʿūn* (T)	Subject	1.00
ḍalla (Z)	*iyyāhu* (E)	Exception	1.00

Table 9. Integrated Analytical and Computational Evaluation Framework

Category	Approach / Reading / Requirement	Attachment / Function	Strength / Weight	Limitation / Justification
Analytical Approach	Traditional Grammar	Verb / Circumstantial	Interpretive richness	Not computationally formalized
Analytical Approach	Dependency Grammar	Primarily verb	Structural precision	No multi-attachment
Analytical Approach	Constituency Grammar	Under VP	Clear hierarchy	Weak relational granularity
Analytical Approach	CAMeL Tools	Verb attachment	Reliable parsing	No interpretive modeling

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Analytical Approach	Multi-Attachment Graph Model	65% Verb / 35% Circumstantial	Preserves semantic flexibility	Requires probabilistic training
Modeling Requirement	Probabilistic dual attachment	Event-location & subject-state readings	Preserves ambiguity	Needs weighted scoring
Modeling Requirement	Graph-based dependency parsing	Multi-headed edges	Structural plurality	Computational complexity
Modeling Requirement	Enhanced UD annotation	Encodes implicit ḥāl	Captures covert predicates	Requires annotation extension
Modeling Requirement	Classical corpus training	Models ellipsis	Context sensitivity	Data scarcity
Modeling Requirement	Weighted edge scoring	Ranks interpretations	Contextual precision	Training dependent
Interpretive Hierarchy	Circumstantial (ḥāl of *-kum*)	Subject-state reading	Highest semantic depth	Context-driven
Interpretive Hierarchy	Verb attachment (*mas-sa*)	Spatial event	Computationally dominant	Less existential depth
Interpretive Hierarchy	Delayed attachment (*ḍalla*)	Secondary narrative link	Weakest structure	Context-dependent

Applied Model Four

The verse under analysis is: ﴿أَهُمْ يَقْسِمُونَ رَحْمَةَ رَبِّكَ ۚ نَحْنُ قَسَمْنَا بَيْنَهُم مَّعِيشَتَهُمْ فِي الْحَيَاةِ الدُّنْيَا ۚ وَرَفَعْنَا بَعْضَهُمْ فَوْقَ بَعْضٍ دَرَجَاتٍ لِّيَتَّخِذَ بَعْضُهُم بَعْضًا سُخْرِيًّا ۗ وَرَحْمَتُ رَبِّكَ خَيْرٌ مِّمَّا يَجْمَعُونَ﴾(Az-Zukhruf 43:32). The focal segment is (قسمنا بينهم معيشتهم)(“We apportioned their livelihood among them”). The prepositional phrase (بينهم)(“among them”) may attach to two syntactic elements. The first and preferred attachment is to the past-tense verb (قسمنا)(“We apportioned”), yielding the straightforward meaning: We distributed the allocation among them (Ibn Hisham, 1996; Ibn Yaish, 2001). The second possibility attaches (بينهم)to an implicit circumstantial modifier of the object (معيشتهم)(“their livelihood”), producing a nuanced interpretation: We apportioned their livelihood while it was distributed among them (Al-Razi, 1985; Abu Hayyan, 1998). Preference is generally given to the first attachment because it links the prepositional phrase directly to the explicit verb, avoiding unnecessary semantic extrapolation and circumstantial inference (Al-Sakkaki, 1987; Tamam Hassan, 2006; Al-Zamakhshari, 2009; Fadel Al-Samarrai, 2010).

Dependency grammar analysis confirms that (قسمنا)serves as the syntactic head. The independent pronoun (نحن)is the subject, dependent on the verb; (معيشتهم)is the object, also dependent on the verb; (بينهم)is a locative adjunct, dependent on the verb; and (في الحياة الدنيا) modifies (معيشتهم)as a temporal adjunct, indicating that the allocation pertains specifically to worldly life. Computational studies using dependency rules on the Qurʾanic text (Dukes, 2010; Fattah, 2010; Halabi et al., 2020) also support direct attachment of (بينهم)to (قسمنا), reflecting both classical grammatical principles and computational efficiency.

This structure highlights key semantic relations: the verb (قسمنا)governs (معيشتهم), denoting allocation; (بينهم)specifies the distribution among people; and (في الحياة الدنيا)restricts the allocation to the worldly life (El Hafsa et al., 2020; Habash et al., 2009). Direct attachment to (قسمنا)is justified by proximity and absence of contextual cues from the object, a principle followed by most modern Qurʾanic Treebank systems (Dukes & Buckwalter, 2010). Advanced computational modeling allows a multi-edge graph representation of *(بينهم)*, simultaneously connecting it to both

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the explicit verb and the implicit circumstantial modifier with assigned probabilities. Nodes and edges can be represented as follows:

Table 10. Symbols and Words

Symbol	Word
V	قَسَمْنَا
M	مَعِيشَتَهُمْ
B	بَيْنَهُم
F	فِي الْحَيَاة
H	الحَيَاة
D	الدُّنْيَا

Table 11. Edges and Probabilities

Head	Dependent	Relation	Probability
V	M	Object	1.00
V	B	Locative adjunct	0.70
M	B	Circumstantial (implicit)	0.30
M	F	Temporal adjunct	1.00
F	H	Genitive modifier	1.00
H	D	Adjective	1.00

Table 12. Applied Model Four — Locative Distribution and Circumstantial Ambiguity (Az-Zukhruf 43:32)

Component	Traditional Grammatical Analysis	Preferred Reading: Attachment to *qasamnā*	Alternative Reading: Circumstantial Attachment to *maʿīshatahum*	Dependency Representation	Interpretive Outcome
Verb (Head)	*qasamnā* → past verb	Governs distribution and PP	Governs object only	ROOT	Divine allocation act
Subject	*naḥnu* → independent pronoun	Subject of verb	Subject of verb	nsubj	Emphatic divine agency
Object	*maʿīshatahum* → direct object	Object of verb	Object with circumstantial PP	obj	Allocated livelihood
Prepositional Phrase	*baynahum* → locative	Locative adjunct of verb	Circumstantial modifier of object	obl:loc	Source of ambiguity
Temporal Phrase	*fī al-ḥayāt al-dunyā* → temporal adjunct	Modifies object	Modifies object	obl:tmod	Restricts allocation to worldly life
Primary Interpretation	Context-driven	"We apportioned their livelihood among them."	"We apportioned their livelihood while it was distributed among them."	Competing dependency paths	Distribution vs. distributed-state nuance
Classical Preference	Direct attachment favored	Strong proximity principle	Requires interpretive inference	Single-head dominant	Structural clarity
Computational Behavior	Modeled in Qurʾanic Treebanks	Direct verb attachment	Rarely encoded	Tree-based attachment	Efficiency-oriented parsing

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Table 13. Probabilistic Multi-Edge Graph Representation

Head	Dependent	Relation	Probability
qasamnā (V)	*maʿīshatahum* (M)	Object	1.00
qasamnā (V)	*baynahum* (B)	Locative adjunct	0.70
maʿīshatahum (M)	*baynahum* (B)	Circumstantial (implicit)	0.30
maʿīshatahum (M)	*fī al-ḥayāt* (F)	Temporal adjunct	1.00
fī (F)	*al-ḥayāt* (H)	Genitive complement	1.00
al-ḥayāt (H)	*al-dunyā* (D)	Adjectival modifier	1.00

Table 14. Comparative Evaluation of Analytical Approaches

Approach	Attachment of *baynahum*	Strength	Limitation
Traditional Grammar	Verb (preferred) / Circumstantial	Interpretive subtlety	Not formally encoded
Dependency Grammar	Verb attachment	Structural precision	No implicit-state modeling
Qurʾanic Treebanks	Verb attachment	Computational consistency	No probabilistic ambiguity
Rule-Based Parsers	Single-head selection	Deterministic output	Semantic loss
Neural Multi-Edge Parsers	70% Verb / 30% Object	Preserves interpretive flexibility	Requires annotated corpora

Interpretive Hierarchy (Strength of Readings)

The interpretive hierarchy demonstrates a clear preference for the verb attachment reading of baynahum. When attached to the verb qasamnā, the construction exhibits high structural strength and strong semantic coherence, as it conveys a clear distributive action. This reading aligns closely with classical grammatical preference and is therefore assigned the greater overall weight (0.70), making it the preferred interpretation. By contrast, the circumstantial attachment reading—linked to maʿīshatahum—shows moderate structural strength. Semantically, it introduces a more subtle nuance of distributed state rather than explicit distributive action. While grammatically defensible and interpretively meaningful, it is considered secondary in strength and thus receives a lower overall weight (0.30).

Computational Modeling Recommendations

The computational modeling framework recommends implementing multi-edge dependency graphs in order to preserve the dual interpretive paths identified in the grammatical analysis. This ensures that both verb attachment and circumstantial attachment readings remain structurally represented within the parsing system. Probabilistic scoring mechanisms should also be incorporated to reflect the classical preference hierarchy, operationalizing the 70/30 distribution between the primary and secondary readings. Additionally, enhanced Universal Dependencies (UD) annotation is necessary to encode implicit circumstantial modifiers, which are often underrepresented in standard syntactic schemes. To ensure alignment with the grammatical tradition, training data should be informed by classical corpora, thereby grounding computational outputs in established exegetical and grammatical authorities. Finally, the adoption of neural semantic dependency parsing is recommended to preserve structural ambiguity without semantic loss, allowing the model to maintain interpretive plurality while ensuring coherence at the semantic level.

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D O I : 10.18860 /ijazarabi.V9i4.42707
I S S N (p r i n t) : 2 6 2 0 - 5 9 1 2 | I S S N (o n l i n e) : 2 6 2 0 - 5 9 4 7

Applied Model Five

The verse under analysis is ﴿وَجَاءَ مِنْ أَقْصَى الْمَدِينَةِ رَجُلٌ يَسْعَى﴾(Yā-Sīn 20, Holy Qur'an). The focal segment is (جاء من أقصى المدينة رجل يسعى)— "A man came from the farthest part of the city, hastening." The prepositional phrase (من أقصى المدينة)("from the farthest part of the city") exhibits syntactic ambiguity, allowing attachment to three elements. The first and preferred attachment links the phrase to the past-tense verb (جـاء)("came"), indicating the place of arrival (Al-Zamakhshari, 1998; Abu Hayyan, 1993). The second possibility attaches it to an implicit circumstantial modifier of the subject (رجـل), producing the reading: a man coming from the farthest part of the city (Al-Alusi, 1994). The third possibility attaches it to the present-tense verb (يسعى)("hastening"), suggesting he hastens from the farthest part of the city, considering possible fronting or delayed attachment. Traditional grammarians predominantly favor attachment to the nearest verb, i.e., (جاء)(Ibn Hisham, 2009).

Dependency grammar analysis confirms that (جـاء)serves as the syntactic head, while constituency grammar views the prepositional phrase as embedded under the VP without resolving precise attachment. Significantly, computational parsing confirms the preferred attachment to the verb: CAMeL Tools identifies (جاء)as the ROOT, (من أقصـــى المدينة)as a locative adjunct to the verb, (رجل)as the subject, and (يسعى)as the circumstantial/attributive clause (Obeid et al., 2020). Farasa provides morphological segmentation but does not capture dependencies (Darwish, 2021). A multi-attachment graph allows simultaneous modeling of both possible syntactic relations. Nodes and edges are represented in Table 20 and Table 21 below.

Table 15. Symbols and Words

Symbol	Word
J	جاء
M	من أقصى المدينة
R	رجل
Y	يسعى

Table 16. Edges and Probabilities

Head	Dependent	Relation	Probability
J	M	Locative adjunct ← Verb	0.75
R	M	Circumstantial ← Subject	0.25
J	R	Subject	1.00
R	Y	Circumstantial/Attributive	1.00

This multi-edge representation illustrates the interpretive and syntactic ambiguity, showing how AI-based tools preserve probabilistic attachment, whereas rule-based parsers enforce a single connection. The verse highlights rhetorical subtleties in component distribution: emphasis may fall on the location of arrival, the state of the arriving man, or the direction of his hastening. Multi-edge graph models enable simultaneous processing of these readings, offering a richer computational representation of classical Arabic syntax and semantics.

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Table 17. Applied Model Five — Triple Locative Attachment Ambiguity (Yā-Sīn 36:20)

Component	Traditional Grammatical Analysis	Preferred Reading: Attachment to *jāʾa*	Alternative Reading 1: Circumstantial Attachment to *rajul*	Alternative Reading 2: Attachment to *yasʿā*	Dependency Representation	Interpretive Outcome
Verb (Head)	*jāʾa* → past verb	Governs PP as arrival source	Governs subject only	Governs subject only	ROOT	Event of coming
Prepositional Phrase	*min aqṣā al-madīnah* → locative	Locative adjunct of verb	Circumstantial modifier of subject	Possible delayed attachment to present verb	obl:loc	Source of ambiguity
Subject	*rajul* → subject of *jāʾa*	Subject of verb	Governs PP (circumstantial)	Subject of verb	nsubj	The arriving man
Attributive Clause	*yasʿā* → descriptive clause	Modifier of subject	Modifier of subject	Governs PP (direction of hastening)	acl	State/action of the man
Primary Interpretation	Context-driven	"A man came from the farthest part of the city."	"A man, coming from the farthest part of the city, came."	"He hastens from the farthest part of the city."	Competing dependency paths	Shifts focus: arrival vs. state vs. motion
Classical Preference	Nearest verb principle	Strongly favored	Secondary	Weakest structurally	Single-head dominant	Emphasis on arrival location
Constituency Grammar	PP under VP	No precise relational resolution	No explicit distinction	No explicit distinction	Hierarchical but non-relational	Structural ambiguity unresolved
Computational Behavior	Modeled in Qurʾanic NLP systems	Verb attachment	Rarely modeled	Rarely modeled	Tree-based selection	Deterministic parsing

Table 18. Probabilistic Multi-Edge Graph Representation

Head	Dependent	Relation	Probability
jāʾa (J)	*min aqṣā al-madīnah* (M)	Locative adjunct (verb)	0.75
rajul (R)	*min aqṣā al-madīnah* (M)	Circumstantial (subject)	0.25
jāʾa (J)	*rajul* (R)	Subject	1.00
rajul (R)	*yasʿā* (Y)	Attributive clause	1.00

Comparative Evaluation of Analytical Approaches

The comparative evaluation reveals significant differences in how analytical frameworks treat the attachment of min aqṣā al-madīnah. Within traditional grammar, the phrase is primarily attached to the verb, though attachment to the subject is also considered possible. This approach is marked by interpretive subtlety and a sensitivity to semantic nuance; however, its major limitation lies in its non-formalized nature, which makes systematic computational implementation difficult. Dependency grammar strongly favors verb attachment, offering relational clarity through explicit head-dependent structures. Its strength lies in this precision, yet it lacks the capacity to formally represent multi-attachment possibilities within a single

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structural model. Constituency grammar typically places the phrase under the VP, thereby maintaining a strong structural hierarchy. Nevertheless, while structurally robust, it demonstrates weaker relational precision when modeling fine-grained semantic distinctions.

Among computational tools, CAMeL Tools adopts verb attachment and provides reliable syntactic parsing. However, it does not include ambiguity scoring, thereby limiting its ability to reflect layered interpretive possibilities. Farasa, by contrast, operates primarily at the morphological level. It excels in segmentation accuracy but does not perform dependency modeling, leaving attachment relations unrepresented.

The proposed Multi-Edge Graph Model advances beyond these limitations by assigning weighted probabilities—75% for verb attachment and 25% for subject attachment. This model preserves semantic plurality while formally encoding interpretive preference. Its primary limitation is the need for probabilistic training to ensure accurate calibration of weights and contextual sensitivity.

Interpretive Hierarchy (Strength of Readings)

The interpretive hierarchy establishes verb attachment to jāʾa as the strongest reading. Structurally, it demonstrates high stability and semantic coherence, emphasizing the location of arrival. This reading corresponds to classical proximity preference and is therefore assigned the highest overall weight (0.75), making it the preferred interpretation. The circumstantial attachment to the subject (rajul) occupies a secondary position. Structurally moderate in strength, it shifts the semantic emphasis from the event of arrival to the state or origin of the man. While grammatically plausible and semantically meaningful, it is less dominant and thus receives a lower overall weight (0.25). A third possibility—attachment to the present verb yasʿā—is considerably weaker. Its semantic focus concerns the direction of motion rather than the point of origin. This reading is highly context-dependent and lacks the structural robustness of the first two interpretations, which explains its limited interpretive weight.

Computational Modeling Recommendations

To adequately represent the triple interpretive possibilities identified in the grammatical analysis, multi-edge dependency graphs are recommended. Such structures allow simultaneous encoding of alternative attachments without forcing premature resolution. Probabilistic scoring mechanisms should be integrated to reflect classical proximity preference, ensuring that structurally stronger readings receive correspondingly higher weights. Enhanced Universal Dependencies (UD) annotation is also necessary to encode circumstantial modifiers explicitly, preventing semantic nuance from being flattened in the parsing process. Training on a Qurʾanic corpus is essential for aligning computational parsing with the classical grammatical tradition, thereby preserving exegetical sensitivity. Finally, neural semantic parsing techniques should be employed to maintain interpretive ambiguity without semantic loss, allowing the system to preserve layered meanings while ensuring coherence and analytical rigor.

Applied Model Six

The analyzed verses are: *"He said: My Lord, I possess no power except over myself and my brother, so separate between us and the defiantly disobedient people"* (5:25) and *"He said: Then it is forbidden to them for forty years; they will wander through the land. So do not grieve over the defiantly disobedient people"* (5:26). The temporal phrase *(forty years)* introduces significant syntactic ambiguity, permitting five valid attachment possibilities. It may attach to *(lā amliku)*, yielding the meaning that Moses possesses no authority except over himself and his brother for forty years. It may attach to *(fa-friq)*, indicating a forty-year duration of separation. It may attach to *(muḥarramah)*, expressing that the land is forbidden to them for forty years. It may attach to *(yatīhūn)*, conveying that they wander for forty years.

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Finally, it may attach to *(fa-lā ta's)*, implying that grief is suspended for forty years. The phrase thus functions as a central temporal anchor within a network of syntactically and semantically viable relations.

Dependency analysis identifies qāla as the governing root across both segments, linking speech act, supplication, prohibition, and consequence. The first segment proceeds along two primary paths:

qāla → lā amliku → (nafsī, akhī)
qāla → fa-friq → (baynanā, bayna al-qawm)

The second segment contains the nominal clause *(fa-innahā muḥarramah 'alayhim)*, the predicate *(yatīhūn fī al-arḍ)*, and the prohibitive clause *(fa-lā ta's 'alā al-qawm)*, while *(forty years)* may attach to several nodes:

qāla → muḥarramah → 'alayhim
qāla → muḥarramah → forty years ← yatīhūn → fī al-arḍ
qāla → fa-lā ta's → 'alā al-qawm

Computational parsing assigns *(forty)* the function *obl:time*, typically attaching it to *(yatīhūn)* as the nearest verbal predicate:

yatīhūn ← obl:time ← forty years

with an alternative attachment:

muḥarramah ← obl:time ← forty years

Farasa provides morphological tagging (PREP + NUM + NOUN) without syntactic resolution.

A probabilistic graph model represents all possible attachments:

(forty years)

Table 19. Node, Meaning And Weight

Node	Meaning	Weight
Y	yatīhūn	0.40
M	muḥarramah	0.35
N	fa-lā ta's	0.10
F	fa-friq	0.08
L	lā amliku	0.07

This distribution shows that dependency grammar tends toward attachment to *(yatīhūn)*, constituency grammar preserves structural hierarchy without semantic resolution, and computational tools privilege proximity. By contrast, the probabilistic graph integrates structural precision, interpretive flexibility, and weighted plausibility, making it particularly effective for modeling the layered syntactic and rhetorical complexity of Qur'anic discourse.

Table 20. Applied Model Six – Structured Syntactic Table

Element	Content
Verses Analyzed	Qurʾān 5:25–26
Speaker	Mūsā (Moses)
Central Ambiguous Phrase	*"forty years"*
Linguistic Function	Temporal modifier (*obl:time*)
Core Issue	Multi-attachment syntactic ambiguity

Table 21. Possible Attachments of "Forty Years"

#	Possible Attachment Node	Resulting Interpretation
1	lā amliku	Moses has no authority except over himself and his brother for forty years
2	fa-friq	Separation lasts for forty years
3	muḥarramah	The land is forbidden to them for forty years
4	yatīhūn	They wander for forty years
5	fa-lā ta's	Grief is suspended for forty years

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Table 22. Dependency Structure Overview

Root Node	Primary Branch	Sub-elements
qāla	lā amliku	nafsī, akhī
qāla	fa-friq	baynanā, bayna al-qawm
qāla	muḥarramah	‘alayhim, forty years
qāla	yatīhūn	fī al-arḍ
qāla	fa-lā ta’s	‘alā al-qawm

Computational Parsing Tendencies

Dependency Grammar attaches the construction to yatīhūn based on proximity to the nearest verbal predicate, while an alternative dependency reading permits attachment to muḥarramah on semantic grounds. Constituency Grammar preserves hierarchical structure without resolving the attachment. The Arabic NLP tool Farasa performs only morphological tagging (PREP + NUM + NOUN), offering no deep syntactic resolution.

Table 23. Probabilistic Graph Model

Node	Meaning	Weight
Y	yatīhūn	0.40
M	muḥarramah	0.35
N	fa-lā ta’s	0.10
F	fa-friq	0.08
L	lā amliku	0.07

Interpretive Model Comparison

Dependency Grammar ensures structural clarity but favors proximity; Constituency Grammar preserves hierarchy yet leaves ambiguity unresolved. Computational parsing is systematic but semantically shallow. The Probabilistic Graph Model integrates structure and plausibility, though it depends on modeling assumptions.

Applied Model Seven

The analyzed verse is: “And you would think them awake while they were asleep. And We turned them to the right and to the left, while their dog stretched his forelegs at the threshold. Had you looked at them, you would have fled from them in terror and would have been filled with dread of them” (18:18). The focus segment — “you would have fled from them in terror and would have been filled with dread of them” — contains the prepositional phrase (from them) twice, and in both occurrences it allows dual syntactic attachment. In the first clause, “you would have fled from them in terror”, the phrase may attach directly to the verb (you would have fled), indicating causal motivation, or attach to (terror) as a specification of source, yielding the meaning that the fleeing occurs in a state of terror originating from them. In the second clause, “you would have been filled with dread of them”, the phrase may attach to the passive verb (you would have been filled), expressing cause, or to (dread) as a specification of the origin of fear. The ambiguity thus operates at both event-level and state-level interpretation.

Dependency analysis identifies the verbal predicates as structural heads. In the first clause:

1. (you would have fled) → head
2. (terror) → cognate accusative
3. (from them) → may attach to the verb (causal relation) or to (terror) (source specification)

In the second clause:

1. (you would have been filled) → head

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2. (dread) → complement
3. (from them) → may attach to the verb (cause) or to (dread) (origin of fear)

This yields two principal dependency paths:

Path A

Verb → from them

Path B

Verb → terror / dread → from them

Constituency representation preserves hierarchical structure without resolving attachment:

"You would have fled from them in terror"

VP
- V (fled)
- PP (from them)
- NP (terror)

"You would have been filled with dread of them"

VP
- V (filled)
- PP (from them)
- NP (dread)

Computational parsing using CAMeL Tools and Stanza typically favors attachment of (from them) to the verb in both clauses.

A probabilistic graph model captures competing attachment likelihoods:

Table 24. A Probabilistic Graph Model

Clause	Verb Attachment	Noun Attachment
Fled	0.60	0.40
Filled	0.55	0.45

These distributions indicate a stronger tendency toward verb-level causation, while retaining a substantial probability for noun-level specification. The verse therefore demonstrates syntactic flexibility and semantic layering: attribution-based grammar preserves multiple interpretive readings, whereas dependency and computational models favor structurally proximal attachment. This interaction illustrates how Qur'anic syntax accommodates interpretive richness within a coherent grammatical framework.

Table 25. Applied Model Seven – Structured Syntactic Table

Element	Content
Verse Analyzed	Qurʾān 18:18
Focus Segment	"You would have fled from them in terror and would have been filled with dread of them"
Central Phrase	*from them* (repeated twice)
Linguistic Issue	Dual syntactic attachment ambiguity
Interpretive Level	Event-level (action) and state-level (emotion)

Clause-Level Ambiguity and Dependency Structure Overview

The two clauses display structural ambiguity due to the attachment of the prepositional phrase "from them." In "You would have fled terror from them," the phrase may attach to the verb, indicating cause (you fled because of them), or to the noun "terror," specifying its source. Likewise, in "You would have been filled with dread from them," the phrase may modify the verb, expressing cause, or attach to "dread," indicating the origin of the fear. In the first clause, the

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verbal predicate functions as the head, "terror" serves as a cognate accusative, and "from them" remains syntactically indeterminate. In the second clause, the passive predicate functions as the head, "dread" as its complement, and the same prepositional phrase allows dual attachment, producing the ambiguity.

Table 26. Principal Dependency Paths

Path	Structure	Interpretation
Path A	Verb → from them	Direct causation
Path B	Verb → Noun → from them	Source specification within emotional state

Table 27. Constituency Representation (Structural Layering)

Clause	Constituency Structure (Simplified)
Fled Clause	VP → V (fled) + PP (from them) + NP (terror)
Filled Clause	VP → V (filled) + PP (from them) + NP (dread)

Note: Constituency grammar preserves hierarchical organization without resolving attachment.

Table 28. Computational Parsing Tendencies

Tool / Model	Preferred Attachment	Rationale
CAMeL Tools	Verb-level	Proximity to verbal head
Stanza	Verb-level	Structural closeness
General Dependency Parsers	Verb-level	Causal interpretation bias

Table 29. Probabilistic Graph Model

Clause	Verb Attachment	Noun Attachment
Fled	0.60	0.40
Filled	0.55	0.45

Interpretive Model Comparison

The interpretive models differ in how they address structural ambiguity. Dependency Grammar offers a clear structural hierarchy by organizing elements according to head–dependent relations; however, it typically adopts a nearest-head bias, which may predispose the analysis toward a particular attachment. Constituency Grammar preserves syntactic layering and phrase structure distinctions, yet it does not in itself resolve ambiguity, as multiple structural representations may remain equally viable. Computational parsing provides consistent and replicable analyses based on formalized rules or algorithms, though it often defaults to verb attachment due to processing preferences embedded in the system. In contrast, the Probabilistic Graph Model captures graded plausibility by assigning weighted probabilities to competing interpretations, but it depends on prior weighting assumptions that influence the final outcome.

The present study set out to examine the syntactic attachment of prepositional and adverbial phrases in Qur'anic discourse through an integrative analytical framework combining traditional grammar, dependency-based modeling, computational parsing, and probabilistic graph representation. The findings confirm that multiple attachment is not merely a theoretical possibility but an empirically observable structural feature across the analyzed Qur'anic examples. Evidence from the applied models demonstrates consistent variation in attachment pathways. In the ninth applied model, the phrase *bi-ni'matihī* exhibited three structurally viable dependency paths: attachment to the copular verb (*aṣbaḥtum*), attachment to the predicate (*ikhwānan*), and adjectival or circumstantial modification of the same predicate. Computational parsing using CAMeL Tools and Stanza overwhelmingly favored verb attachment, classifying the phrase as an oblique modifier (obl:mod). However, the graph-based probabilistic model provided a more nuanced representation: attachment to the verb registered the highest likelihood (0.55), followed by circumstantial

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attachment to the predicate (0.25), and adjectival attachment (0.20). This distribution reflects the coexistence of structurally grounded interpretations rather than exclusive alternatives.

A comparable pattern emerged in the tenth applied model, where the repeated phrase *minhum* displayed dual attachment possibilities in both occurrences. In the clause *la-wallayta minhum firāran*, dependency parsing again prioritized attachment to the governing verb (*wallayta*), treating the phrase as a causal adjunct. Yet constituency analysis revealed that structural hierarchy permits its association with the cognate accusative (*firāran*) as a genus-specifying modifier. The probabilistic graph model quantified this interpretive competition, assigning a stronger likelihood to verbal attachment (0.60) compared to nominal association (0.40). Similarly, in the clause *wa-lamuli'ta minhum ru'ban*, the model recorded probabilities of 0.55 for attachment to the passive verb and 0.45 for attachment to the accusative specification (*ru'ban*). These figures illustrate that while computational parsers gravitate toward syntactic proximity, probabilistic modeling captures a broader interpretive spectrum.

Across the dataset, modern NLP tools—including CAMeL Tools, Stanza, spaCy, UDPipe, and Farasa—demonstrated consistent tendencies toward single-head attachment resolution. In most instances, prepositional phrases were linked directly to overt verbs, reflecting algorithmic biases rooted in training corpora and dependency annotation schemes such as Universal Dependencies. While this behavior enhances processing efficiency and structural clarity, it simultaneously obscures alternative readings well attested in classical grammar. Dependency grammar proved more adaptable than constituency-based analysis in representing these relationships, particularly through its capacity to encode hierarchical yet flexible head–dependent relations. Unlike constituency models, which simply display structural inclusion (e.g., VP → V + PP + NP), dependency paths explicitly capture relational dynamics between elements. For example, the triadic structure observed in the ninth model—*aṣbaḥtum → ikhwānan → bi-ni'matihī*—encodes a semantic progression from transformation to identity to causation. Such structures cannot be adequately represented within strictly hierarchical phrase-structure trees.

The incorporation of graph-based multi-headed modeling marked a critical advancement in reconciling interpretive plurality with computational formalism. By assigning probabilistic weights to competing attachments, these models preserved the interpretive richness identified in traditional grammar while maintaining computational tractability. Rather than collapsing ambiguity into a single resolution, the graph framework enabled simultaneous representation of syntactic alternatives—thereby aligning machine analysis more closely with exegetical and linguistic traditions.

Taken together, the applied models reveal a methodological hierarchy. Traditional attribution grammar provides the widest interpretive range but lacks formal operationalization. Constituency grammar clarifies structural organization yet remains descriptively neutral. Dependency grammar bridges structure and meaning, offering a relational framework suitable for computational encoding. Computational parsers supply speed and consistency but exhibit interpretive reductionism. Finally, probabilistic graph models integrate these perspectives by quantifying syntactic competition without eliminating it (De Marneffe & Nivre, 2019). This layered analytical approach demonstrates that modeling Qur'anic syntax requires more than structural accuracy; it necessitates representational pluralism. The probabilistic distributions observed across the applied models underscore that syntactic attachment in Arabic—particularly

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in rhetorically dense texts—should be understood as a gradient phenomenon rather than a categorical one. Consequently, future advancements in Arabic NLP and digital Qur'anic studies must move toward frameworks capable of encoding structured ambiguity rather than resolving it prematurely.

CONCLUSION

The applied models collectively demonstrate that prepositional and temporal phrases in Qur'anic discourse frequently function as structurally mobile elements capable of attaching to more than one syntactic head without violating grammatical well-formedness. Across the analyzed verses, ambiguity does not arise from indeterminacy or deficiency in structure, but from the coexistence of multiple legitimate dependency paths. Traditional Arabic grammatical analysis accommodates this flexibility through contextual interpretation and semantic prioritization, while modern dependency frameworks formalize these relations by identifying syntactic heads and tracing attachment hierarchies.

The findings show a consistent pattern: classical analysis preserves interpretive plurality, dependency grammar clarifies structural relations but tends toward single attachment, and constituency grammar captures hierarchical organization without resolving functional linkage. Computational tools—while effective in morphological tagging and primary parsing—generally privilege proximity-based attachment, most often linking ambiguous phrases to the nearest explicit verb. However, probabilistic graph modeling proves particularly valuable in representing Qur'anic syntactic behavior, as it allows simultaneous encoding of multiple attachment possibilities with weighted plausibility rather than enforcing a single deterministic reading.m This integrative perspective confirms that Qur'anic syntax operates through a balance of structural precision and semantic expansiveness. Ambiguity is not an obstacle to interpretation but a feature that enhances rhetorical depth and exegetical potential. Accordingly, the study supports the adoption of multi-edge dependency representations in future computational work on Arabic, as such models align more closely with the interpretive elasticity recognized in the classical grammatical tradition.

This study shows that syntactic ambiguity in Qur'anic discourse is a functional feature that supports layered meaning, confirming the continued relevance of classical Arabic grammatical insights within modern linguistic frameworks. The alignment between attribution-based analysis and dependency grammar demonstrates that traditional models can be formalized without sacrificing interpretive depth. Computationally, the findings expose the limitations of single-attachment parsing and highlight the need for probabilistic, graph-based models capable of representing multiple valid relations. Such approaches can enhance Qur'anic annotation, machine translation, and Arabic NLP by reducing interpretive rigidity and improving structural accuracy. Overall, integrating classical linguistic theory with AI-based parsing offers a promising path toward more nuanced and faithful computational analysis of Arabic texts.

ETHICAL APPROVAL/ الموافقة الأخلاقية

All participants received a comprehensive explanation regarding the research objectives and procedures, including their right to participate voluntarily. Participants were assured that participation was not mandatory and that they had the right to withdraw at any time during the

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study without negative consequences. To ensure the confidentiality of identities, all data obtained in this study underwent an anonymization process.

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CONFLICT OF INTEREST/ تضارب المصالح

The author(s) declare that there is no conflict of interest related to the research, authorship, or publication of this article.

يقر المؤلف (أو المؤلفون) بعدم وجود أي تضارب في المصالح يتعلق بالبحث أو تأليف المقالة أو نشرها

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