

From Lexicon to Cosmology: A Review of Linguistic Dimensions in Cultural Astronomy

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Abstract:

Cultural astronomy, the study of human relationships with the sky has long been dominated by archaeology and the history of astronomy, while its linguistic dimensions remain systematically undertheorized. This narrative review critically examines representative literature from 2005 to 2026 across four thematic domains: star-name semantics, grammatical encoding of celestial knowledge, linguistic relativity in time concepts, and transmission mechanisms of Indigenous astronomical knowledge. The review finds that celestial naming exhibits stable embodied cognitive patterns across languages, yet borrowing and semantic change pathways are more complex than existing models suggest, as demonstrated by Ge'ez planetary nomenclature and Mesopotamian-Greek star-name transmission. Grammatical encoding – noun classification, numeral classifiers, evidential marking, and absolute spatial frames – reveals language as an active structuring mechanism for astronomical cognition rather than a passive mirror, with Tariana evidentiality and Guugu Yimithirr solar-anchored coordinates providing particularly strong evidence. The Amondawa and Aymara cases both challenge and refine the linguistic relativity hypothesis, while their methodological limitations warrant equal scrutiny. Oral genres, Wardaman songlines, Polynesian wayfinding chants, and Rapa Nui material anchors – function as differentiated cognitive storage technologies whose poetic features serve knowledge preservation rather than decoration. The review identifies three systematic limitations in existing scholarship: corpus imbalance favoring written traditions, insufficient interdisciplinary dialogue between linguists and cultural astronomers, and methodological fragility of "absence" judgments. To address these, the paper proposes "celestial semantic domain" as an integrative analytical framework comprising lexical, grammatical, and discourse-genre levels, and argues that cultural astronomy should become a regular domain of semantic typology and language documentation rather than a marginal curiosity. Future priorities include cross-linguistic celestial vocabulary databases, integration of celestial semantics into fieldwork protocols, experimental research on evidentiality and causal reasoning, and cognitive-linguistic models of oral astronomical genres.

Keywords:

cultural astronomy; semantic typology; linguistic relativity; star-name studies; language documentation

I. Introduction

Human relationships with the sky constitute a core dimension of cultural evolution. From Mesopotamian constellation naming to Polynesian star-compass navigation, from calendrical calibration by celestial motion to the Aboriginal "dark emu in the sky," the sky has always been an object of human cognition, naming, and utilization (Holbrook et al., 2008). Yet the linguistic dimension of this knowledge system; how language lexicalizes, grammaticalizes, and transmits celestial knowledge has remained at the margins of scholarly attention.

This marginality has disciplinary-historical roots. Since its emergence in the latter half of the twentieth century, cultural astronomy has drawn its core methodology from archaeology (measurement of astronomical orientations at sites) and the history of astronomy (interpretation of astronomical records in ancient texts). In sub-Saharan Africa, the empirical foundation was laid by Lynch and Robbins's (1978) controversial claim that the Namoratunga II megalithic site in northwestern Kenya constituted "the first archaeoastronomical evidence in sub-Saharan Africa," a claim immediately contested by Soper (1982), who found angular errors of up to 17 degrees in the original measurements and concluded that "Lynch's astronomical hypothesis cannot be maintained" (p. 145). This early debate exemplifies a persistent methodological pattern: cultural astronomy's evidentiary standards have been shaped by archaeoastronomical and historical-astronomical concerns, in which linguistic data serve at best an ancillary role. The question of what the linguistic structure of star names themselves signifies, and what cognitive mechanisms the grammatical encoding of celestial knowledge reveals, has rarely been posed with theoretical rigor (Holbrook et al., 2008; Goshu and Ridwan, 2026).

The disciplinary landscape has shifted in recent years. Holbrook et al.'s (2008) *African Cultural Astronomy* marked the first scholarly collection explicitly weaving together astronomy, anthropology, and African knowledge systems, including analyses of celestial terminology and oral traditions. Alula's (2026) work on Ethiopian planetary nomenclature demonstrates how linguistic continuity; the persistence of Amharic names such as አጣርድ (At'ard, Mercury) and ዝሁራ (Zihura, Venus) that parallel their Arabic counterparts, preserves astronomical heritage across the Red Sea corridor. Eckstein's (2025) reconstruction of Tupaia's rua mata'i wind positioning system reveals how Tahitian wind names, star positions, and swell patterns constituted a unified cognitive model for navigation. Goshu and Ridwan's (2025) mixed-methods study of Ethiopian Indigenous Astronomical Knowledge (EIAK) documents oral transmission rates of 64.3% and validates Borana calendar predictive skill against modern meteorological records ($r^* = 0.889$ for rain onset). These developments suggest that the linguistic dimensions of cultural astronomy are becoming visible, but without an integrative theoretical framework.

This review aims to bridge that gap. Its core question is: What analytical tools does linguistics offer cultural astronomy, and what challenges and corrective opportunities does the corpus of cultural astronomy pose for linguistic theory? Addressing this question requires moving beyond the descriptive documentation of celestial terminology toward systematic engagement with semantic typology, grammatical encoding, and the cognitive functions of oral genres. The review proceeds through four substantive domains, star-name semantics, grammatical integration of celestial referents, linguistic relativity in time concepts, and oral transmission mechanisms, before proposing an integrative framework and assessing methodological limitations.

II. Review of Literatures

2.1 Star-Name Semantics: From Etymology to Cognition

a. Borrowing and Semantic Change in Star Names

Cross-linguistic transmission of star names is among the most direct evidence of cultural contact. Kurtik and Militarev (2005), working with correspondences among Mesopotamian, Greek, Latin, and Semitic star names, proposed four "naming-borrowing strategies": (1) echoing, the complete translation of Sumerian-Akkadian terms; (2) shift of meaning, the interpretive transformation of borrowed terms; (3) material borrowing, direct transliteration; and (4) folk etymology, the misconstrued reconstruction of original terms. Kurtik and Militarev (2005) noted that these four strategies "may be universal," and that examples persist in Hausa (Chadic), Ahaggar (Berber), and Coptic, demonstrating that these strategies have operated continuously across time and space throughout the Semito-Hamitic (Afrasian) world.

The value of this classification lies in redirecting star-name studies from traditional "etymological tracing" toward process analysis. Researchers no longer merely ask "where does this word come from?" but analyze "what happened to this word in transmission?" Kurtik and Militarev's (2005) conclusion carries methodological significance: the transmission of Mesopotamian star names was not simple replication but a process of creative misreading and adaptive transformation. The ancient borrowing of astronomical concepts and terms proceeded "far from precisely and directly."

et the model's limitations are equally evident. It is based on ancient Near Eastern written materials, and the universality of its "four strategies" has yet to be systematically tested in oral traditions. Whether the transmission of Polynesian star names—such as "Matariki" (Pleiades) across Māori, Hawaiian, and Tahitian distributions—follows the same strategic categories remains an open question. Notably, systematic phonological correspondences exist among Māori "Matariki," Tongan "Mataliki," Marquesan "Mata'iki," and Hawaiian "Makali'i," suggesting that these names share a Proto-Polynesian root; however, their semantic change pathways have not been systematically analyzed.

b. Star-Name Classification from a Cognitive-Semantic Perspective

Kozma's (2009) cognitive-semantic analysis of Hungarian and German popular star and constellation names offers another pathway. Using Langacker's conceptual prototypes (human body and face, physical objects, agents, actions, instruments, etc.) as an analytical framework, she found that star names most frequently instantiate the following conceptual categories: persons, body parts, and animals, with fewer involving plants, objects, places, concepts, and features.

The significance of this finding lies in revealing the embodied cognition mechanism in star naming: humans project bodily experience onto the celestial domain, a process structurally consistent with metaphorical mapping at other linguistic levels. Kozma's (2009) analysis shows a systematic "cognitive translation" between official Arabic-Greek star names and popular star names, the former leaning toward mythologico-scholarly tradition, the latter toward everyday experiential categories.

Table 1 summarizes the distribution of conceptual prototypes instantiated in star names in Kozma's study and their cognitive bases.

Table 1. Distribution of Conceptual Prototypes in Hungarian and German Popular Star Names

Conceptual Category	Prototype	Frequency	Cognitive Basis	Examples (Hungarian/German)
Persons		High	Anthropomorphic projection	Shepherd, Hunter
Body parts		High	Embodied experience	Eye, Heart
Animals		High	Ecological cognition	Bear, Eagle, Fish
Plants		Low	Agricultural association	Wheat ear, Tree
Objects/tools		Low	Technological cognition	Cart, Net, Scales
Places		Very low	Spatial anchoring	Bridge, Gate

(Source: Compiled based on data from Kozma, 2009)

However, Kozma's sample is limited to two Central European languages, and whether her findings generalize to other language families requires testing. A key unresolved question is: Do languages from different families use the same conceptual prototypes to name celestial bodies? If yes, this would support the hypothesis of cognitive universality in celestial naming; if no, a more refined cross-cultural cognitive typology is needed.

c. Linguistic Significance of Ethiopian Planetary Naming

Alula's (2026) research on Ethiopian and Arabic astronomical terminology provides another exemplar of star-name semantic analysis. Planetary names in Ge'ez/Amharic show systematic correspondences with Arabic, as shown in Table 2. Alula (2026) noted that these names "demonstrate how astronomical knowledge traveled across regions and how language preserves scientific heritage."

Table 2. Semantic Correspondences between Ge'ez/Amharic and Arabic Planetary Names

Ge'ez/Amharic	Arabic	Meaning	Corresponding Planet	Semantic Motivation
አጥረድ (At'ard)	عطارد ('Uṭārid)	"the swift one"	Mercury	Rapid motion
ዝሁራ (Zihura)	الزهرة (al-Zuhara)	"the bright one"	Venus	Anomalous brightness
መሪህ (Merih)	المريخ (al-Mirīkh)	"the burner"	Mars	Red appearance
መሸተሪ (Meshtiri)	المشتري (al-Mushtarī)	"the wanderer"	Jupiter	Slow drift
ዙሐል (Zuhal)	زحل (Zuḥal)	"the slow one"	Saturn	Sluggish motion

(Source: Compiled based on Alula, 2026, and SAAO conference materials)

The semantic motivation of these names is not random mythological association but direct categorization of observable planetary features: Mercury's rapid motion, Venus's anomalous brightness, Mars's redness, Jupiter's slow drift, Saturn's sluggishness. Ge'ez manuscripts directly corroborate this pattern. Alula (2026) cited the Ge'ez manuscript text: "ወዳግደ ሰማይ ሀሎ ራ ካከበ ክሰው ሜርኩሪናዩ ዘውእቱ ዐጥረድ" ("In the second heaven there is a star [planet], whose name is Mercurius, that is, At'ard"; Goshu and Ridwan, 2025).

This finding carries important implications for star-name semantics: even within written scientific traditions, celestial naming retains linguistic traces of observational experience. The mythological layer and the perceptual layer are superimposed rather than mutually exclusive.

From a cognitive-semantic perspective, this pattern supports Kozma's (2009) finding regarding the embodied cognitive basis of star names, while simultaneously demonstrating that written and oral traditions exhibit continuity in the semantic mechanisms of star naming.

2.2 Grammatical Encoding of Celestial Knowledge

a. Noun Classification and Numeral Classifiers

The integration of celestial referents into grammatical systems is a core question in the linguistic analysis of cultural astronomy. Different languages grammatically classify celestial bodies through noun class/gender systems and numeral classifiers. These classifications are not arbitrary but reflect speakers' cognitive models of celestial nature.

Table 3. Grammatical Encoding Mechanisms for Celestial Referents

Grammatical Mechanism	Language Example	Encoding Method	Cognitive/Cultural Function
Noun class	Bantu languages	Celestial bodies assigned to specific class prefixes	Linked to mythological roles and functional attributes
Numeral classifier	Japanese	Dedicated lunar-phase counters	Distinguishes moon phases from general object counting
Evidential marking	Tariana, Tuyuca	Obligatory marking of information source	Marks epistemological status of astronomical knowledge
Absolute spatial reference	Guugu Yimithirr	Solar-anchored directional coordinates	Celestial bodies as spatial orientation framework

(Source: Compiled based on Garuda journal review)

Table 3 synthesizes four grammatical mechanisms through which languages integrate celestial referents into core structural systems. Noun class assignment in Bantu languages links celestial bodies to mythological roles and functional attributes, with star names predominantly reconstructed in Classes 9/10; the animal class, suggesting grammaticalized agency (Maho, 1999). Japanese lunar-phase counters demonstrate dedicated classifier systems that distinguish moon phases from general object counting, encoding observational precision at the grammatical level. Evidential marking in Tariana and Tuyuca represents the most epistemologically consequential mechanism: speakers are grammatically compelled to mark information source for astronomical events, rendering celestial knowledge an epistemologically marked object (Aikhenvald, 2003). Absolute spatial reference in Guugu Yimithirr transforms celestial bodies into obligatory anchors for all spatial cognition, embedding astronomical knowledge into everyday grammatical infrastructure (Levinson, 1996; Goshu and Ridwan, 2026). Together, these mechanisms demonstrate that celestial knowledge penetrates grammar, not merely lexicon.

Bantu noun class systems assign celestial bodies to specific classes. According to Proto-Bantu reconstructions, Class 9/10 (prefix *ni-*) is dedicated to animals, and star names in Bantu lexical reconstructions are predominantly assigned to Class 9/10. This assignment is not accidental: star names sharing the same grammatical class as animals may reflect the agency or animate properties attributed to celestial bodies in Bantu cosmology. Maho's (1999) reconstruction shows that Class 3/4 is used for trees and plants, Class 9/10 for animals, while "star" and "moonlight" exhibit class交叉 across multiple Bantu languages—stars are sometimes assigned to Class 9/10, sometimes to Class 3/4. This class instability is itself a linguistic problem worthy of investigation: celestial bodies occupy a liminal zone between animate and inanimate, animal and plant in Bantu grammar.

Japanese lunar-phase counting demonstrates another grammatical strategy. Japanese has a dedicated naming system for lunar phases, from "朔" (new moon) to "十五夜" (full moon) to "更待月" (the 19th-day moon), with each day's phase having an independent name. This system not only distinguishes lunar phases at the lexical level but also encodes the pragmatic experience of moonrise timing: "立待月" (17th day) means "the moon that rises while one waits standing," "居待月" (18th day) means "the moon that rises while one waits sitting," and "寝待月" (19th day) means "the moon that rises while one waits lying down"—the change in waiting posture precisely reflects the astronomical regularity that moonrise is delayed by approximately 50 minutes each night. This naming system integrates astronomical observation with bodily experience through grammatical-lexical means, with a degree of precision far exceeding that required for general object counting.

The existence of such grammatical devices demonstrates that celestial knowledge is not merely a lexical matter but penetrates the core of grammatical structure. The Garuda review explicitly states: "Grammatical systems integrate celestial referents into linguistic structure through noun class/gender assignment, numeral classifiers, evidential marking, and absolute spatial frames of reference."

b. Evidentially and the Epistemological Status of Astronomical Knowledge

Evidentiality, the grammatical marking of information source—holds particular significance in astronomical contexts. In Amazonian languages, evidential systems encode astronomical knowledge with particular salience. Tariana (Arawakan) possesses obligatory evidential marking: speakers must grammatically indicate the source of knowledge, visual evidence (*-naka*), non-visual evidence (*-mba*), inference (*-nihka*), or hearsay (*-pida*). For astronomical events such as eclipses or meteors, Tariana speakers are grammatically compelled to make epistemological distinctions: whether they saw it with their own eyes, learned of it through others, or inferred it from traces.

In Tariana, the use of evidential markers is directly linked to speaker credibility. Aikhenvald (2003) notes: "A major hallmark of a skilled speaker and a reliable person is their appropriate use of evidentials. Those who deviate from the norm are considered incompetent, or expose themselves to **潜在的危險力量** (if they overuse visual evidentials, as if they were shamans or witches)." Tariana people even say that "white people always lie because they never tell you how they know things", precisely because Portuguese and Spanish lack obligatory evidential marking.

Aboriginal languages' evidential systems provide another model. Ngiyambaa and Garrwa possess "sensory evidence" markers, used to mark information the speaker knows through direct sensory experience. For example, Ngiyambaa's *-gara* marker: "You're sick (I can see it)." These languages also have "linguistic evidence" markers, used to mark information learned through hearsay or report, typically translated as "it is said that..." Garrwa's *=wali* marker is used for future-oriented inference, indicating "based on currently visible evidence, something is likely to happen"; for example, "It might rain heavily later" (said while looking at cloudy skies) (Mushin, 2012)

This finding carries methodological implications for linguistic relativity research. If a language's evidential system requires speakers to mark the source of knowledge for astronomical events (such as eclipses or meteors), then speakers are grammatically compelled to make epistemological distinctions when discussing celestial bodies. For cultural astronomy, this means

that astronomical knowledge in language is not only content but also an epistemologically marked object. An eclipse in Tariana must be marked as "seen with my own eyes" or "learned through hearsay", this grammatical compulsion keeps the epistemological status of astronomical events perpetually in the foreground of speakers' consciousness.

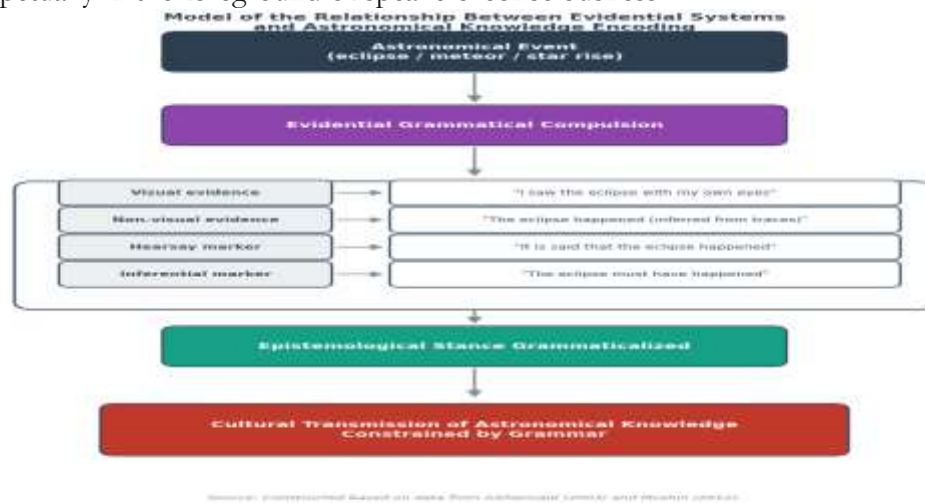


Figure 1. Model of the Relationship Between Evidential Systems and Astronomical Knowledge (Source: Constructed based on data from Aikhenvald, 2003, and Mushin, 2012)

Figure 1 models the pathway through which evidential grammar mediates astronomical knowledge encoding. The sequence begins with an astronomical event; eclipse, meteor, or star rise, which triggers an obligatory evidential choice, represented here as grammatical compulsion rather than speaker discretion (Aikhenvald, 2003). The central panel specifies four strategies: visual evidence ("I saw the eclipse with my own eyes"), non-visual evidence inferred from traces, hearsay ("It is said that the eclipse happened"), and inferential marking ("The eclipse must have happened"). Each strategy grammaticalizes a distinct epistemological stance, converting sensory or reported experience into obligatory morphological marking. The model's terminal node shows that cultural transmission of astronomical knowledge is constrained by these grammaticalized stances: what can be transmitted, and with what epistemic authority, depends on the evidential resources a language makes mandatory (Mushin, 2012). This figure thus visualizes the argument that evidentially renders celestial knowledge an epistemologically marked object rather than neutral content.

3.3 Absolute Spatial Frames of Reference and the Orientational Function of Celestial Bodies

Guugu Yimithirr (Queensland, Australia) provides an extreme case: the language lacks relative spatial frames of reference (left/right/front/back), and all spatial descriptions use absolute coordinates (north/south/east/west), anchored to solar position. Levinson's (1996) experiments showed that Guugu Yimithirr speakers also use absolute coordinates in non-linguistic spatial memory tasks, while Dutch speakers use relative coordinates—language structure and non-linguistic cognition are systematically aligned.

For cultural astronomy, the significance of this finding is that in languages lacking relative spatial frameworks, celestial bodies become obligatory anchors for spatial cognition. The sun's position is not an "optional" reference but the grammatical-semantic foundation of all spatial description. This means that speakers are unconsciously deploying astronomical knowledge when discussing any spatial relationship, not only astronomical topics. Celestial

knowledge is therefore not a separate "knowledge domain" but a grammatical foundation permeating everyday spatial cognition.

The Garuda review summarizes this mechanism as "absolute spatial frames of reference (such as Guugu Yimithirr's solar-anchored directions)." This framework, together with evidentiality systems, constitutes two fundamental modes of grammatical embedding of astronomical knowledge: evidentially marks the source of astronomical knowledge, while absolute spatial reference marks the function of astronomical knowledge.

III. Research Methods

3.1 Linguistic Relativity in Time Concepts: Challenges and Revisions

The intersection of cultural astronomy and linguistics is perhaps most intensely contested in the study of linguistic encoding of time concepts. Since Whorf's (1950) claim that Hopi lacks "time reference," the linguistic relativity hypothesis in this domain has undergone a complex trajectory from sensation to refutation to revision. Whorf (1950) asserted that in Hopi there is "no word, grammatical form, structure, or expression directly referring to what we call 'time,'" and inferred that Hopi "contains no reference to 'time,' either explicit or implicit." The methodological flaws of this claim have long been identified; Whorf relied on secondary sources rather than fieldwork, and his analysis is internally contradictory (he claimed on one hand that Hopi has "no tenses at all," while acknowledging on the other that Hopi has three tenses). Yet Whorf's core question—to what extent time concepts are shaped by linguistic structure, remains unresolved.

a. The Amondawa "No-Time-Words" Case

Sinha et al.'s (2011) field research on the Amazonian Amondawa language (Tupi Kawahib family) provides a direct counterexample to the "universality of spatiotemporal metaphor." Combining observational data with structured field-linguistic tasks, the research team found that Amondawa possesses rich spatial motion and location vocabulary and constructional resources but systematically does not deploy these resources to express temporal relations. Amondawa has no abstract noun for "time," no number-based calendrical system; its temporal reference is based on social activities, kinship relations, and ecological regularities. Sinha et al. (2011) accordingly proposed the Mediated Mapping Hypothesis, arguing that number-based and artifact-based "time-based" interval systems rather than event-based systems are the causal conditions under which spatiotemporal metaphorical mapping emerges.

The impact of this finding lies in its direct challenge to "Time as Space" as a cognitive universal. Fauconnier and Turner (2008) had asserted that "Time as Space is a deep cognitive metaphor, cross-culturally universal, psychologically real, productive, and deeply entrenched in thought and language." The Amondawa case demonstrates that this assertion requires at minimum a qualification: spatiotemporal metaphorical mapping is a matter of cultural emergence, not biological necessity. Sinha et al. (2011) explicitly framed this position as "against a Universal Space-Time Mapping Hypothesis."

Yet the methodological limitations of this research warrant equal scrutiny. Sinha's team relied on a single field investigation; judgments of "absence" require broader naturalistic corpora and longer-term observation of language socialization. Moreover, the history of Amondawa contact with Portuguese and bilingual speakers' comprehension of Portuguese spatiotemporal metaphors, suggests that "absence" may be a language-internal historical process rather than an essential difference in cognitive structure.

b. From "Absence" to "Alternative Patterns": A Cross-Linguistic Spectrum of Temporal Organization

The theoretical value of the Amondawa case lies not in proving that "some language has no time concept" but in revealing an alternative mode of temporal organization: time anchored to events and social relations rather than to an independent quantifiable dimension. This mode, together with Aymara's "past in front, future behind" spatialization strategy and Pirahã's "all-present" orientation, constitutes a spectrum of cross-linguistic variation in time concepts.

Núñez and Sweetser's (2006) research on Aymara provides one of the most methodologically rigorous cases in this spectrum. Aymara possesses a predominant static time model in which "the future is behind the self, and the past is in front of the self" (FUTURE IS BEHIND EGO and PAST IS IN FRONT OF EGO). This spatialization strategy is diametrically opposed to the "future in front, past behind" model of English and other languages. Núñez and Sweetser's contribution lies in their convergent evidence methodological design: they simultaneously analyzed Aymara temporal lexicon, grammatical structure, and speakers' gesture patterns, finding that linguistic evidence and gestural evidence were systematically aligned. This convergent evidence design elevates the Aymara case from a mere "linguistic fact" to a cognitive fact, because gesture is embodied behavior less subject to linguistic conscious monitoring.

Table 4 compares patterns of temporal concept organization across four languages.

Table 4. Cross-Linguistic Comparison of Temporal Concept Organization Patterns

Language	Time–Space Mapping	Core Spatialization Strategy	Calendrical System	Methodological Evidence
English (reference)	Full mapping	Future in front / past behind	Numerical calendar	Linguistics + psychological experiments
Amondawa	No constructional-level mapping	Event-anchored	No numerical calendar	Field linguistic tasks
Aymara	Full mapping (reversed)	Future behind / past in front	Agricultural calendar	Language + gesture convergence
Pirahã	No direct mapping	All-present	None	Field documentation

(Source: Compiled based on Sinha et al., 2011; Núñez & Sweetser, 2006; Everett, 2005)

Table 3 reveals that time–space mapping is not a cognitive universal but a culturally contingent outcome conditioned by calendrical technology. English exhibits full mapping underwritten by a numerical calendar, supported by converging linguistic and psycholinguistic evidence (Fauconnier & Turner, 2008). Amondawa shows no constructional-level mapping and no numerical calendar, its temporal reference anchored instead to social activities and ecological regularities (Sinha et al., 2011). Aymara demonstrates that full mapping can run in the opposite direction, future behind, past in front confirmed through the convergent analysis of language and gesture, a methodologically stronger design because gesture resists conscious monitoring (Núñez & Sweetser, 2006). Pirahã lacks direct mapping entirely, consistent with its "all-present" orientation and absence of calendrical systems (Everett, 2005). The table thus supports the Mediated Mapping Hypothesis: numerical-artifact calendars enable spatiotemporal metaphor, while their absence redirects temporal organization toward celestial and ecological anchors.

Figure 2 diagrams the cross-linguistic spectrum of temporal concept organization as a decision structure conditioned by calendrical technology. The root question, whether a numerical calendrical system is present, generates two pathways. The "Yes" branch yields full spatiotemporal mapping, subdividing into the English-type (future front, past behind) and the Aymara-type reversed orientation (past front, future behind), the latter confirmed through convergent language-and-gesture evidence (Núñez & Sweetser, 2006). The "No" branch yields event-anchoring predominance, exemplified by Amondawa, whose temporal reference rests on social activities and ecological regularities rather than an independent quantifiable dimension (Sinha et al., 2011). Pirahã occupies a dashed extension of this branch, exhibiting all-present orientation with no direct mapping (Everett, 2005). The figure thus visualizes the Mediated Mapping Hypothesis: numerical-artifact calendars enable spatiotemporal metaphor, while their absence redirects temporal organization toward event- and celestial-anchored frameworks.

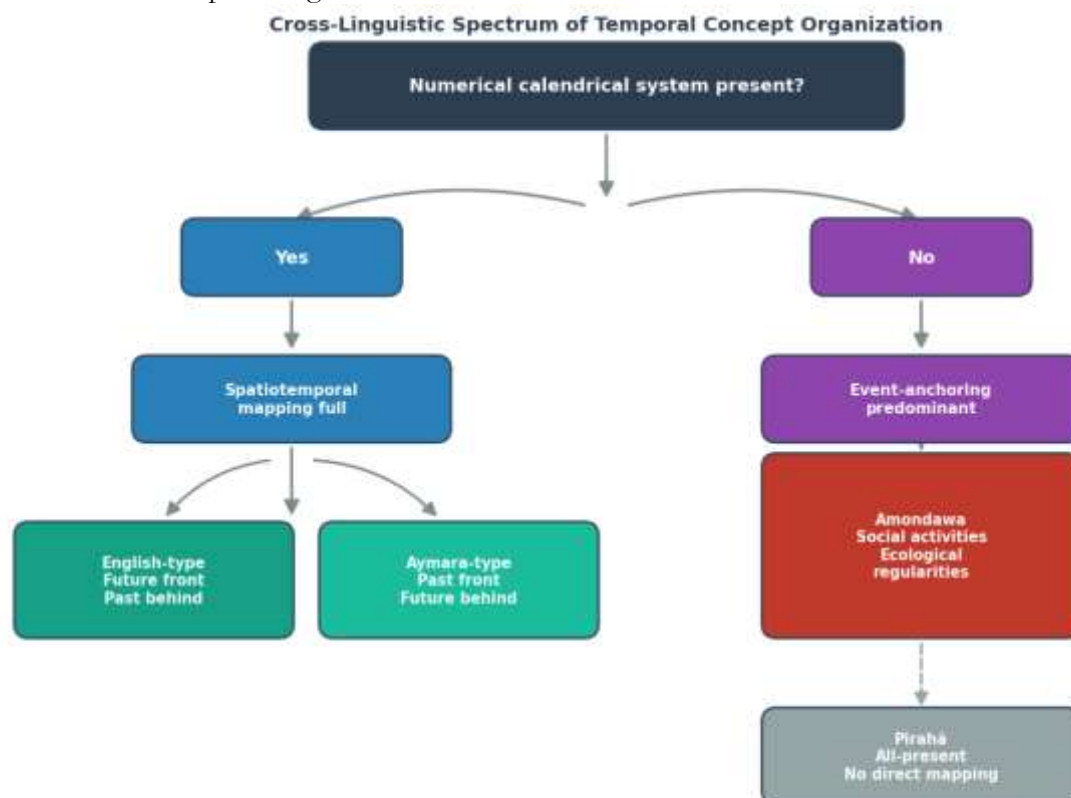


Figure 2. Cross-Linguistic Spectrum of Temporal Concept Organization (Source: Constructed based on the Mediated Mapping Hypothesis of Sinha et al., 2011)

For cultural astronomy, this spectrum carries direct theoretical significance. The time-indicating function of celestial motion may bear a heavier cognitive load in these languages than in languages with fully developed spatiotemporal metaphors. If a language lacks an independent "time" category (as in Amondawa) or spatializes time in a direction opposite to the mainstream (as in Aymara), then sun position, lunar phase, and constellation rising and setting become primary grammatical-lexical means of temporal organization. The Aymara agricultural calendar is precisely anchored to solar and stellar positions; the past-in-front, future-behind spatialization does not prevent it from possessing a fine-grained astronomical time system, but rather embeds it in a cognitive framework directly grounded in observational experience.

Sinha et al.'s (2011) Mediated Mapping Hypothesis provides a causal explanation for this phenomenon: artifact-based (e.g., calendars, clocks) time interval systems are the cultural

mediating conditions that drive the full development of spatiotemporal metaphor. In languages lacking such systems, celestial motion naturally assumes the time-indicating function due to its periodic observability. This means that linguistic analysis in cultural astronomy must treat the presence and type of calendrical systems as a core variable, rather than merely recording astronomical vocabulary.

IV. Result and Discussion

4.1 Transmission Mechanisms of Indigenous Astronomical Knowledge

The transmission of Indigenous astronomical knowledge is not a simple "transfer of information" but a multimodal, structured cognitive technology system. Unlike written scientific traditions that rely on textual storage, oral societies preserve and transmit celestial knowledge through the coordinated operation of genre forms, embodied practices, and material anchors. This section analyzes two core dimensions of this system: oral genres as cognitive storage devices, and the sky as an absolute spatial frame of reference.

a. Oral Genres as Knowledge Repositories

In societies without widespread literacy, astronomical knowledge is preserved and transmitted through highly structured oral genres. These genres function as "cognitive and cultural technologies" that encode large bodies of information in memorable, repeatable forms. Two major genre types merit distinction: narrative genres (such as Australian Aboriginal Dreaming stories) and procedural genres (such as Polynesian wayfinding chants and Maya agricultural instruction speech).

The Wardaman case is particularly instructive. Bill Yidumduma Harney, the last fully initiated senior custodian of the Wardaman people, recorded that his people possess hundreds of names for visible stars, systematically linked to Dreaming narratives, songlines, and navigation path systems. Wardaman people preferred traveling at night and used stars for navigation. The night sky here is not only a "clock and calendar" but a dual cognitive infrastructure for temporal and spatial orientation.

From a linguistic perspective, the formal features of these genres; parallel structure, repetition patterns, rhythmic constraints are not decorative but constitute cognitive storage devices. Information violating rhythm is less likely to survive intergenerational transmission. The Polynesian star compass is a case in point: it is a "mental map of the horizon divided into 32 'houses,'" memorized through chants and oral instruction. This knowledge system is similarly systematized at the linguistic level: Polynesian languages possess verb classes for celestial motion, distinguishing the "rising" and "setting" of stars from their "apparent motion," and include specialized terminology for "guide stars" with fixed rising points and "wanderers" (planets).

Table 5. Typology of Oral Genres as Astronomical Knowledge Storage Devices

Genre Type	Language/Cultural Example	Structural Features	Knowledge Function	Cognitive Mechanism
Narrative genre	Wardaman Dreaming	Parallel structure, repetition	Star name–songline linkage	Narrative memory anchoring
Procedural genre	Polynesian wayfinding chants	Rhythmic constraint, sequence	Star compass orientation memory	Rhythm–sequence encoding
Instructional genre	Maya planting speech	Conditional–action	Astronomical–agricultural	Procedural memory

		structure	calendar calibration	
Materialized genre	Rapa Nui petroglyphs	Visual symbols + ritual	Pleiades observation records	Material anchoring

(Source: Compiled based on Goshu & Ridwan, 2026; Norris & Harney, 2014; Edwards et al., 2023)

Table 5 distinguishes four genre types through which oral societies store astronomical knowledge, each pairing a distinct structural form with a specific cognitive mechanism. Narrative genres, exemplified by Wardaman Dreaming, deploy parallel structure and repetition to bind star names to songlines and navigation paths, achieving storage through narrative memory anchoring (Norris & Harney, 2014). Procedural genres, such as Polynesian wayfinding chants, rely on rhythmic constraint and sequential ordering to encode star-compass orientation, exploiting rhythm-sequence encoding for retrieval under navigational stress. Instructional genres, illustrated by Maya planting speech, use conditional-action structures to calibrate agricultural activity against celestial cycles, engaging procedural memory. Materialized genres, exemplified by Rapa Nui petroglyphs, combine visual symbols with ritual practice to record Pleiades observations, achieving durability through material anchoring independent of living performers (Edwards et al., 2023). The typology demonstrates that oral transmission is not a single mechanism but a differentiated cognitive technology system.

b. The Sky as Cognitive Map

The Polynesian star-compass navigation system transforms the sky into an absolute spatial frame of reference. Archaeoastronomical research on Rapa Nui (Easter Island) provides a fine-grained case of this system. Edwards et al. (2023) re-evaluated the Matariki (Pleiades) stone and associated petroglyphs at Papa Ui Hetu'u ("observatory rock"), placing collected data in a digital planetarium environment for the first time, enabling researchers to identify alignment relationships between astronomical phenomena and observation points in situ and under corresponding chronological conditions. The study confirmed 58 alignment records on Rapa Nui, with observation platforms (tupa) primarily oriented toward the Pleiades and Orion's Belt, and also including Vega and Alpha/Beta Centauri.

The consolidated Rapa Nui astronomy concept inventory records 25 star names, along with names for the Milky Way (Te Ngo'e), Venus (multiple names), and Mars (Matamea). Key time-keeping stars include: Matariki (Pleiades), Nga Vaka (Alpha and Beta Centauri), Tau Ehu or Te Pou o Te Rangi (Sirius), Atutahi (Canopus), and Orion. Notably, the star name element mata means "eye," reflecting the embodied cognitive basis of Polynesian star naming.

Research on Tupaia's wind positioning system (rua mata'i) reveals a more complex picture. Eckstein's (2025) systematic reconstruction of Molyneux's recorded Tupaia wind system found that it contains 14 named wind positions, but according to Puhoro's 16-position teaching and Kaveia's insistence on wind pairs, Tupaia's system may be incomplete, with as many as 18 wind positions potentially unrecorded. More importantly, Eckstein notes that rua mata'i is "a cognitive system, not merely a passive recording and organizing of winds." The Taumakoan phrase te nohoanga te matangi, in which nohoanga means the "positioning," "seating," or "placement" of winds, reveals the deep grammar of cognitive anchoring and spatial organization in the Polynesian wind-star-swell knowledge system.

Semantic analysis of wind names reveals the multi-domain integrative character of this system. For example, "Fa'arua" literally means "double valley" or "double swell," marking the westerly wind system in Tupaia's system that signals the transition from to'erau toward cyclone positions. "Tumutumuroa" means "distant origin" or "great foundation," carrying cosmogenic and genealogical resonances, possibly linked to the Polynesian tradition in which Huatau (north wind) comes from Ta'aro'a ("great foundation"). These wind names are not merely meteorological terms but lexicalized nodes of astronomical, meteorological, oceanographic, and cosmological knowledge.

The linguistic carriers of this multidimensional cognitive model; wind names, star names, pathway terms, constitute a highly specialized lexical subsystem. Its internal structure merits semantic domain analysis: the semantic mapping relationships between wind names and star names (which stars correspond to which wind positions), the absolute referential features of spatial vocabulary (the directional grammar of the 32-house system), and the metaphorical extension patterns of multi-domain terminology (the sky pattern "mirrored" in ocean swells) are all core questions for linguistic analysis in cultural astronomy.

Figure 3 models the multimodal transmission system through which Indigenous astronomical knowledge is preserved across generations. The structure comprises three parallel transmission layers converging on a single synthesis node. The Oral Genre Layer operates through Dreaming narratives, wayfinding chants, and rhythmic constraints, achieving storage via narrative memory and rhythm-sequence encoding (Norris & Harney, 2014). The Material Anchor Layer employs petroglyphs, stone arrangements, the Matariki stone, and observation platforms (tupa), securing durability through physical inscription independent of living performers (Edwards et al., 2023). The Spatial Reference Layer encodes celestial knowledge as navigational infrastructure; the star compass's 32 houses, the rua mata'i wind system, and absolute coordinates, transforming the sky into a cognitive map (Eckstein, 2025). Their convergence produces a multimodal coordinated cognitive system in which rhythmic memory, material anchoring, and spatial grammar operate jointly, demonstrating that oral transmission is a differentiated cognitive technology rather than a single mechanism.

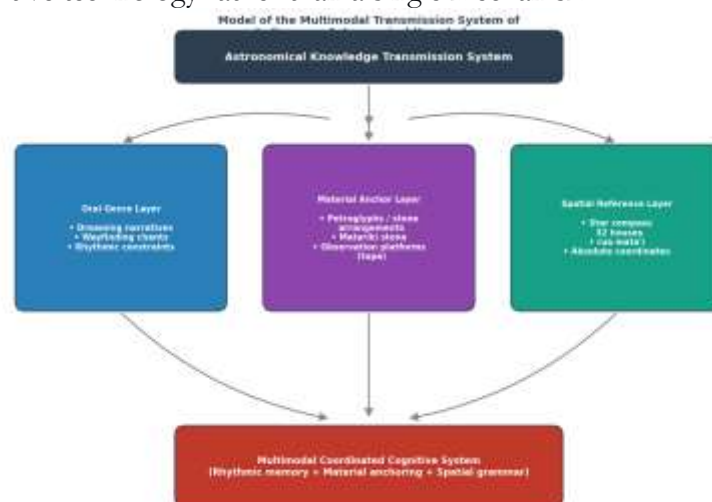


Figure 3. Model of the Multimodal Transmission System of Indigenous Astronomical Knowledge (Source: Constructed based on Goshu & Ridwan, 2026; Eckstein, 2025; Edwards et al., 2023)

4.2 Methodological Reflection and Integrative Framework

a. Limitations of Existing Research

The reviewed literature reveals several systematic methodological limitations that constrain the field's theoretical development.

First, corpus imbalance Existing research disproportionately focuses on written traditions; Mesopotamian, Egyptian, and Greek astronomical texts and a limited set of field cases: Amondawa (Sinha et al., 2011), Australian Aboriginal (Norris & Harney, 2014), and Polynesian (Eckstein, 2025). Vast oral traditions across Africa, South America, and Southeast Asia lack systematic linguistic documentation. Goshu (2026) acknowledges this limitation explicitly, noting that "celestial domains are only beginning to receive such attention" (p. 45). The Ethiopian Borana calendar research represents a positive exception: Dinsa et al. (2022) employed a mixed-methods design combining focus group discussions, experimental knowledgeable groups, and direct observation, validating indigenous weather forecasting against seasonal outcomes. This design provides a template for systematic study of African Indigenous astronomical knowledge that integrates linguistic elicitation with astronomical verification (Goshu & Ridwan, 2026). However, even this exemplary study remains isolated; no comparable framework exists for synthesizing Borana calendrical terminology with semantic typological analysis.

Second, insufficient interdisciplinary dialogue

Linguists' and cultural astronomers' research proceeds in parallel without theoretical intersection. Star-name studies are predominantly conducted by historical linguists (Kurtik & Militarev, 2005), lacking dialogue with semantic typology; grammatical encoding studies are conducted by linguistic anthropologists (Aikhenvald, 2003), lacking concrete connections to astronomical content. Holbrook (2012) identified this gap over a decade ago, arguing that cultural astronomy is "an aspect of environmental adaptation that is often overlooked by scholars today" (p. 345). Yet the disciplinary integration she envisioned remains incomplete. The Garuda review (2026) confirms that while languages "actively categorize, structure, and transmit skylore through distinct linguistic mechanisms," the analytical frameworks remain fragmented across disciplinary boundaries.

Third, methodological fragility of "absence" judgments

The Amondawa "no time words" case (Sinha et al., 2011), and similar assertions of "lacking" cognitive categories, require more rigorous standards: multi-period fieldwork, naturalistic corpora, and language socialization observation rather than single-session elicitation. Sinha et al. (2011) themselves acknowledge the Mediated Mapping Hypothesis requires testing across additional languages. Núñez and Sweetser's (2006) convergent evidence design—integrating linguistic and gestural data, offers one methodological remedy, but the field lacks systematic protocols for distinguishing genuine absence from documentation gaps.

Table 6. Methodological Limitations and Proposed Remedies

Limitation	Manifestation	Proposed Remedy	Exemplar
Corpus imbalance	Written traditions overrepresented	Systematic oral corpus collection	Borana calendar study (Dinsa et al., 2022)
Interdisciplinary isolation	Parallel research programs	Integrated elicitation protocols	Holbrook's framework (2012)

Fragile absence claims	Single-session elicitation	Multi-modal convergent evidence	Aymara gesture study (Núñez & Sweetser, 2006)
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(Source: Constructed based on analysis of Holbrook, 2012; Sinha et al., 2011; Núñez & Sweetser, 2006; Dinsa et al., 2022)

Table 6 diagnoses three methodological deficiencies constraining cultural astronomy's linguistic development. Corpus imbalance manifests in the overrepresentation of written traditions (Mesopotamian, Greek, Egyptian) relative to oral systems, for which systematic oral corpus collection, exemplified by the Borana calendar study's mixed-methods design combining focus groups and predictive validation, offers a corrective template (Dinsa et al., 2022). Interdisciplinary isolation manifests as parallel, non-intersecting research programs by linguists and cultural astronomers; Holbrook's (2012) "Cultural Astronomy for Linguists" framework proposes integrated elicitation protocols that treat celestial knowledge as environmental adaptation rather than disciplinary curiosity. Fragile absence claims arise from single-session elicitation, as in the Amondawa "no time words" case; the Aymara gesture study demonstrates how convergent linguistic and gestural evidence strengthens absence claims against documentation-gap objections (Núñez & Sweetser, 2006). The table thereby links each limitation to a specific, replicable remedy.

b. Celestial Semantic Domain: An Integrative Analytical Framework

Based on the review findings, this paper proposes "celestial semantic domain" as an integrative analytical framework for linguistic research in cultural astronomy. The framework comprises three analytical levels that correspond to the primary loci of linguistic encoding:

Level One: Lexical

Celestial naming strategies, semantic motivations (perceptual features, mythological roles, functional attributes), and cross-linguistic borrowing and semantic change pathways. This level encompasses Kurtik and Militarev's (2005) four borrowing strategies and Kozma's (2009) embodied cognition findings.

Level Two: Grammatical

Noun classification of celestial referents, numeral classifiers, evidential marking, and spatial frame of reference integration. This level captures the mechanisms through which celestial knowledge penetrates core grammatical structure, as documented in Bantu noun classes (Maho, 1999), Japanese lunar-phase counters, Tariana evidentiality (Aikhenvald, 2003), and Guugu Yimithirr absolute spatial frames (Levinson, 1996).

Level Three: Discourse-Genre. Structural features of oral genres encoding astronomical knowledge (narrative, song, instruction), cognitive storage functions of genre, and variation and stability mechanisms in intergenerational knowledge transmission. This level encompasses Wardaman songlines (Norris & Harney, 2014), Polynesian wayfinding chants (Eckstein, 2025), and the material anchoring documented at Rapa Nui (Edwards et al., 2023).

Table 7 operationalizes this framework using core cases from this review.

Table 7. Application of the Celestial Semantic Domain Analytical Framework

Analytical Level	Analytical Dimension	Case Evidence	Theoretical Significance
Lexical	Naming strategy	Ge'ez planetary names (perceptually driven) (Alula, 2026)	Superimposition of myth and perception
	Borrowing process	Mesopotamian-Greek star-name four strategies (Kurtik & Militarev, 2005)	Star-name transmission as creative transformation
Grammatical	Noun classification	Bantu celestial class assignment (Maho, 1999)	Language actively structures astronomical cognition
	Evidentiality	Tariana obligatory source specification (Aikhenvald, 2003)	Grammar compels epistemological distinction
	Spatial reference	Guugu Yimithirr solar-anchored directions (Levinson, 1996)	Celestial bodies as obligatory spatial anchors
Discourse	Oral genre	Wardaman songlines and star-name linkage (Norris & Harney, 2014)	Poetic form as cognitive storage device
	Knowledge transmission	Borana calendar education model (Dinsa et al., 2022)	Genre-knowledge co-evolution

(Source: Constructed based on synthesis of reviewed literature)

Table 7 operationalizes the celestial semantic domain framework across three analytical levels, each pairing case evidence with theoretical significance. At the lexical level, Ge'ez planetary names demonstrate perceptually driven naming in which mythological and observational layers are superimposed (Alula, 2026), while Mesopotamian-Greek star-name transmission reveals borrowing as creative transformation rather than replication (Kurtik & Militarev, 2005). At the grammatical level, Bantu celestial class assignment shows language actively structuring astronomical cognition (Maho, 1999); Tariana obligatory evidential marking compels speakers to grammaticalize epistemological distinctions about celestial events (Aikhenvald, 2003); and Guugu Yimithirr solar-anchored directions render celestial bodies obligatory spatial anchors (Levinson, 1996). At the discourse level, Wardaman songlines demonstrate poetic form functioning as cognitive storage (Norris & Harney, 2014), while the Borana calendar education model evidences genre-knowledge co-evolution (Dinsa et al., 2022). The table thus integrates lexical, grammatical, and discourse mechanisms into a unified analytical structure.

The framework's theoretical contribution lies in its integrative logic: the three levels are not independent analytical domains but mutually constitutive mechanisms. Lexical choices reflect cognitive categorization, grammatical encoding constrains epistemological stances, and discourse genres determine transmission fidelity. The Garuda review (2026) supports this integrative approach, demonstrating that "languages are not passive reflectors of celestial reality; they actively categorize, structure, and transmit skylore through distinct linguistic mechanisms."

Figure 4 presents the celestial semantic domain as a three-tier integrative framework for linguistic research in cultural astronomy. The root node branches into three analytical levels. Level One (Lexical) encompasses naming strategies, semantic motivations, and borrowing

pathways, capturing how celestial referents are categorized and transmitted across languages (Kurtik & Militarev, 2005). Level Two (Grammatical) comprises noun class, classifiers, evidentiality, and spatial frames, demonstrating that celestial knowledge penetrates core grammatical structure rather than remaining lexical (Aikhenvald, 2003; Levinson, 1996). Level Three (Discourse-Genre) covers narrative genres, procedural genres, and material anchoring, addressing transmission mechanisms in oral societies (Norris & Harney, 2014). Their convergence produces a multimodal cognitive system integrating lexical categorization, grammatical structuring, and genre-based transmission. The framework's theoretical contribution is its integrative logic: the three levels are mutually constitutive, jointly determining how astronomical knowledge is encoded, constrained, and preserved.

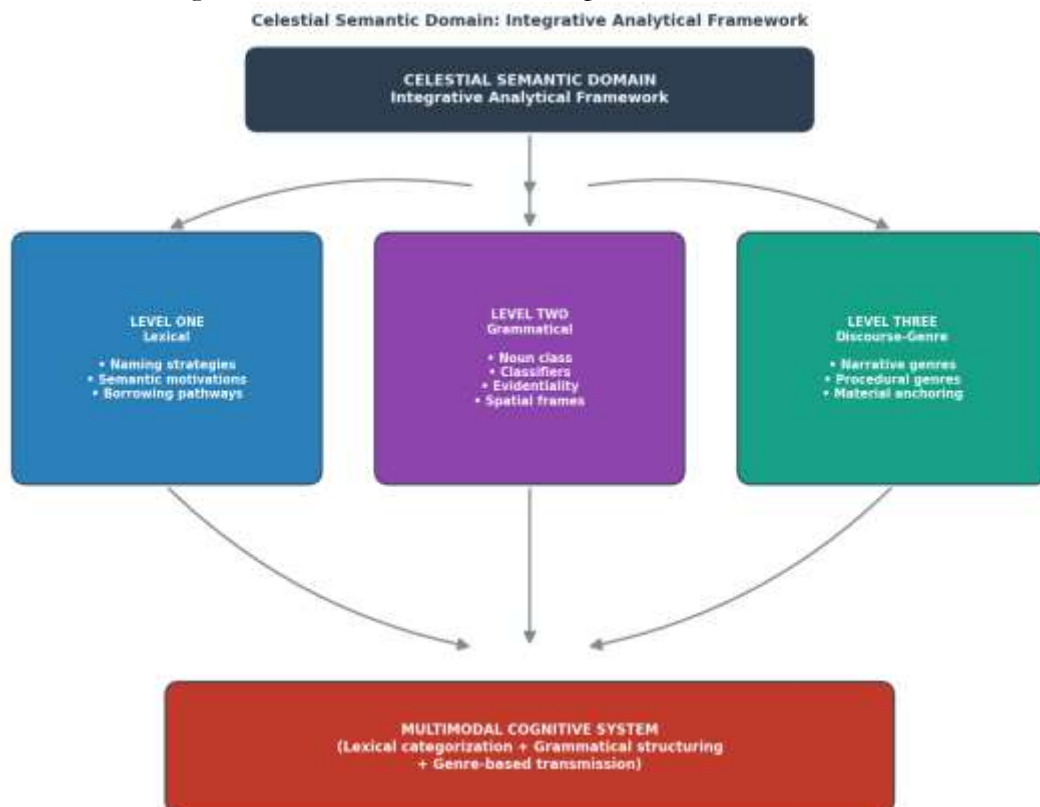


Figure 4. Celestial Semantic Domain: Integrative Analytical Framework (Source: Constructed based on synthesis of Holbrook, 2012; Sinha et al., 2011; Kurtik & Militarev, 2005; Aikhenvald, 2003)

The framework addresses the three limitations identified in Section 6.1. Against corpus imbalance, it provides a structured elicitation protocol that can be applied to undocumented oral traditions. Against interdisciplinary isolation, it integrates linguistic and astronomical analytical categories at each level. Against fragile absence claims, it requires multi-level evidence: a claim of "absence" at the lexical level must be corroborated by grammatical and discourse-level analysis before it can be considered a genuine cognitive finding rather than a documentation gap.

V. Conclusion

The linguistic dimension of cultural astronomy is a systematically neglected research domain. This review's analysis demonstrates that language is not merely a carrier of astronomical knowledge but its structuring mechanism: lexical choice reflects cognitive categorization, grammatical encoding compels specific epistemological stances, and genre structure determines the fidelity and variation patterns of knowledge transmission.

For linguistic theory, the corpus of cultural astronomy provides rich material for testing core hypotheses of semantic typology, linguistic relativity, and cognitive linguistics. The Amondawa case's challenge to the universality of spatiotemporal metaphor, the linguistic marking of astronomical knowledge's epistemological status through evidentiality systems, and the cross-linguistic stability and variability of star-name cognitive prototypes are all theoretically productive research questions.

For cultural astronomy, linguistic analysis provides an analytical leap from "what is recorded" to "how it is organized." The semantic structure of star names, the grammatical embedding of astronomical knowledge, and the cognitive functions of oral genres are necessary analytical levels for understanding the internal logic of astronomical knowledge systems.

Future research priorities include: (1) establishing comparable cross-linguistic databases of celestial vocabulary with unified semantic dimension annotation; (2) systematically incorporating the celestial semantic domain into field language documentation to avoid "silent absence"; (3) conducting experimental research on evidentiality–astronomical knowledge relationships to test the influence of grammatical marking on causal reasoning; (4) developing cognitive-linguistic co-analysis models for oral astronomical knowledge genres.

Cultural astronomy should not be regarded as a "marginal interest" of linguistics but as a regular domain of semantic typology and language documentation. The sky was among humanity's earliest objects of knowledge; language is humanity's most fundamental cognitive tool. Their intersection merits more systematic scholarly investment.

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