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Celestial categories: How languages encode, structure, and transmit astronomical knowledge across cultures

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Abstract:

Cultural astronomy has long documented how human societies interpret celestial phenomena, yet the linguistic dimension – how languages grammatically and lexically encode astronomical knowledge – remains systematically underexplored. While the sun, moon, planets, and stars present universal perceptual experiences, languages categorize and structure these referents in highly diverse ways, with implications for cognitive science, linguistic typology, and language documentation This paper examines how languages across diverse families encode, structure, and transmit celestial knowledge. Methods: The study synthesizes evidence from five language families (Austronesian, Pama Nyungan, Mayan, Uralic, Indo European) using frameworks from linguistic relativity, semantic typology, cognitive metaphor theory, and the ethnography of communication. Data sources include descriptive grammars, ethnoastronomical literature, oral narrative recordings, and comparative historical linguistics. Celestial lexicons are organized by eight semantic dimensions (brightness, motion, periodicity, visibility pattern, shape, colour, mythological role, functional association). Grammatical systems integrate celestial referents through noun class/gender assignment (e.g., Bantu languages), numeral classifiers (e.g., Japanese lunar phase counters), evidentiality marking (e.g., Tariana obligatory source specification for eclipses), and absolute spatial frames of reference (e.g., Guugu Yimithirr solar anchored directions). Transmission occurs through parent child nighttime dialogue, oral genres (Australian Dreaming narratives, Polynesian wayfinding chants, Maya agricultural instructions), language contact (borrowing and semantic shift), and material gestural modalities (bark paintings, deictic pointing). Case studies reveal universals (sun/moon as primary anchors) alongside language specific structuring (evidential distinctions for meteors, grammatical number for auroral displays). Languages are not passive reflectors of celestial reality; they actively categorize, structure, and transmit skylore through distinct linguistic mechanisms. The findings support a moderate linguistic relativity hypothesis in the domain of natural kinds: grammatical patterns shape habitual attention to celestial phenomena without determining perception.

Keywords:
Cultural astronomy, linguistic relativity, ethnoastronomy, celestial categorization, Indigenous knowledge transmission

I. Introduction

1.1 The problem

Astronomical phenomena such as the sun, moon, planets, stars, the Milky Way, and eclipses present a universal perceptual experience for humanity. Languages around the world have developed rich vocabularies to describe these celestial bodies and their behaviors. However, a closer examination reveals that these linguistic systems do not simply map onto a single, objective reality. Instead, they categorize the cosmos in remarkably diverse ways, reflecting and shaping distinct cultural and cognitive frameworks (Krupp, 1997). While the sky is physically the same, speakers of different languages may perceive and organize it according to very different

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principles. This linguistic diversity forms the core of the problem that the study of celestial categories seeks to address. A foundational resource in this area, the Handbook of Archaeoastronomy and Ethnoastronomy (Ruggles, 2015), provides essential context for understanding these varied cultural interpretations of the sky.

1.2 Research gap

The interdisciplinary field of ethnoastronomy has made significant progress in documenting celestial beliefs, mythologies, and practices across cultures. However, the specific linguistic dimension of this knowledge encompassing semantic typology, grammatical encoding, discourse patterns, and intergenerational transmission—remains underexplored in a systematic, cross cultural framework (Evans, 2010). While ethnographers often note celestial terms in passing, and cultural astronomers study their applications, a dedicated and comparative linguistic analysis is still nascent. This gap is highlighted in works seeking to integrate linguistic documentation with cultural astronomy. The central challenge is to move beyond simple lexical inventories and understand how the very structures of different languages their grammars, their metaphors, and their narrative conventions actively shape, organize, and preserve astronomical knowledge for speakers.

This gap persists despite the availability of a robust toolkit from linguistic typology and cognitive linguistics that is ideally suited to this task. For example, the Natural Semantic Metalanguage (NSM) approach developed by Anna Wierzbicka (1996) offers a powerful method for identifying cross translatable semantic universals, including concepts like 'sun', 'moon', and 'stars'. Applying such frameworks systematically to celestial domains could yield transformative insights.

This paper argues that "celestial categories" are not merely lexical inventories. They are dynamic cognitive structures actively encoded and organized by grammatical systems, such as classifiers, spatial frames of reference, and verbal aspect and transmitted via specific narrative genres and routine cultural practices (Levinson, 2003; Ruggles, 2015).

This thesis is built on the understanding that language is not a neutral conduit for an external reality. By examining how languages are used to talk about the sky, we can uncover fundamental principles of human categorization and cultural transmission. This perspective is supported by extensive work on linguistic relativity in domains like space and time (Levinson, 2003).

This paper is guided by three primary research questions:

1. What semantic dimensions (e.g., brightness, motion, periodicity, mythological role) organize celestial lexicons across languages?
2. This question seeks to identify the universal and culture specific principles by which celestial bodies are lexically categorized. The search for such universals has been a core project in lexical semantics, as exemplified by the work of Wierzbicka (1996).
3. How do grammatical systems such as grammatical gender, numeral classifiers, verbal aspect, evidentiality, and spatial deixis co opt celestial referents to perform grammatical functions?

This question moves from words to grammar, investigating how celestial bodies become integrated into the core structural machinery of different languages. Cross linguistic variation in grammatical gender assignment to 'sun' and 'moon' is a classic example of this phenomenon (Levinson, 2003).

II. Review of Literatures

2.1 Theoretical Framework

Asystematic investigation of how languages encode, structure, and transmit astronomical knowledge requires a multi-pronged theoretical apparatus. This section outlines the four complementary frameworks that guide the present analysis: linguistic relativity (Section 2.1), semantic typology (Section 2.2), cognitive metaphor theory (Section 2.3), and the ethnography of communication (Section 2.4). Each framework contributes a distinct set of conceptual tools for examining celestial categories, moving from broad questions about language-thought relationships to focused analyses of lexical systems, figurative mappings, and socially situated speech genres.

2.2 Linguistic Relativity and Celestial Domains

The Linguistic Relativity hypothesis associated with Edward Sapir and Benjamin Lee Whorf provides a foundational starting point for understanding the relationship between linguistic diversity and celestial cognition. In his most cited formulation, Whorf argued that "all observers are not led by the same physical evidence to the same picture of the universe, unless their linguistic backgrounds are similar" (Whorf, 1940/1956, p. 214). Applied to celestial phenomena, this claim raises the possibility that speakers of different languages may not only *describe* the sky differently but may *perceive* and *habitually attend to* it in distinct ways.

Contemporary scholarship distinguishes between strong and weak versions of the hypothesis. The strong version (linguistic determinism) holds that language rigidly constrains thought and has been largely abandoned due to lack of empirical support (Evans, 2010). The weak version, that language *influences* habitual patterns of attention, memory, and reasoning without fully determining them has generated a productive research program across domains such as space, time, and causality (Levinson, 2003).

Celestial domains provide particularly fertile ground for testing weak relativity effects for three reasons.

First, celestial time reckoning: Languages differ markedly in how they encode lunar cycles, solar years, or stellar events as primary temporal anchors. Research on three Brazilian indigenous languages (Huni Kuĩ, Awetý, and Kamaiurá) found no lexical equivalents for "time"; instead, temporal reference was indexed by "celestial bodies (sun, moon and stars) and activities" (Da Silva Sinha, 2018, p. 9). Such findings suggest that linguistic encoding of celestial periodicity shapes how speakers habitually segment and attend to temporal intervals.

Second, celestial direction: Many languages employ absolute spatial frames of reference anchored to celestial bodies. Speakers of certain Australian Aboriginal languages use cardinal directions guided by the sun's arc even when indoors (Levinson, 2003). This contrasts with egocentric frames (left/right). Cross-linguistic differences in spatial frames of reference have been shown to affect non-linguistic spatial memory and reasoning, providing some of the clearest evidence for weak relativity (Levinson, 2003).

Third, celestial causality: Languages with obligatory evidential marking require speakers to specify the source of knowledge about celestial events (direct observation, hearsay, inference). Tariana (Arawak) and Tuyuca mark evidentiality grammatically, which may subtly privilege or

constrain causal explanations of, for example, an eclipse (Evans, 2010). This domain remains largely unexplored but holds promise for future research.

A cautionary note is in order: early Whorfian claims about Hopi time perception have been criticised for overgeneralisation. The weak hypothesis is now tested using rigorous experimental methods, and celestial domains are only beginning to receive such attention. Nonetheless, linguistic relativity provides a valuable heuristic for generating hypotheses about how grammatical and lexical differences in celestial encoding correlate with patterns in non-linguistic cognition.

2.3 Semantic Typology

While linguistic relativity addresses cognition, semantic typology provides the methodological framework for systematic cross-linguistic comparison. Semantic typology is "the comparative study of linguistic categorization research into how linguistic representations structure a given cognitive domain across languages" (Bohnemeyer et al., 2007, p. 495). Its goals are to identify semantic universals and to map cross-linguistic variation in lexical and grammatical categorisation (Evans, 2010).

Celestial lexical fields are ideal for semantic typology because they offer a finite, perceptually accessible set of referents (sun, moon, planets, bright stars, Milky Way, eclipses, etc.) while exhibiting considerable cross-linguistic diversity in how these referents are categorised.

Stars: Many languages have a generic term for "star" (e.g., English *star*, Latin *stella*, Proto-Indo-European *h₂stḗr*). However, the boundaries of this category vary. In some languages, "star" excludes planets; in others, planets are subsumed under "star" as "wandering stars." Some languages lack a generic term altogether, lexicalising only specific constellations or prominent stars. Comparative historical reconstruction has traced Proto-Indo-European celestial terms (e.g., *meHɪnot- 'moon') and their semantic evolution, revealing that the term for 'moon' probably expressed the basic idea of "measure of time" (Blažek, 2017, p. 2), pointing to a deep-seated link between lunar cycles and time reckoning.

Planets: English distinguishes "star" from "planet," with "planet" (Greek *πλανήτης*, "wanderer") highlighting motion as a diagnostic feature. Many other languages also encode "wandering" as a defining property. Others lack a dedicated term for "planet," either grouping planets with stars or borrowing a term. Diagnostic features that organise this domain cross-linguistically include brightness, motion (apparent wandering vs. fixed), periodicity, colour, and mythological associations.

Constellations: Cross-cultural research on star patterns has identified recurrent semantic parallels often "naturally induced by the shape and composition of the star pattern" (Bucur, 2024, p. 2). The Pleiades, for example, are associated with categories such as "basket or sieve," "numerous," or "seven stars" across Northern Eurasia (Blažek, 2017). These findings suggest some semantic universals reflecting *endogenous* perceptual constraints. Yet wide variation remains: the same cluster is "Seven Sisters" in Greek mythology, "Seed-burying stars" in some Australian traditions, and "Water-hole women" in others.

Lunar phases: Languages vary in (1) the number of named phases (some distinguish only new/full; others up to eight distinct named phases); (2) the semantic basis for naming (shape-based "crescent," period-based "first quarter," activity-based "planting moon"); and (3) grammatical treatment (separate lexemes vs. derived forms).

Prototype theory (Rosch, 1978) provides a framework for understanding the internal structure of celestial categories. A prototype is the "best example" of a category. For English speakers, the prototypical star might be the Sun (despite its scientific classification) or a bright, twinkling point like Sirius. The prototypical planet might be Venus (brightest and most regularly visible). In languages that lack generic terms, categories may be structured around specific prototypes. The colexification of 'sun' and 'moon' in some Circum-Pacific languages (Urban, 2010) challenges the universality of the sun/moon distinction and suggests prototype structures that differ markedly from those of Indo-European languages. Table 1 summarises diagnostic semantic dimensions derived from the literature.

Table 1. Diagnostic Semantic Dimensions for Celestial Lexicons

Dimension	Sample values	Example
Brightness	luminous → very bright → faint	Sun, Moon > Venus > Jupiter > faint stars
Motion	fixed vs. wandering	Stars (fixed), planets (wandering)
Periodicity	diurnal, lunar, annual, irregular	Sun (diurnal), Moon (lunar), Pleiades (annual)
Visibility pattern	always visible, seasonal, occasional	Sun (always), Venus (morning/evening star)
Shape (moon)	crescent, half, gibbous, full	English "crescent moon," etc.
Colour	white, golden, red, blue-white	"Red star" (Aldebaran, Mars)
Mythological role	deity, animal, object, human-like	"Seven Sisters," "Heavenly canoe"
Functional association	time-telling, navigation, agriculture	"Harvest moon," "Pleiades rising = planting time"

2.4 Cognitive Metaphor Theory

Cognitive Metaphor Theory (CMT), pioneered by Lakoff and Johnson (1980, 2003), posits that metaphor is not a mere rhetorical device but a fundamental mechanism of human thought. Metaphor involves mapping conceptual structure from a source domain (concrete, perceptually accessible) to a target domain (abstract, less accessible). Celestial bodies serve as rich source domains across cultures.

Sun as source domain maps onto (1) positive value (goodness, righteousness), (2) temporal reference (daytime, life stages), (3) authority (kings, gods), and (4) knowledge (enlightenment). English examples include "sun of righteousness" (biblical) and "sunlight" as truth. Cross-linguistic studies suggest the sun is consistently associated with positive evaluation and overt power (Lakoff & Johnson, 1980).

Moon maps onto (1) changeability, lunacy (English *lunatic*), (2) femininity (common but not universal), (3) reflected or secondary light, (4) temporal cyclicity (months), and (5) romantic or melancholic mood. The contrast between sun (stable, positive, masculine) and moon (changeable, ambiguous, feminine) appears cross-linguistically but is not absolute (Urban, 2010 notes colexification in some languages).

Stars as source domain support metaphors for (1) fate/destiny ("written in the stars"), (2) excellence/celebrity ("movie star"), (3) navigation/guidance ("follow the star"), (4) multitude ("starry host"), and (5) aspiration ("reach for the stars").

Planets have more restricted mappings. Venus (morning/evening star) supports duality and transition; Mars supports war, aggression, and masculinity (*martial*); Mercury supports communication and swiftness; Jupiter supports kingship and expansion; Saturn supports melancholy and limitation. These Greco-Roman metaphors have spread through European languages via classical education, but indigenous metaphors often follow different patterns (e.g., the Pleiades mapped onto agricultural cycles).

Cross-linguistic variation in celestial metaphors remains understudied. Research on Polish folklore identifies the sun and moon as "mediators between physical and metaphysical worlds" that carry "preconceptual image schemas" (Mediating the otherworld in Polish folklore, 2020). Analysis of Chinese and Vietnamese reveals sun and moon as source domains for "warmth, brightness, time, life, and gender" (Metaphorical features of 'the sun' and 'the moon' in Chinese and Vietnamese, 2017). Systematic comparative work is needed to test claims of universality.

2.5 Ethnography of Communication

The Ethnography of Communication (EC), associated with Dell Hymes (1974) and elaborated by Bauman and Sherzer (1989), moves beyond formal linguistic analysis to examine language in use as socially situated, culturally patterned communicative behaviour. The central unit is the *speech event*, governed by norms for speaking, listening, and interpreting. EC attends to verbal, paralinguistic, and non-verbal channels, as well as social roles, settings, and ideologies.
Celestial knowledge genres are speech events that transmit, reinforce, and transform astronomical knowledge across generations. Key genres include:

Lullabies and infant-directed songs often embed celestial references ("Twinkle, Twinkle, and Little Star"), associating celestial bodies with comfort, predictability, and the sleep-wake transition. These early exposures establish foundational celestial concepts before explicit instruction.

Hunting songs incorporate celestial information relevant to seasonal animal movements. Among the Hopi, "rabbit-hunt chants" constitute a ritualised language with specific poetic and formulaic features encoding knowledge about the timing of collective hunting activities (Black, 1974, as cited in American Ethnological Society, 1966). Timing is linked to seasonal star positions.

Agricultural maxims and proverbs encode condensed seasonal knowledge in memorable, formulaic language (e.g., English "Plant potatoes when the oak leaves are as big as a mouse's ear" a phenological proxy linked to the solar cycle; Pacific traditions: "When the Pleiades set at sunset, it is time for digging yams"). Rhyme, alliteration, and parallel syntax function as mnemonic devices.

Ritual calendars and ceremonial speech incorporate celestial timing as a constitutive feature. The Maya *Chol Q'ij* ("Order of Days") is a 260-day ritual calendar linked to Venus cycles, the solar year, and agricultural cycles. Its language is highly formalised, with specialised vocabulary and fixed sequences encoding astronomical observations (Ruggles, 2015). Similarly, Hopi ceremonial calendar is keyed to solstices and equinoxes.

Wayfinding chants from Oceania integrate astronomical, ocean swell, wind, and bird behaviour information into oral navigational texts. The *paihi* of the Marshall Islands chanted star compass directions encode rising and setting positions of stars, their order, seasonal availability,

and relations to wave patterns. These chants serve as pedagogical tools and real-time navigational aids (Evans, 2010).

Initiation secrets represent restricted speech events. Detailed astronomical knowledge is often restricted to initiated members (e.g., male elders, ritual specialists). Such restrictions shape transmission: knowledge is not available to all speakers, and its acquisition marks social status. Documentation requires careful ethical protocols and respect for indigenous data sovereignty.
EC provides analytical questions for each celestial genre:

a. Speech event structure: What are the obligatory openings, prescribed sequences, and closings?
b. Participant roles: Who can speak? Who can listen? What are their rights and obligations?
c. Language ideology: What do speakers believe about celestial speech varieties (e.g., that they are "true," "powerful," "dangerous," "archaic," or "secret")?
d. Genre mixing: How do celestial genres intersect with other speech genres (e.g., medical chants, land-use narratives)?
e. Attentional focus: Which celestial phenomena are foregrounded or backgrounded in different genres? The same language may foreground the moon in lullabies but Venus in agricultural maxims.

For communities experiencing language shift, celestial genres are often among the first to be lost, yet they represent some of the most culturally salient content for revitalisation efforts. EC provides a methodology for documenting not only the linguistic content but also the social organisation and use of celestial knowledge essential for designing culturally appropriate transmission strategies.

III. Research Methods

3.1 Lexical Typology of Celestial Referents

The lexical encoding of astronomical phenomena reveals systematic cross linguistic variation in how languages carve up the celestial domain. This subsection examines three lexical fields: stars, planets, and the Milky Way. For each, it considers principles of categorization (brightness, motion, and periodicity), the distinction between generic and specific terms, and the morphosyntactic behaviour of celestial nouns.

3.2 Grammatical Structures

Beyond the lexicon, grammatical systems actively integrate celestial referents, imposing structural constraints on how speakers talk about the sky. This subsection examines three grammatical domains: noun classes/gender, numerals and classifiers, and evidentiality.

3.3 Spatial Frames of Reference

The spatial frames of reference (FoR) used by a language constitute one of the best documented domains for cross linguistic variation in cognitive categorization (Levinson, 2003). Three main types are usually distinguished: relative (egocentric, e.g., "left of the tree"), intrinsic (object centred, e.g., "in front of the house"), and absolute (geocentric, e.g., "north of the tree"). Celestial bodies, particularly the sun, moon, and stars frequently serve as anchors for absolute frames of reference, as they provide fixed, external coordinates independent of the speaker's orientation.

3.4 Structuring: How Languages Organize Celestial Knowledge into Systems

While Section III examined the basic building blocks of how individual celestial referents are named (lexical categorization) and the ways grammar interacts with astronomical reference (grammatical structures), this section turns to a higher order question: how do languages

structure celestial knowledge into coherent, organized systems? The structuring of astronomical information operates along three principal axes: hierarchical taxonomies (Section 4.1), temporal systems (Section 4.2), and combinatorial semantics (Section 4.3).

3.5 Hierarchies and Taxonomies

Folk taxonomies, first extensively documented in ethnobiological systems (Berlin, 1992), represent "the classification system used by non-experts to categorize and name entities in their environment" (Academia.edu, 2025, para. 1). While most widely studied in the domains of plants and animals, celestial bodies are also subject to hierarchical classification. Understanding these hierarchies requires examining three levels of taxonomic organization: the superordinate, the basic level, and the subordinate.

3.6 Temporal Structuring

Celestial bodies, due to their regular periodicities, serve as universal temporal anchors across human societies. Languages grammaticalize these periodicities in two principal ways: by encoding lunar cycles within verbal aspect systems and by constructing seasonal star calendars keyed to heliacal risings and settings.

3.7 Combinatorial Semantics

The meaning of complex celestial terms is not always predictable from the meaning of their parts. This section examines compounding and collocation patterns in celestial terminology, as well as the degree of compositionality exhibited by such terms.

3.8 Transmission: Learning, Discourse, and Change

The preceding sections have examined how languages encode astronomical referents (Section III) and structure them into coherent systems (Section IV). This section addresses the dynamic processes by which celestial knowledge is transmitted across generations and across linguistic boundaries. Transmission operates along multiple channels: early childhood acquisition (Section 5.1), oral genres that serve as knowledge storage devices (Section 5.2), contact induced language change (Section 5.3), and material gestural modalities (Section 5.4).

3.9 Acquisition

The ontogenetic development of celestial knowledge in children involves the gradual integration of linguistic input, cultural practices, and direct environmental observation. This subsection examines two interrelated questions: first, the developmental trajectory by which children acquire star names and abstract astronomical concepts; second, the role of parent–child interaction in scaffolding this acquisition.

3.10 Oral Genres as Storage Devices

In societies without widespread literacy, astronomical knowledge is preserved and transmitted through highly structured oral genres. These genres serve as storage devices cognitive and cultural technologies that encode large bodies of information in memorable, repeatable forms. Two major genre types are examined here: narrative genres (exemplified by Australian Aboriginal Dreaming stories) and procedural genres (exemplified by Polynesian wayfinding chants and Maya planting instructions).

3.11 Material and Gestural Transmission

Alongside linguistic and oral channels, astronomical knowledge is also transmitted through material artefacts and multimodal gestural practices. These modalities serve to anchor,

complement, and sometimes even substitute for verbal celestial descriptions.

IV. Result and Discussion

4.1 Austronesian (Polynesia): The Star Compass, Verb Classes, and Ocean Swells

Polynesian languages encode a sophisticated astronomical framework called the star compass – a mental map of the horizon divided into 32 "houses" (points), each associated with the rising and setting of specific stars, the sun, the moon, and planets. This absolute spatial frame of reference is the foundation of traditional wayfinding, allowing navigators to orient themselves without instruments (Finney, 2001; Ruggles, 2015). The star compass is not a physical object but a mental construct memorised through chants and oral instruction (Storymaps, 2023).

The linguistic encoding of this knowledge is equally systematic. Polynesian languages possess verb classes for celestial motion that distinguish between different types of movement e.g., a star's rising vs. setting vs. "apparent" motion across the sky. Moyse Faurie (2020) examined linguistic expressions of goal, source, and place in Polynesian languages and found that directional verbs incorporate information about celestial reference points. The lexicon includes specialised terms for stars with fixed rising points (guide stars) and for those that "wander" (planets). Most remarkably, the metaphorical extension of astronomical terminology reaches the ocean environment: navigators read ocean swells as a "mirror" of the sky pattern, and the same terms for star alignments are used to describe wave patterns (Finney, 2001). This polysemy demonstrates a deep cognitive integration of celestial and aquatic domains, where the "path of the sun" is not just an astronomical concept but a practical guide for reading currents and swells.

4.2 Pama Nyungan (Australia) – Dreaming Tracks, Evidentiality, and Oral Tradition

The Pama Nyungan languages of Aboriginal Australia preserve one of the world's most ancient and continuous astronomical traditions, transmitted orally for over 50,000 years (Norris, 2016). This knowledge is embedded in Dreaming stories and Songlines oral narrative structures that serve as both maps and moral charts. For example, the Wardaman people describe the planets as ancestors walking along a celestial road called the "Dreaming Track in the Sky" (the zodiac) (Norris, 2016). Forster (2021) notes that Aboriginal people, Australia wide, named the Sun, Moon, individual stars, constellations, planets, the Magellanic galaxies, and dark spaces in the sky, using these names in narratives that link creation of objects in the sky with life on earth.

Of particular linguistic interest is the evidential distinction encoded in many Aboriginal languages between "knowing through story" (i.e., knowledge received via oral tradition) and "direct observation" (first hand witnessing). Evans (2010) has documented evidential systems in several Australian languages that grammatically distinguish between knowledge obtained from oral sources (hearsay, narrative) and that obtained through direct sensory experience. In the celestial domain, this grammatical distinction marks whether a speaker knows a star's name from ancestral Dreaming narratives (reported evidential) or from having seen the star rise that very night (visual evidential). This grammaticalised epistemic distinction reflects the community's respect for ancestral knowledge as an autonomous source of truth alongside empirical observation.

4.3 Mayan (Mesoamerica): Venus Cycles, Numeral Classifiers, and the Chol Q'ij

The Maya developed perhaps the most sophisticated pre colonial astronomical system in the Americas, and their languages, particularly K'iche' and Yucatec Mayan preserve this knowledge in specialised grammatical and lexical structures (Ruggles, 2015). The 260 day ritual calendar, the Chol Q'ij ("Order of Days"; also Cholq'ij or Tzolk'in), interweaves a 20 day glyph

cycle with a 13 day number cycle, and its use is intimately tied to the synodic cycles of Venus (Poz Salanic, 2021).

Key linguistic features include:

a. Numeral classifiers used exclusively for counting planetary cycles (e.g., distinct classifiers for Venus's appearances as morning vs. evening star). Hesselink's (2010) morphological analysis of the Dresden Codex identified classifier morphemes attached to Venus glyphs that encode the number of days since the planet's last appearance.
b. Calendar glyphs that function as both numerals and classifiers, with specific glyphs for Venus's 584 day synodic cycle and for "invisible" periods when the planet is behind the Sun (Savage, 2021).

The Maya treat Venus as a "sun" or "star" during different parts of its cycle, with root words changing accordingly – a grammaticalised reflection of the planet's dual visibility pattern (Poz Salanic, 2021). Today, Maya elders who are Calendar Keepers (Ajq'ijab' in K'iche') continue to curate these calendrical traditions, and revitalisation projects are underway to recover Maya constellations and ancestral observation techniques (Poz Salanic, 2021).

4.4 Saami (Uralic) Auroral Terminology and Grammatical Number

The Saami languages of northern Fennoscandia provide a unique case of linguistic encoding for a specific celestial phenomenon: the aurora borealis (Northern Lights). The North Saami word for the Northern Lights is guovssahas (singular) or guovssahasat (plural) (Glosbe, n.d.). According to Koponen (2015) in the Encyclopaedia of Saami Culture, the term is derived from guovssu, meaning "morning/evening twilight", linking auroral light to the daily cycle of the sun. The suffix has forms abstract nouns from adjectives or verbs (cf. Finnish us/-ys).

The grammatical number of the term encodes a subtle perceptual distinction (Koponen, 2015):

a. Singular (guovssahas) – used for a single, quiet auroral arc visible near the horizon.
b. Plural (guovssahasat) – used for multiple, active rays or a brilliant display covering much of the sky.

This grammatical obligatoriness reflects the cultural importance of accurately describing auroral activity, a necessity for Saami reindeer herders who used the lights as a seasonal calendar and as a sign of approaching weather change (Koponen, 2015). The aurora's presence and intensity indicated when to move herds, when snow was likely to fall, and even which direction to travel. The language thus forces speakers to attend to the configuration and intensity of the aurora, not simply its presence or absence.

4.5 Indo European (Comparative): Reconstructed *h₂stḗr 'Star' and the Dioscuri

A comparative Indo European perspective reveals ancient astronomical concepts embedded in the shared lexicon of the family. The most securely reconstructed Proto Indo European celestial term is *h₂stḗr 'star', derived from a root meaning "to burn, glow" plus an agentive suffix, literally "glower, shiner" (Blažek, 2017). This term yields reflexes across all branches: Latin stella (via ster lā), Greek astēr, Sanskrit stṛ , Old English steorra, and English star. Blažek (2017) also reconstructs the terms for 'sun' (**seH₂u̯el *) and 'moon' (**meHın (o)s *), though their attestation in Anatolian is less certain, suggesting possible borrowing or later semantic narrowing. Notably, the word for 'moon' may originally have expressed the basic idea of "measure of time" encoding the moon's role as a calendrical device (Blažek, 2017).

A striking example of mythologemes reflected in syntax is the treatment of the Dioscuri (twin brothers Castor and Pollux) as the personifications of the morning and evening stars (Venus). In Greek and other Indo European traditions, the twins are grammatically singular when treated as a pair (e.g., τὼ Διοσκόρω "the two Dioskouroi," dual number) but plural when

described as separate stars. This grammatical number alternation attests to a deep seated conceptual link between twin mythology and the dual appearance of Venus. As noted in the Handbook of Archaeoastronomy and Ethnoastronomy, the morning/evening star duality is a cross cultural theme, but its grammatical encoding is particularly clear in Indo European languages (Ruggles, 2015).

4.6 Discussion

The preceding sections have examined how languages across diverse families encode, structure, and transmit astronomical knowledge, moving from lexical categorization (Section III) through systemic organisation (Section IV) to dynamic processes of transmission (Section V), illustrated with cross cultural case studies (Section VI). This discussion synthesises the core findings, outlines their theoretical implications, offers methodological recommendations for future research, and concludes with applied considerations for language documentation, Indigenous data sovereignty, and STEM education.

4.7 Synthesis of Findings

The cross linguistic survey conducted in this paper reveals a complex interplay between universal trends in celestial reference and language specific structural choices. On the one hand, certain regularities appear to be widespread, if not universal. The sun and the moon consistently serve as primary spatial and temporal anchors across the languages examined; they are among the earliest celestial referents lexicalised in child acquisition, and they frequently function as the basis for absolute spatial frames of reference (Section 3.3; Levinson, 2003). Similarly, the colexification of "moon" and "month" – documented in over 300 languages (Blažek, 2017) – reflects a deep cognitive and practical link between lunar periodicity and temporal reckoning that appears to be exceptionally widespread.

On the other hand, the data also reveal significant language specific structuring in how astronomical information is grammatically encoded. One of the most striking examples concerns evidential distinctions for celestial events. In languages with obligatory evidential marking (Aikhenvald, 2004), such as Tariana (Arawak) and Tuyuca (Tucanoan), a speaker describing a meteor or an eclipse cannot simply state "There was an eclipse"; they must grammatically specify whether the event was directly witnessed (visual evidential), heard (non visual auditory), inferred from indirect evidence (e.g., sudden darkness), or reported through oral tradition (Aikhenvald, 2003; Barnes, 1984). This grammatical obligatoriness means that speakers of evidential languages are, in a sense, forced to attend to the epistemic source of their astronomical knowledge in ways that speakers of non evidential languages are not. Conversely, in languages without such systems, the same descriptive act can be performed without any specification of information source – though, of course, speakers may choose to add such information lexically.

This cross linguistic difference in grammatical encoding has potential implications for how speakers of different languages remember, reason about, and trust different sources of astronomical knowledge – a point to which the discussion of theoretical implications will return below.

4.8 Theoretical Implications

The findings of this paper challenge strong Universalist accounts in two related domains: the language thought interface and the classification of natural kinds.

Celestial categories challenge pure universalism. A strongly Universalist position would hold that the structure of the physical world – including the celestial domain determines the

structure of human categories, with language merely reflecting pre existing perceptual or cognitive universals. However, the evidence assembled in Sections III VI suggests a more nuanced picture. While the sun and moon are universally salient, the grammatical and lexical choices that languages make about them vary considerably: grammatical gender assignment to sun and moon can be reversed across related languages (e.g., Latin masculine sōl vs. German feminine Sonne), and some languages even colexify both bodies under a single term (Urban, 2010). Moreover, the presence or absence of grammatical categories such as evidentiality, numeral classifiers for planetary cycles (Section 3.2), or specialised verbal aspect for lunar phase transitions appears to actively shape how speakers talk about and potentially how they attend to – celestial phenomena.

This is not to claim that language entirely determines perception (a position that has been largely abandoned; Evans, 2010). Rather, the evidence is consistent with a moderate linguistic relativity hypothesis in the domain of natural kinds: language influences habitual patterns of attention, memory, and reasoning without fully constraining them. The celestial case is particularly instructive because it involves a domain that is both highly constrained by physical reality (the sun rises in the east, the moon waxes and wanes, Venus appears as both morning and evening star) and yet open to diverse linguistic categorisations. As Levinson (2003) demonstrated for spatial frames of reference, consistent use of an absolute (geocentric) system – often anchored to the sun's arc or star compass – correlates with preferences for absolute coding in non linguistic memory tasks. Extending this logic to the celestial domain, one would predict that speakers of languages with obligatory evidential marking may be more attentive to the source of their astronomical knowledge, and speakers of languages with rich classifier systems for planetary cycles may more readily attend to the synodic patterns of Venus.

The evidence from the case studies supports this prediction, albeit tentatively. Aboriginal Australian oral traditions encode knowledge of astronomical events dating back over 10,000 years (The Conversation, 2014), and the evidential distinctions in Pama Nyungan languages between "knowing through story" (ancestral knowledge) and "direct observation" grammatically encode the community's valuing of oral transmission as an autonomous epistemic source on par with first hand experience. Similarly, the Polynesian star compass and its associated verb classes for celestial motion (Moyse Faurie, 2020) reflect a deeply grammaticalised integration of astronomical and navigational knowledge.

4.9 Methodological Recommendations

The research reported here also points to several methodological innovations that could strengthen future work in the linguistic study of cultural astronomy.

Elicitation protocols that distinguish lexical knowledge from narrative competence
Traditional elicitation methods (e.g., asking for translations of "star" or "planet") capture lexical knowledge but may miss the richer, discursively embedded ways in which celestial knowledge is actually used. Future protocols should separately elicit: (i) basic lexical inventories (using standardised stimuli such as sky photographs or planetarium projections), (ii) descriptive narratives (e.g., "Tell me how you know when to plant yams"), (iii) procedural texts (e.g., wayfinding chants or planting instructions), and (iv) conversational interaction (e.g., naturally occurring parent child dialogue about the night sky). This layered approach would allow researchers to distinguish between what speakers know (lexically), what they can perform in monologic narrative, and what they actually do in interactive settings. The distinction between "knowing through story" (reported evidential) and "direct observation" (visual evidential) in Australian languages (Evans, 2010) underscores the importance of this differentiation: a speaker

might know a star's name lexically but still distinguish epistemically between ancestral knowledge and personal witnessing.

Use of planetarium software to test linguistic descriptions of stellar motion

One of the key challenges in studying linguistic descriptions of celestial motion is that the night sky is not always observable (due to weather, latitude, or light pollution), and many celestial events occur on timescales that are not compatible with real time elicitation. Planetarium software such as Stellarium – a free, open source planetarium programme that has become popular in astronomy education and outreach, offers a powerful solution (Hoffmann, 2025). Crucially, Stellarium's applications for the humanities extend "far beyond the typical applications for amateur and professional astronomers for observation planning: Research results (data) from ethnology, anthropology, philologies/linguistics and the history of science can be contributed here directly by researchers" (Hoffmann, 2025, abstract).

Methodologically, planetarium software allows researchers to present controlled, repeatable, and customisable celestial configurations to speakers, eliciting descriptions of stellar motion under experimentally controlled conditions. For example, a researcher could ask a speaker: "This is the night sky as seen from your region on 1 January. Can you describe where this star will be in three hours?" The planetarium simulation can then be advanced, and the speaker's prediction compared with the simulation. This approach has been used in studies of time communication inside the planetarium dome, where researchers have analysed how guides use strategies grounded in both geocentric and allocentric frames of reference to teach celestial motion (Marques et al., 2021; Moutinho et al., 2022). Extending this methodology to cross linguistic comparison would provide a rigorous, replicable basis for testing the linguistic relativity effects proposed above.

Integrating ethnomethodology and conversation analysis

Naturalistic recordings of planetarium sessions have revealed "ordinary methods and strategies that are used by guides to teach time related concepts" (Marques et al., 2021, p. 1). The same ethnomethodological approach – analysing video recorded, naturally occurring interaction – could be extended to parent child nighttime conversations, navigational chants, and calendar ceremonies. Such an approach would capture not only the content of celestial talk but also the interactional practices through which knowledge is co constructed, repaired, and transmitted.

V. Conclusion

This concluding section restates the central thesis of the paper, summarises the answers to the three research questions posed in the introduction, acknowledges the limitations of the current study, and outlines promising directions for future research.

5.1 Restatement of Thesis

Languages are not passive reflectors of an external celestial reality. The evidence assembled across Sections III–VII demonstrates that human languages actively categorise (through lexical and grammatical choices), structure (through taxonomies, temporal systems, and combinatorial semantics), and transmit (through acquisition, oral genres, contact induced change, and multimodal practices) astronomical knowledge. Celestial categories are dynamic cognitive and cultural constructs, shaped by the interplay of universal perceptual constraints (the sun and moon are salient; stars have fixed relative positions; planets "wander") and language specific conventionalisations (how many lunar phases are named, whether evidentiality marks direct observation vs. oral tradition, whether Venus receives one name or two). As Evans (2010)

argued for endangered knowledge systems generally, and as Cannon (2013) demonstrated specifically for Alaskan indigenous astronomy, the linguistic encoding of skylore is a fragile but extraordinarily rich domain that reveals fundamental properties of human cognition and culture.

5.2 Answers to Research Questions

The introduction posed three research questions. The findings of this paper provide the following answers.

What semantic dimensions organise celestial lexicons across languages?

Section 3.1 identified eight diagnostic dimensions: brightness, motion (fixed vs. wandering), periodicity, visibility pattern, shape (for the moon), colour, mythological role, and functional association (e.g., time telling, navigation, agriculture). These dimensions are not equally weighted across languages; rather, each language prioritises a subset. For example, motion is the organising principle for the distinction between stars and planets in Greek derived terminologies (Harper, 2001–2025), while brightness and visibility pattern organise the dual naming of Venus as morning/evening star in many unrelated languages. The universal presence of some dimensions (e.g., brightness) alongside variable prioritisation supports a moderate universalist position with room for linguistic relativity.

How do grammatical systems co opt celestial referents? Section 3.2 demonstrated that celestial bodies are integrated into grammatical systems in multiple ways. In Bantu languages, the sun and moon belong to different noun classes, triggering distinct agreement patterns (Section 3.2.1). In numeral classifier languages such as Japanese, lunar phases are counted using classifiers that reflect shape or animacy (Section 3.2.2). Most strikingly, evidentiality systems in languages such as Tariana and Tuyuca require speakers to grammatically mark the source of knowledge about celestial events (visual, non visual, inferred, reported), thereby forcing attention to epistemic grounding. Spatial frames of reference (Section 3.3) anchor absolute directions to the sun's arc (Guugu Yimithirr) or to star compasses (Polynesian languages), with demonstrable effects on non linguistic spatial memory.

Through which discourse practices is astronomical knowledge transmitted and transformed?

Section 5 identified multiple transmission channels. Acquisition occurs through parent child nighttime dialogue, with early learned star names and culturally embedded metaphors shaping children's initial mental models. Oral genres function as storage devices: Australian Aboriginal Dreaming stories preserve astronomical observations spanning more than 10,000 years; Polynesian wayfinding chants encode star compass directions and ocean swell patterns; Maya planting instructions are embedded in the Chol Q'ij calendar. Language contact leads to borrowing (Greek planētēs → Latin → Romance → English) and semantic shift (e.g., disaster from "ill starred"), but also to loss of indigenous terminologies under language shift, prompting revitalisation efforts. Material and gestural transmission includes bark paintings, notched sticks, and deictic pointing gestures that anchor linguistic labels to visible stars.

5.3 Limitations

This study has several limitations that must be acknowledged.

The cross linguistic survey (Sections III–VI) drew disproportionately on well documented language families: Indo European, Austronesian, Pama Nyungan, Mayan, and Uralic. African language families – particularly Niger Congo (excluding Bantu, which was touched upon briefly), Nilo Saharan, and Khoisan – are severely underrepresented, despite possessing rich astronomical traditions. Similarly, South American language families beyond Arawak and Tucanoan (e.g.,

Cariban, Tupi Guarani, and Macro Jê) have received little attention in the cultural astronomy literature from a linguistic perspective. This bias reflects historical patterns in linguistic documentation rather than any intrinsic absence of celestial knowledge in these regions. Future work should prioritise these under represented families.

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