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Articles are inversely associated with inflectional case in Indo-European

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Abstract

The relationship between inflectional case marking and the emergence of definite and indefinite articles has long been hypothesized but seldom examined quantitatively. This study presents a large-scale statistical analysis of the relationship across ninety-four Indo-European languages. Bayesian logistic regression models account for phylogenetic and spatiotemporal autocorrelation while integrating over phylogenetic uncertainty. The results establish a robust inverse association between case-inventory size and the presence of articles. Estimated probabilities indicate that smaller case inventories are associated with higher probabilities of definite articles. A similar association holds for indefinite articles. The posterior median predicted probability exceeds 0.5 at four cases for definite articles and between three and four cases for indefinite articles. These thresholds correspond to reduced case inventories composed primarily of grammatical cases. Even after accounting for case-inventory size, the presence of a definite article is associated with a higher probability of an indefinite article. The analysis shows that the observed association is compatible with direct, mediated, and common-cause accounts and does not uniquely identify a causal pathway. These findings sharpen the empirical basis of the debate and identify the causal and evolutionary questions that remain open.

1. Introduction

The effects of case loss extend far beyond the realization of nominal forms (Dragomirescu & Nicolae 2016:911, Reinöhl 2016:8). One widely discussed consequence is the increased use of adpositions, which assume functions previously expressed by inflectional case (Meillet 1918:98–99, Pinkster 1990:195, 207, Norde 2001:246, Hewson & Bubeník 2006:viii, Dragomirescu & Nicolae 2016:911). Word order is likewise often argued to take over some of the functions formerly encoded by case, including the marking of grammatical relations (Meillet 1918:98–99, Kiparsky 1997:461, Liu et al. 2025:340, 342).[1]

Another proposed consequence of case loss is the emergence of definite and indefinite articles, as illustrated by the contrast between Russian and Bulgarian.

[1] It has also been argued that increases in the inventory or frequency of adpositions may facilitate case loss (Vincent 1999:1132, Reinöhl 2016:8). On this view, greater use of adpositions may be both a cause and a consequence of reduced case inventories. The role of adpositions is discussed further in Section 6.3.2.

(1) Russian
knig-**a** lezhit na stol-**e**
book-**NOM.SG** lie.3SG.PRS on table.**LOC.SG**
'The book is on the table.'

(2) Bulgarian
kniga-**ta** e na masa-**ta**
book-**DEF** be.3SG.PRS on table-**DEF**
'**The** book is on **the** table.'

Russian, like most Slavic languages, has a relatively rich case system (typically around six cases) but lacks articles. Bulgarian, by contrast, has a definite article and makes only limited use of inflectional case. This contrast exemplifies a broader pattern that has been proposed for several Indo-European clades. As inflectional case is reduced, articles tend to emerge. This inverse relationship between case-inventory size and articles has been argued for Romance (Giusti 1995, 2015, Posner 1996:126, Ledgeway 2011:720), Germanic (Paul 1919:§149, Tschirch 1975:168, Giusti 1995, Crisma 2011:175, Jones & Jones 2019:§43, §266, van Gelderen 2024:19), and South Slavic (Hewson & Bubeník 2006:21). On some accounts, it has been extended to the family as a whole (Hewson 1972:14, Krámsky 1972:49, Martin et al. 2021), and on others proposed as a universal tendency across languages (Wahlström 2015:170).

Beyond its typological interest, this relationship has direct implications for syntactic theory. Proposals concerning the structure of the nominal domain, such as those of Giusti (1995) and Giusti and Iovino (2016), are partly motivated by the association between case loss and the emergence of articles. Clarifying the nature of this relationship is therefore essential, since it bears directly on how case loss restructures the grammar of a language.

Claims of a relationship between case and articles have not gone unchallenged, however. Wood (2003:74), for instance, observes that apparent counterexamples occur in both directions. There are languages characterized by both rich inflection and articles (such as Classical Armenian), and languages that lack both (such as Chinese). She concludes that 'it cannot be assumed that when a language loses case morphology it has to develop articles' (see also Anward & Swedenmark 1997, Philippi 1997:64, Barðdal 2001:192–93, 2009:131). Börjars, Harries, and Vincent (2016:e30–e31) raise a different objection. They argue that case loss and article grammaticalization are independent processes that may cooccur but are not causally linked.

Part of the difficulty is that several distinct questions are often conflated in this debate. The first concerns the empirical form of the relationship: do articles arise specifically in the absence of case, or do they become more likely as case inventories are reduced? The second concerns its nature: under either interpretation, is the relationship deterministic or probabilistic? The third concerns causation: does case loss play a causal role in the emergence of articles, either directly or indirectly, or do both phenomena reflect a common underlying process? These questions require different types of evidence and should be evaluated separately.

The exceptions observed by Wood (2003:74) and Barðdal (2009:131) show that the relationship between case loss and articles is not deterministic. This is unsurprising, given the rarity of absolute universals (Evans & Levinson 2009:439). Wood and Barðdal invoke these counterexamples with a more ambitious aim, however—to deny a **causal** relationship between case loss and the emergence of articles. That conclusion does not follow directly from the evidence. Their examples undermine a deterministic account, but they do not rule out a probabilistic association, which may or may not reflect an underlying causal structure (Eells 1991).

At present, it remains unclear whether a statistical association between case inventories and articles exists in Indo-European. Three major limitations of previous studies have left this question unresolved. First, they have relied on samples that are too small or too unevenly distributed across clades to support general conclusions. Second, they have not accounted for phylogenetic and geographic

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nonindependence,[2] even though the distribution of case inventories (Kulikov 2012:291) and articles (Heine & Kuteva 2005:110, 120, Goldstein 2022) in Indo-European exhibits both. Third, they have rarely employed statistical methods appropriate to this problem. Addressing these limitations requires broader data coverage together with models that account for phylogenetic and spatial structure.

One common approach to nonindependence in typology is strategic sampling (e.g. Dryer 1989, 1992), but this is unsatisfactory for at least two reasons. First, it only mitigates the issue, since samples with closely related languages are still likely to exhibit nonindependence that violates the assumptions of standard statistical methods (Shcherbakova et al. 2024:3). Second, it requires excluding languages, the result of which is that already limited data become even more restricted (Cysouw 2011:416–17, Cathcart et al. 2018:4, Guzmán Naranjo & Becker 2021:617). This practice is particularly problematic with ancient languages, which offer crucial information about linguistic history but are only sparsely attested.

The relationship between case and articles is further complicated by the association between definite and indefinite articles. Building on earlier typological work, Goldstein 2022 argues that within Indo-European, indefinite articles emerged at a faster rate among languages that already had a definite article than among those without. This evolutionary trajectory underpins the implicational universal that languages with an indefinite article are likely to have a definite article but not vice versa (Moravcsik 1969:87, Heine 1997:69). When the role of case is taken into consideration, it remains unclear whether the association between definite and indefinite articles persists or whether their cooccurrence reflects their shared relationship with case.

This study addresses four questions. First, is there a probabilistic relationship between case-inventory size and the presence of definite articles in Indo-European? Second, does a comparable relationship hold for indefinite articles? Third, does the association between definite and indefinite articles persist once case inventory is taken into account? Fourth, does the available evidence support a causal interpretation of these relationships? To address these questions, I employ Bayesian logistic regression models that incorporate both phylogenetic comparative methods and a spatiotemporal Gaussian process (Rasmussen & Williams 2006). This framework enables the estimation of statistical associations while accounting for nonindependence among languages and provides explicit quantification of uncertainty in both parameter estimates and predictions.

The results provide statistical support for an inverse association between case-inventory size and the presence of articles. As case inventories are reduced, the probability that a language exhibits a definite article increases, with posterior median probabilities exceeding 0.5 at four cases. A similar pattern holds for indefinite articles, although the transition occurs at somewhat smaller case inventories. Median predicted probabilities approach and exceed 0.5 between three and four cases. These results suggest that articles are more likely in languages whose case systems have been reduced to core grammatical cases. They thus challenge the view that articles are expected only in languages that have lost case entirely. Under the revised picture, Ancient Greek, which retains four cases alongside a definite article, is not the anomaly it has sometimes been taken to be (pace Martin et al. 2021:256–57). Its case inventory falls squarely within the range at which article emergence is predicted.

The results further indicate that the presence of a definite article is associated with a higher probability of an indefinite article even after controlling for case inventory and phylogenetic and spatiotemporal nonindependence. This association is, however, more sensitive to model specification than the relationship between case-inventory size and the presence of articles, and should therefore be interpreted with greater caution. The question of causation remains unresolved. Although the observed associations are consistent with several causal scenarios, the present analysis is based on observational data and does not provide a basis for identifying the underlying causal structure.

The article is structured as follows. Section 2 provides an overview of the history of case and articles in Indo-European. Sections 3 and 4 introduce the data and methods used in this study, respectively. The

[2] Phylogenetic and geographic autocorrelation are instances of Galton's problem (Naroll 1965, Nunn 2011:18, 141, Roberts & Winters 2013, Bromham 2024, Jäger 2025), the distortion of cross-cultural or crosslinguistic statistical inference when observations are not independent due to shared ancestry or horizontal transmission.

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results are presented in Section 5 and discussed in Section 6. Section 7 brings the article to a close with summary remarks and an overview of future research.

2. Inflectional-case inventories and articles in Indo-European

2.1. Inflectional case

The earliest Indo-European languages are characterized by cumulative exponence and comparatively rich case inventories. Traditional reconstructions of Proto-Indo-European posit at least eight cases: nominative, genitive, dative, accusative, ablative, instrumental, locative, and vocative (Hewson & Bubeník 2006:334, Clackson 2007:90–92, Barðdal & Kulikov 2009:470, Fortson 2010:113–19, Kulikov 2012:290, Klein 2018:79). The status of a ninth case, the allative, remains contested (Kim 2013:128, Melchert 2017, Miller 2019:103). Kim (2013) argues that Proto-Indo-European nominal inflection was more fluid and typologically mixed than traditionally reconstructed, with a core set of fusional case endings alongside adverbial suffixes of varying productivity, many of which were later reanalyzed as case markers.

Across the family, the dominant diachronic tendency is toward case reduction (Hewson & Bubeník 2006:21; for case loss more generally, see Blake 2001:175–80), as illustrated in Figure 1. Two mechanisms are typically invoked to account for this development: sound change and syncretism. Sound change contributes to the erosion of case distinctions through the weakening of word-final syllables, which are the primary locus of case morphology (Paul 1919:§277). Syncretism, in turn, collapses formally distinct cases into a smaller set of exponents.

Case loss in Indo-European, however, is not reducible to the disappearance or neutralization of morphological markers (see e.g. Calabrese 1998:110 on Latin). It frequently involves the restructuring of the case system through the fusion of formal exponents and morphosyntactic functions. In such cases, the functional domain of a declining case is absorbed by a surviving one (Luraghi 1987, 2000, 2009:147, Kulikov 2012:291, Dragomirescu & Nicolae 2016:912, Klein 2018, Rappaport 2020). The Latin ablative

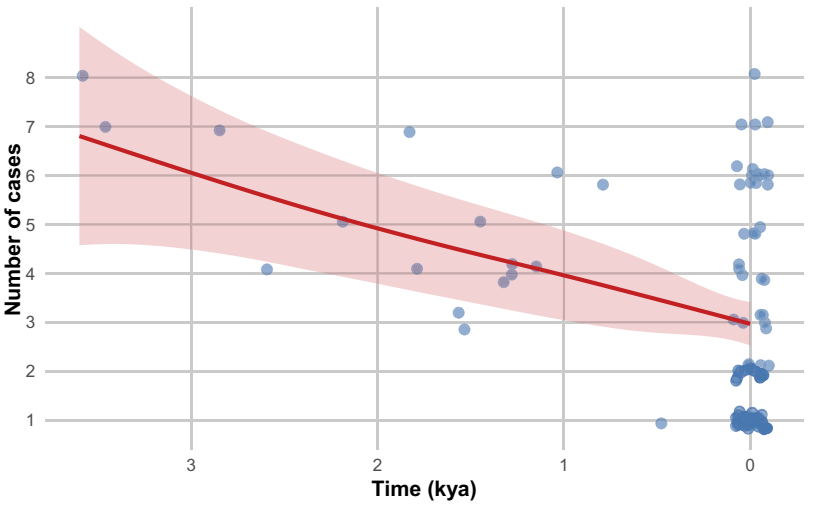

Figure 1. *Case inventories as a function of time, which is measured in millennia before the year 2000 (kya). Jitter has been added to the number of cases. Contemporary languages are assigned an age of 0, whereas the ages of premodern languages are estimated from their earliest textual attestation. Data from earlier languages are sparse but suggest higher case inventories. A generalized additive model (GAM) is used for the smoothed trend on account of the uneven chronological distribution of the data.*

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provides a canonical example. Its morphosyntax reflects the merger of earlier ablative, instrumental, and locative categories.

Although the dominant tendency in Indo-European is toward case reduction, new cases have nonetheless arisen in Baltic (Senn 1966:92–93, Petit 2007:338–60), Indic (Masica 1991:231; cf. Kulikov 2012:295–96), Ossetic (Cheung 2008, Stilo 2009:711–12, Belyaev 2010), and Russian (Kulikov 2012:293). Armenian and Balto-Slavic also exhibit a relative resistance to case loss compared to other clades (Kulikov 2009:452, 2012:293–94). Classical Armenian is particularly conservative in this respect, as it preserves a case system that largely reflects traditional Proto-Indo-European distinctions (Kortlandt 2003 [1984]).

2.2. Articles

The diachronic development of articles in Indo-European follows a trajectory that contrasts sharply with that of inflectional case (Figure 2). The earliest attested languages (such as Hittite, Vedic Sanskrit, and Mycenaean Greek) uniformly lack articles, and Proto-Indo-European is accordingly reconstructed without them. The absence of cognate articles across clades further suggests that articles grammaticalized only after the major Indo-European lineages had diverged (Goldstein 2022:671–72). Articles are therefore treated as innovations within individual clades (Hewson & Bubeník 2006:4, Goldstein 2022:670–73).

Whether articles within a clade reflect inheritance from an intermediate ancestor, contact-induced diffusion among related languages, or parallel independent grammaticalization is not always clear, and different mechanisms may be operative in different clades. The relative roles of inheritance and contact have been widely debated (Putzu & Ramat 2001, Heine & Kuteva 2006:97–139, Goldstein 2022:693–94). Borrowing of articles is thought to have occurred in at least some languages, notably Assamese, Bengali, and Oriya (Masica 1991:250), but more commonly contact leads to pattern borrowing rather than the transfer of article forms, in line with Matras 2020:236. The postposed definite article, as in the Bulgarian example in 2 above, is often considered an areal feature of the Balkan Sprachbund (Friedman & Joseph 2025:576–99, Sobolev 2025:39). Under such an account, it would represent a case of pattern borrowing, since the languages involved derive their postposed articles from different etymological

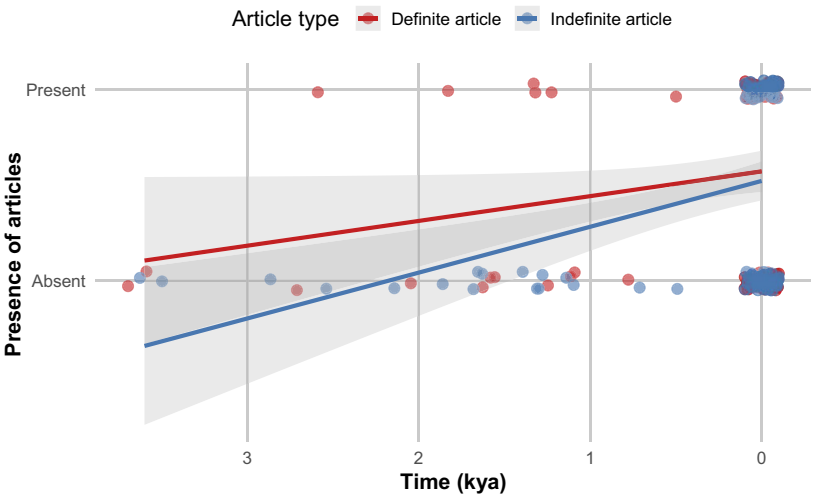

Figure 2. *Article inventories as a function of time, measured in millennia before the year 2000 (kya). Jitter has been applied to the article data to improve visibility. Contemporary languages are assigned an age of 0, while the dates of premodern languages are based on their earliest textual attestation.*

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sources. Some accounts attribute the development of articles in Romance and Germanic to contact as well (Dahl 2004:127), which would likewise represent pattern borrowing rather than the transfer of forms.

In languages that possess both definite and indefinite articles, establishing their relative chronology is not always straightforward. In Romance, for example, the available evidence does not decisively determine their order of development. Where the diachronic sequence can be identified, however, definite articles consistently precede indefinite ones, as in Greek and Armenian (see Goldstein 2022:673–76 for additional cases). More broadly, Goldstein 2022 argues that the emergence of a definite article increases the likelihood of subsequent indefinite article development. The overall tendency in Indo-European is therefore toward two-article systems (Lakoff 1972:174).

Altogether these observations suggest a broad generalization: reductions in case inventories tend to precede the emergence of articles. Establishing the precise onset of case loss is often difficult, but in several well-documented languages, such as Ancient Greek, English, and German, it is clear that case reduction was already underway prior to the grammaticalization of articles. In other cases, however, the relative chronology is difficult to determine. In the transition from Latin to Romance, for example, the dominant view holds that articles emerged after the loss of case marking (Hertzenberg 2015:18), but Renzi (1992) suggests that the broader OV-to-VO typological shift led to the grammaticalization of articles, which in turn facilitated the subsequent collapse of the case system.

3. Data

This study is based on a sample of ninety-four Indo-European languages, comprising sixteen premodern and seventy-eight contemporary varieties. The sample corresponds to that used in Chang et al. 2015a and Goldstein 2022.[3] The geographic distribution of the sampled languages is shown in Figure 3. According to Glottolog 5.1, Indo-European contains 586 languages (Hammarström et al. 2024), so the present sample represents approximately 16% of the family.

3.1. Measuring case inventories

An explicit definition of morphological case is required in order to operationalize case-inventory size. In the typological literature, case is commonly defined as a system marking the relationship between dependent nouns and their heads (Blake 2001:1), a definition that encompasses both synthetic affixes and analytic adpositions. This broader view reflects the fact that even in languages with extensive inflectional systems, adpositions often contribute to encoding grammatical relations (Blake 2001:8). The present study adopts a narrower definition: case is restricted to bound morphology. This restriction is motivated by the hypothesis under investigation, namely the relationship between articles and inflectional case. The criteria used to measure case inventories are summarized in Table 1 and discussed below.

3.1.1. Criteria 1 and 2

The first two criteria follow directly from the focus on the relationship between inflectional case and articles. Including analytic markers such as postpositions or clitics would distort the measurement. As a result, several phenomena commonly described as case markers are excluded. These include the secondary cases of Tocharian (Pinault 2008:462–74, 2011:383, Kim 2013:130–35, Adams 2015:73–78), most 'layer II' markers in Indic (e.g. Spencer 2005), and possessive clitics in English and other Germanic languages.

3.1.2. Criterion 3

In his typological survey, Iggesen (2013) operationalizes case-inventory size in terms of morphological contrasts. A zero-marked base form counts as a case only when it contrasts with an overtly marked form,

[3] Maithili is used as the representative of Bihari, and Adapazar is treated as Western Armenian.

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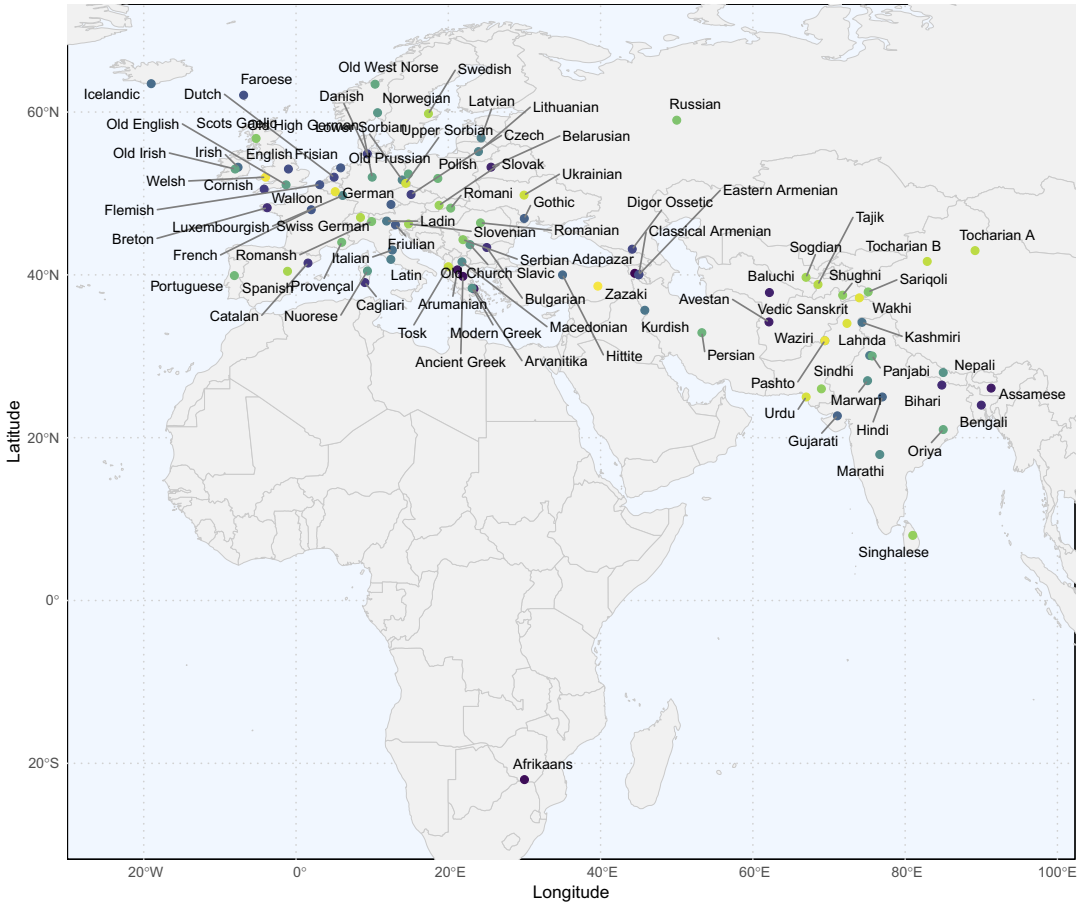

Figure 3. *Geographic distribution of sampled languages (*N = *94).*

Criterion	Description
1	Only synthetic case markers are considered; analytic case markers such as adpositions are not.
2	Only cases on nouns (as opposed to pronouns) or determiners are considered.
3	The counts for each language are based on the number of rows in the nominal paradigm (the noun paradigm in languages with affixal case marking on nouns and the determiner paradigm in languages where case is realized on determiners) and not the number of case markers.
4	Vestigial case markers are excluded.
5	Vocatives are excluded.

Table 1. *Criteria for measuring case inventories.*

and languages without any such contrasts receive a count of zero. Although this operationalization is explicit and internally coherent, it introduces a complication for statistical modeling. Since zero exponence counts as a case only when it participates in a contrast, one-case systems are impossible and inventories skip directly from zero to two. This gap is not an empirical property of case systems but a byproduct of the criterion. Languages without overt case marking could just as well be analyzed as having a single noncontrastive case.

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Singular	Plural
dog	dogs

Table 2. *English noun paradigm.*

By contrast, this study measures case inventories as the number of rows in a nominal paradigm, which sets the lower bound at one rather than zero. In English, for example, the noun paradigm consists of a single row (Table 2). This operationalization has three consequences. First, the locus of case marking is not taken into consideration. In languages such as German, Romanian (Gönczöl-Davies 2020:§2.4), and Shughni (Edelman & Dodykhudoeva 2009:794), where case is realized on determiners rather than nouns, the determiner paradigm supplies the row count, which ensures that inventories are measured uniformly across languages regardless of exponence. Second, variation in morphological realization is ignored (Kulikov 2009:451). In Latin, for instance, the number of distinct exponents for a given case varies according to number, gender, and declensional class, but the number of paradigm rows remains constant. Third, nonautonomous cases, which lack a dedicated exponent and are realized instead through paradigm-specific patterns of syncretism, are not distinguished from the cases whose forms they share and therefore do not contribute a separate row to the count (Zaliznjak 1973:69–74 = Zaliznjak 2002:629–36, Mel'čuk 1986:66–68, Blake 2001:22–24, Corbett 2010).

3.1.3. Criterion 4

Vestigial case refers to forms that preserve historical case morphology but no longer participate in the synchronic paradigm. In Old English, for example, certain adverbial forms descend from an earlier instrumental case but are not analyzed as such synchronically. Comparable cases include the Gothic instrumental (Miller 2019:§4.2), the Latin locative, and the instrumental and ablative in Sindhi (Khubchandani 2003:639).

3.1.4. Criterion 5

The vocative is excluded on functional grounds. Unlike other cases, it does not encode a relationship between a predicate and a dependent (Blake 2001:8, 156, Daniel & Spencer 2009). It is therefore unlikely that it has any relationship to definiteness marking, and its inclusion would introduce noise into the analysis.

3.2. Measurement uncertainty

For many languages in the sample, the size of the case inventory is uncontroversial. In others, however, legitimate analytic disagreements yield different counts (Blake 2001:10–12, Heine 2009:458), a situation analogous to variation in phoneme inventories (Anderson et al. 2023:150). Such disagreements are well known in Indo-Iranian (e.g. Zograf 1976:§68, Friedman 1991:86, Jahani & Korn 2009:651) and arise even in a language as well described as English (Payne 2009, Anderson 2013).

In ambiguous cases, I follow the diagnostics proposed by Blake (2001:11–12): phonologically conditioned allomorphy is taken as evidence for affixhood, and distribution across coordinated noun phrases serves as a secondary test. These criteria are informative but not always decisive, as they may conflict when a marker shows phonological integration yet behaves syntactically like a postposition (Blake 2001:11–12, Lowe 2016).

To assess the sensitivity of the results to such uncertainty, I conduct a measurement-error analysis (see Section S3 of the supplementary materials for details). The analysis models case counts as imprecise rather than exact and asks how much the results change as the assumed degree of imprecision increases. Disagreement of ±1–2 cases has negligible effects on the parameter estimates. The results change appreciably only when the uncertainty is far larger than any plausible analytic disagreement would

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warrant (see supplementary Figure S3). Only a small number of languages in the sample are subject to this degree of uncertainty: Digor Ossetic, Nepali, Romani, and the Tocharian languages. The counts assigned to three of these run counter to the inverse association argued for in this article. Nepali is assigned one case and lacks articles; Romani is assigned seven cases and has a definite article; and the Tocharian languages are assigned three cases and lack articles. Alternative analyses (larger inventories for Nepali and Tocharian or a smaller one for Romani) would strengthen rather than undermine the results reported in Section 5.

3.3. The distribution of case inventories

Figure 4 shows the frequency distribution of case inventories across the ninety-four languages in the sample (see supplementary Table S5 for individual counts). The distribution is strongly right-skewed. Most languages have inventories of one to three cases. Frequencies are generally lower at larger inventory sizes, although there is a notable concentration of six-case systems driven primarily by Baltic and Slavic. Most other clades cluster more tightly around lower median values with relatively limited internal variation, although Indic stands out for its broader spread (Figure 5). Figure 6 situates these inventories geographically. Smaller case inventories are concentrated in central and western Europe, particularly among Romance and Germanic languages, whereas larger inventories predominate in eastern Europe. The Indian subcontinent exhibits substantial heterogeneity.

3.4. Measuring article inventories

The identification of definite and indefinite articles is straightforward in many Indo-European languages. Romance and Germanic, for example, clearly exhibit both, while Anatolian and most Slavic languages are equally clear in lacking them. In other cases, however, article status is less straightforward. Two recurrent sources of ambiguity arise. One concerns the boundary between definite articles and demonstratives (Dryer 2013a); the other concerns the distinction between the numeral 'one' and an indefinite article (Dryer 2013b). Upper Sorbian illustrates the first type of ambiguity (Berger 2007:1), while Kashmiri illustrates the second (Wali & Koul 1997:101). To address these issues, this study adopts the criteria for articlehood proposed by Becker (2021).

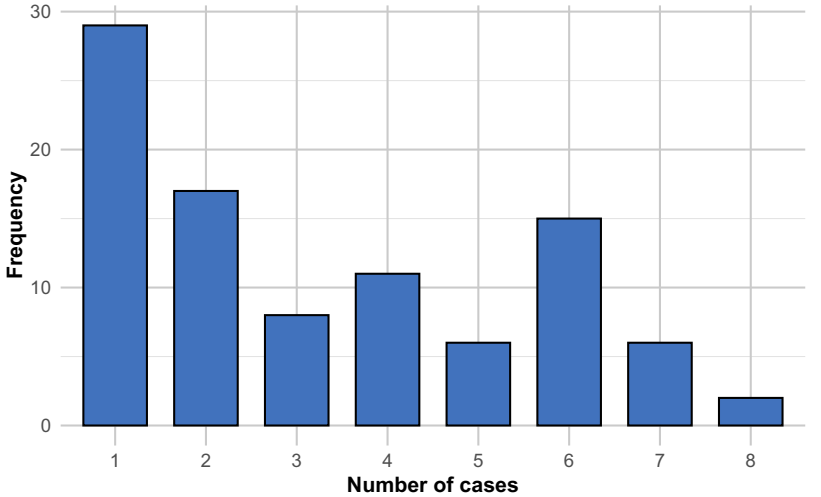

Figure 4. *The frequency distribution of case inventories. Most languages have fewer than four cases. The prominence of the six-case inventories is due primarily to Baltic and Slavic.*

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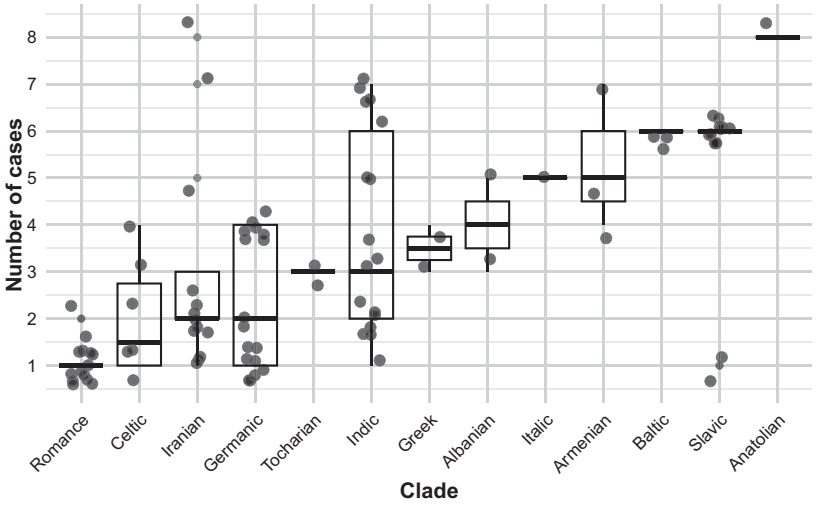

Figure 5. *The distribution of case inventories by clade. Most clades exhibit little variation around the median (jitter has been added to enhance the visibility of individual data points), but Indic stands out for its spread.*

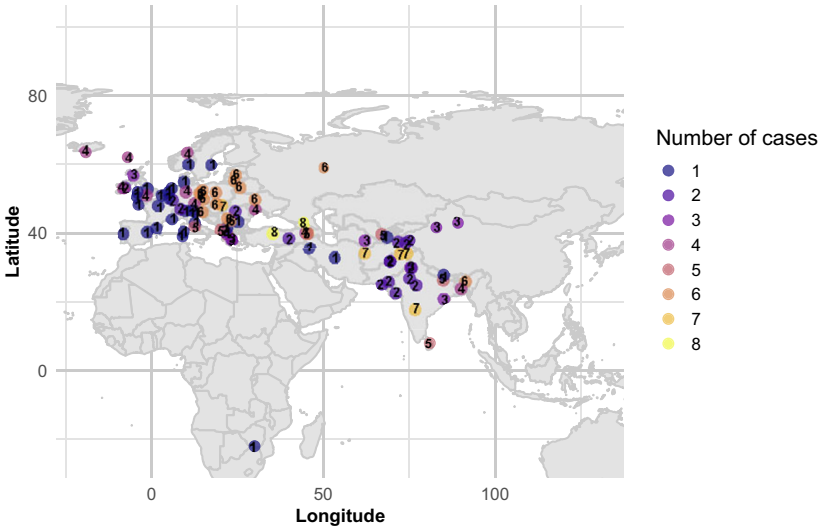

Figure 6. *The geographic distribution of case inventories. Smaller case inventories preponderate in central and western Europe, whereas the languages of eastern Europe generally have more than five cases. The Indian subcontinent is characterized by a diverse range of case inventories.*

3.4.1. Criteria

Becker (2021:37) defines articles in terms of three properties. First, they function as referential markers. Second, they cooccur with lexical referential expressions, typically nouns. Third, they occur systematically (allowing for limited exceptions) in contexts consistent with their referential function. Building on earlier work (Himmelmann 1997:41, Wendtland 2011:24, Becker 2018:70, 2021:139), I further argue that the consistent use of definite articles with semantically definite referents, in addition to pragmatically definite ones, distinguishes them from demonstratives (Goldstein 2022:665).

Pragmatically definite referents are identifiable only through contextual information.

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(3) Pragmatic definite
Caesar used both cavalry and infantrymen to subdue the Gauls. **The infantrymen** were particularly fierce.

The phrase *the infantrymen* refers anaphorically to the infantrymen in the first sentence. By contrast, semantically definite referents are identifiable independently of context (Goldstein 2022:664).

(4) Semantic definite
The sun is a star at the center of our solar system.

Since there is only one salient referent of this type, contextual information is unnecessary.

Descriptive grammars do not always document the full range of semantically definite contexts in which a determiner is used. Given this limitation, I classified a determiner as a definite article if it is used systematically in at least one pragmatically definite and one semantically definite context (Goldstein 2022:665–66). This criterion excludes disputed cases, which typically arise from nonobligatory or inconsistent usage. In Old English, for example, disagreement often centers on whether article-like uses of a determiner that are not obligatory suffice for classification as an article. On this basis, I distinguished between a narrow data set, which excludes such cases, and a broader data set, in which they are included despite failing the systematicity criterion. I adopt the narrow data set in the present study (see supplementary Table S6).

Indefinite articles are commonly analyzed as having two readings, specific and nonspecific.

(5) Specific indefinite
I saw **an eland** on my way to work this morning.
(6) Nonspecific indefinite
Do you have **a job** for me today?

In 5, the referent is specific, whereas in 6 it need not be. I classified determiners as indefinite articles if they are used consistently with either type of indefinite reference (Goldstein 2022:666).

3.4.2. The distribution of article inventories

Figure 7 shows the frequency distribution of article inventories across the ninety-four languages in the sample. Most languages either lack articles altogether or possess both a definite and an indefinite article (Lakoff 1972:174). Figure 8 situates these inventories in their geographic and phylogenetic contexts and reveals several general patterns. Languages without articles are the most geographically dispersed, which is consistent with their status as the ancestral state of the family. Languages with only a single article are comparatively rare and show no clear geographic clustering. Those with only a definite article are scattered across multiple regions and clades, particularly in Europe and the Balkans, whereas languages with only an indefinite article form a tightly clustered group within Iranian (Goldstein 2022:690–92). By contrast, languages with both articles are concentrated in central and western Europe, which reflects their presence throughout Germanic and Romance. Although languages can lose articles, there is no evidence for loss among the languages in my sample (Goldstein 2022:673).

3.4.3. The distribution of article and case inventories

Figure 9 shows the distribution of case-inventory sizes across the four article-system types. A clear contrast emerges between languages with and without articles. Languages lacking articles have substantially larger case inventories, with a median of six, whereas languages with both definite and indefinite articles have much smaller inventories, with a median of one. Languages with only a single article fall between these extremes but are comparatively few in number. The overall distribution anticipates the inverse association between case-inventory size and the presence of articles demonstrated in Section 5 below.

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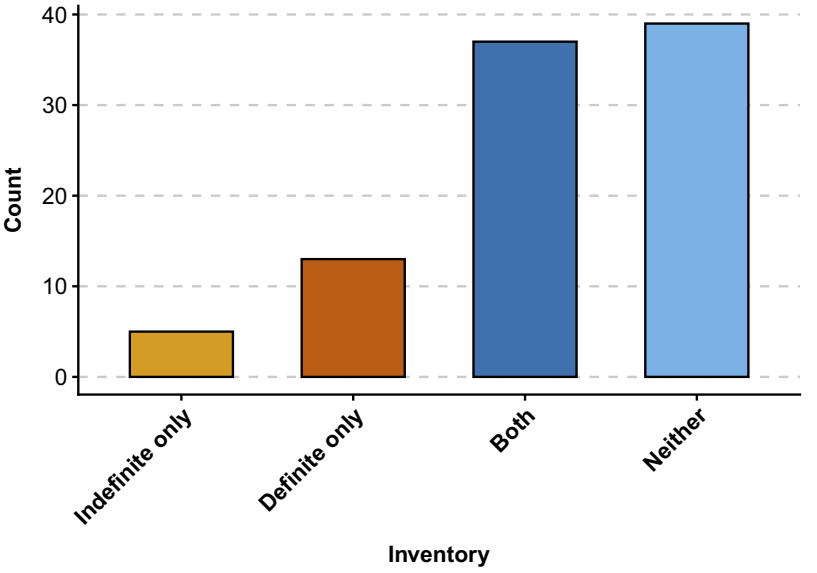

Figure 7. *The frequency distribution of definite and indefinite article inventories in Indo-European. Most languages either lack articles altogether or possess both a definite and an indefinite article. Languages with only a single article are comparatively rare, particularly those with only an indefinite article.*

3.5. Spatiotemporal and phylogenetic data

Three types of data are used to capture nonindependence among languages: geographic coordinates, language dates, and phylogenetic trees. Geographic distances are computed as pairwise great-circle (Haversine) distances from latitude and longitude coordinates obtained primarily from Glottolog 5.1 (Hammarström et al. 2024), supplemented where necessary with data from the *World atlas of language structures* (*WALS*; Dryer & Haspelmath 2013b), Grambank (Skirgård et al. 2023), and IE-CoR (Anderson et al. 2025), and rescaled to units of 1,000 km.

For temporal data, contemporary languages are assigned a date of 0, while premodern languages are associated with intervals based on their approximate dates of textual attestation (measured in centuries relative to the present). Temporal distance between languages is defined as the absolute difference in their dates. For premodern languages, dates are treated as latent variables with uniform priors over these intervals, and temporal distances are computed on the latent values. Since contemporary languages all have date 0, the temporal component does not differentiate among them and contributes only to relationships involving premodern languages. These spatial and temporal distances are incorporated into a separable spatiotemporal Gaussian process using Matérn-3/2 covariance kernels in space and time, as described in Section 4 below and Section S1.4 of the supplementary materials.

Phylogenetic structure is incorporated using a sample of fifty posterior trees inferred under the A3 model of Chang et al. 2015a,[4] rather than a single tree, so that phylogenetic uncertainty is propagated into the parameter estimates. The A3 configuration is selected because its estimate of the Indo-European root age aligns with current specialist consensus (Anthony & Ringe 2015). The maximum clade credibility tree from this analysis is shown in Figure 10 with the observed article inventories mapped onto the tips.

[4] This corresponds to configuration file a1-c2-d0-g2-l2-s1-t1-z3. The associated BEAST .xml file is available in Chang et al. 2015b. Running the analysis requires the customized version of BEAST available at https://github.com/whdc/ieo-beast. See Chang et al. 2015b for full implementation details.

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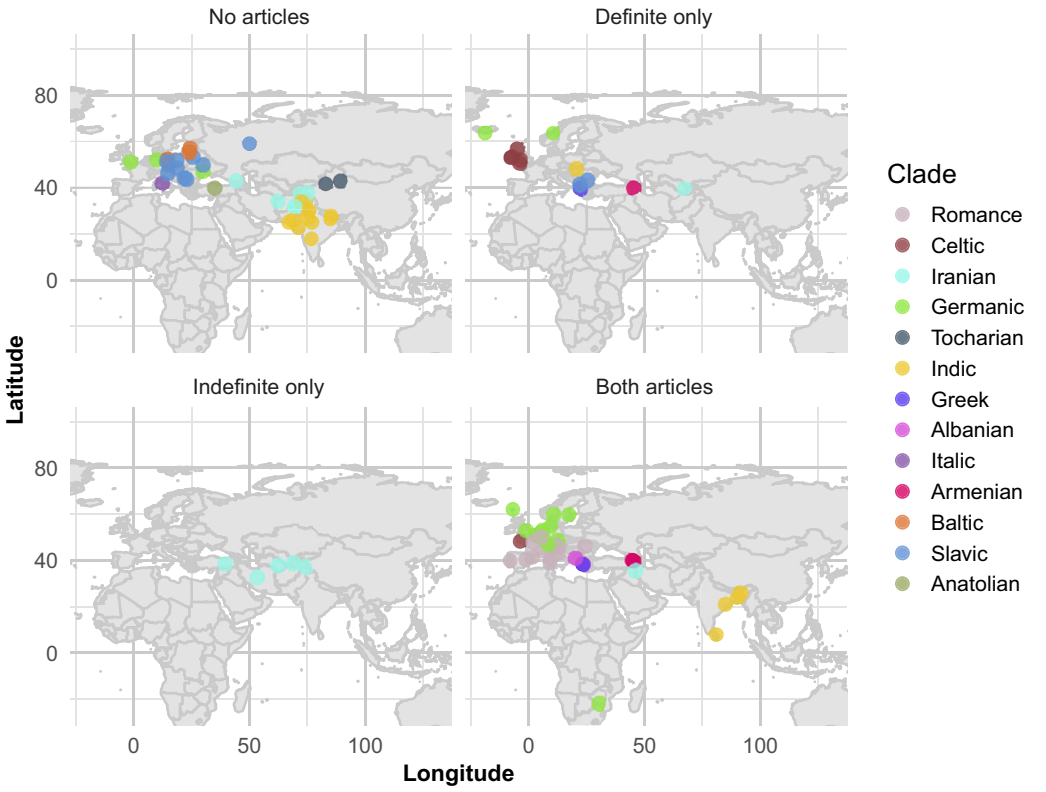

Figure 8. *The geographic and phylogenetic distribution of article inventories. Languages without articles are the most widely dispersed. Languages with both articles are concentrated in central and western Europe. Systems with only a definite article are scattered across several regions, whereas those with only an indefinite article are restricted to a small number of Iranian languages.*

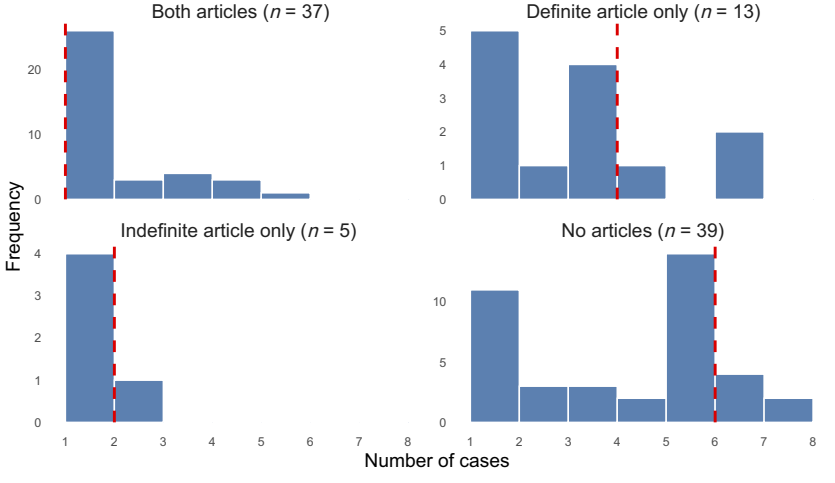

Figure 9. *Distribution of case-inventory sizes by article system. Each panel shows the frequency of languages with a given number of cases within an article-inventory type. The dashed red line indicates the median.*

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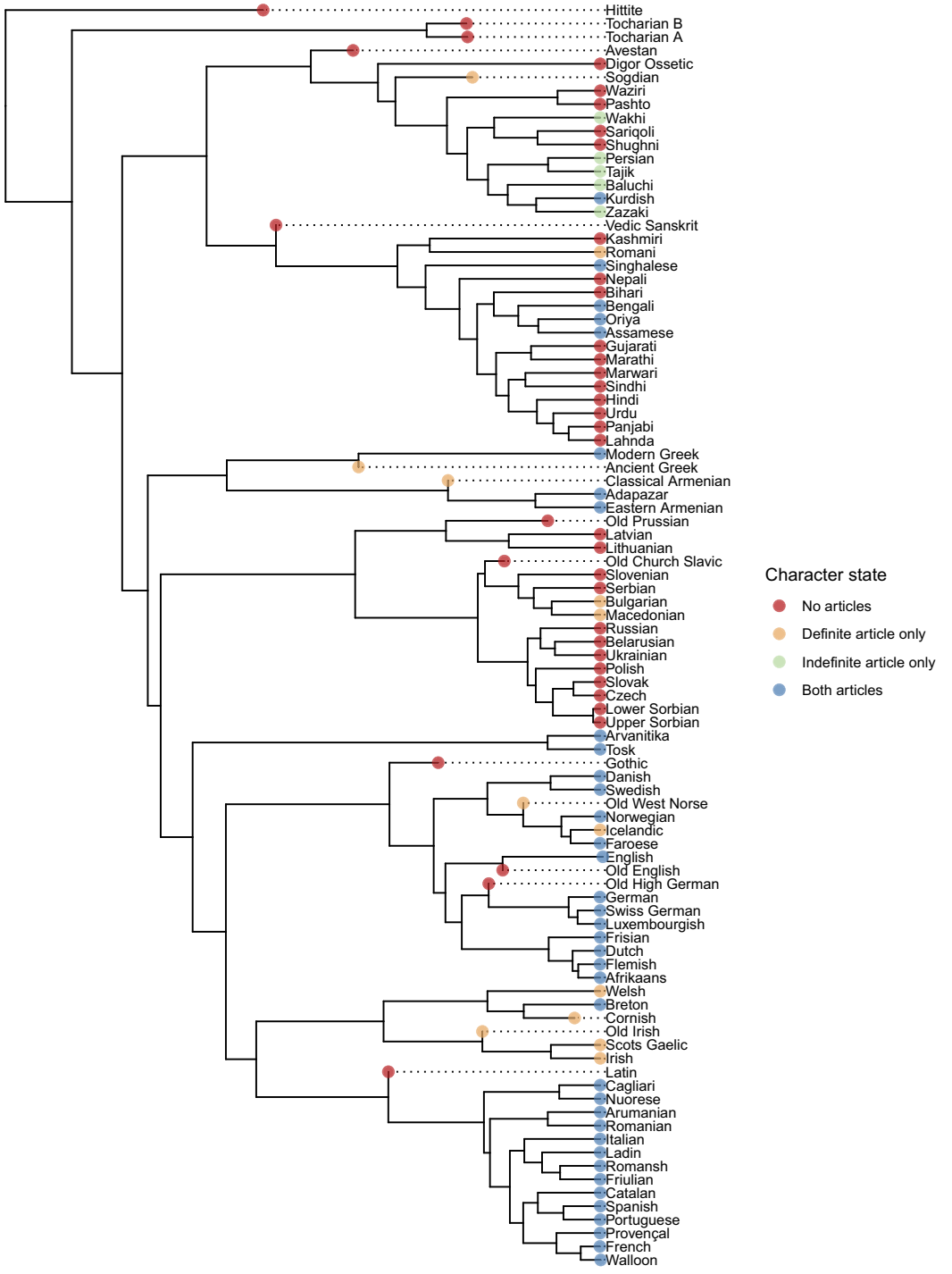

Figure 10. *Maximum clade credibility tree of the A3 data set and model of Chang et al. 2015a with observed article inventories.*

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Variable	Description	Type	Status
Definite article	The presence or absence of a definite article in a language	Dichotomous	Outcome and predictor
Indefinite article	The presence or absence of an indefinite article in a language	Dichotomous	Outcome
Case inventory	Number of inflectional noun cases in a language	Ordinal	Predictor

Table 3. *Summary of variables.*

Name	Description
Intercept Definite article ($\beta_{0,\text{def}}$)	Baseline probability of a definite article being present when predictors are at their reference values
Case → Definite article (θ_{def})	Effect of case inventory on the presence of a definite article
Intercept Indefinite article ($\beta_{0,\text{indef}}$)	Baseline probability of an indefinite article being present when predictors are at their reference values
Case → Indefinite article (θ_{indef})	Effect of case inventory on the presence of an indefinite article
Definite → Indefinite article ($\beta_{\text{def}\rightarrow\text{indef}}$)	Effect of having a definite article on the presence of an indefinite article

Table 4. *Main parameters of the logistic regression models.*

4. Methods

This study models the relationship between case-inventory size and article systems using Bayesian logistic regression. Each language contributes two binary outcomes: the presence of a definite article and the presence of an indefinite article. These outcomes are modeled jointly using two interrelated logistic submodels that share an ordinal predictor for case-inventory size. Table 3 summarizes the variables and their roles.

To account for phylogenetic and spatial nonindependence among languages, two hierarchical random-effect components are used: a phylogenetic term and a separable spatiotemporal Gaussian process. Four model specifications are then compared. They correspond to the four possible combinations of these two components: a baseline model without hierarchical structure, a model with a phylogenetic term only, a model with a spatiotemporal Gaussian process only, and a model including both components. See Table 4 for the main parameters of the models. The combined model provides the best predictive fit among these specifications. The parameter estimates reported below are therefore based on this model, which assumes that shared ancestry and geographic proximity affect the two article outcomes in the same way. Alternative specifications that relax this assumption performed worse under leave-one-out cross-validation, which suggests that the latent phylogenetic and spatiotemporal factors that predict definite articles operate similarly for indefinite articles.

In addition to the four primary specifications, a complete-mediation model is also considered, in which case inventory affects indefinite articles only indirectly via definite articles. This model yields slightly worse predictive performance than the primary specification. Additional details are given in Section S1 of the supplementary materials, and the results of all model comparisons are reported in Section S2.5.

4.1. Limitations

The modeling approach adopted here has several limitations, which fall into four broad categories: data representation, historical processes, model assumptions, and directionality of effects.

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At the level of data representation, case inventories are represented solely by their size. As a result, changes in case systems that do not affect the number of cases are not captured (Kulikov 2009:451). Articles are likewise represented as binary presence–absence indicators, which means that languages whose articles derive from different etymological sources receive identical codings. Within Romance, for example, definite articles derive from both the demonstrative *ille* 'that' and the intensifier *ipse* 'self', which implies at least two grammaticalization events that are indistinguishable under the current coding (see further Goldstein 2022:671–73).

The analysis is synchronic rather than dynamic. It does not model the transition processes by which case systems and article inventories evolve over time (Greenberg 1969, Guzmán Naranjo & Becker 2021:658–60). Languages are represented spatially as point locations, even though they are spoken over geographic areas (Guzmán Naranjo & Becker 2021:660–61). Although polygon-based representations are increasingly available (Ranacher et al. 2025), they are not yet available for many ancient languages, which provide crucial information for the early history of Indo-European. Language contact is also not modeled directly. Instead, geographic distance serves as a proxy, which may only partially capture contact dynamics (Guzmán Naranjo & Becker 2021:661, Becker & Guzmán Naranjo 2025:599–600).

The statistical model also relies on several simplifying assumptions. The Gaussian process kernel used to model spatiotemporal nonindependence is stationary and isotropic. Covariance depends only on pairwise spatial and temporal distances rather than on absolute location or time, and correlation decays uniformly with distance. The kernel is also separable. As a result, the model cannot capture spatiotemporal diffusion processes in which spatial dependence varies over time or temporal dependence varies across space. The phylogenetic component assumes that trait similarity between related languages reflects inheritance from a common ancestor. This assumption does not hold in languages where articles arise within a clade, such as Romance and Germanic, rather than being inherited from a common ancestor. The prior on the total residual scale parameter partially mitigates this limitation by restricting the degree to which the phylogenetic component absorbs between-clade variation (see supplementary Section S1.3).

Finally, the model does not allow for bidirectional effects between case inventories and articles. Although some authors have argued that articles influence the development of case systems (Tiraspol'skij 1980:73–74, Hewson & Bubeník 2006:364), I am not aware of any empirical evidence for such an effect within Indo-European.

Despite these limitations, the present study provides a more detailed and methodologically rigorous account of the relationship between case inventories and articles than previous work.

5. Results

Figure 11 shows the posterior distributions of the regression coefficients with the 50% and 89% highest posterior density intervals (HPDIs). None of these intervals includes zero, which corresponds to a null relationship.[5] The results indicate a robust negative association between nominal case-inventory size and the presence of both definite and indefinite articles, alongside a positive association between definite and indefinite articles. An additional analysis reported in Section S2.2 of the supplementary materials separates the case-article association into within-clade and between-clade components. The between-clade component is stronger. Clades that have undergone extensive case loss, such as Germanic and Romance, are also those where articles have emerged. The weaker within-clade

[5] I follow McElreath (2020:89) in presenting 89% HPDIs, which are less prone to misinterpretation as significance tests than conventional 95% intervals. For completeness, corresponding 95% quantile-based credible intervals are reported in Section S2.1 of the supplementary materials. For θ_{def}, the 89% HPDI excludes zero, while the 95% interval marginally includes it (upper bound = 0.02). The posterior probability $P(\theta_{def} < 0)$ is 0.97, which indicates strong evidence for a negative association.

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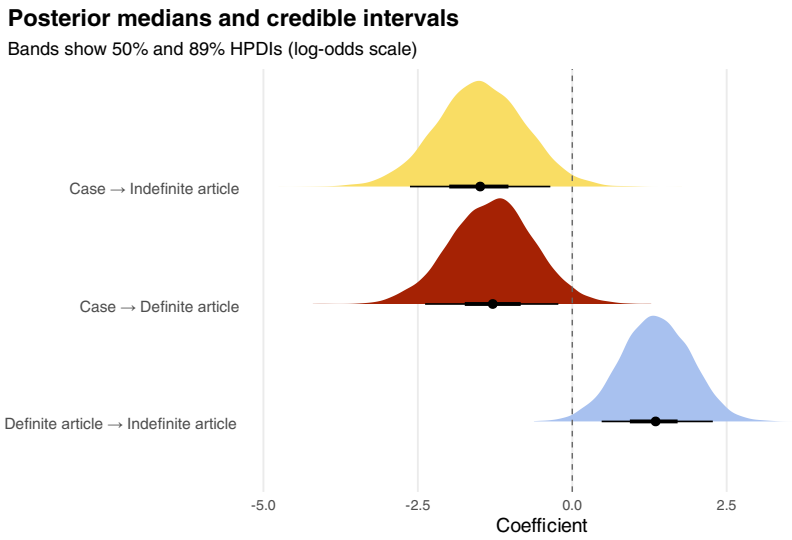

Figure 11. *Posterior distributions of the regression coefficients. Points denote posterior medians, and horizontal bars show 50% and 89% highest posterior density intervals (HPDIs) on the log-odds scale. The dashed vertical line indicates zero (no effect). All 89% HPDIs exclude zero.*

component reflects the fact that by the time articles emerge within a clade, substantial case loss has already occurred, which leaves limited residual covariation between the two features at the synchronic within-clade level. The association between definite and indefinite articles is robust at both levels of analysis.

Figures 12 and 13 present posterior predictions for the probability of definite and indefinite articles across the observed range of case inventories. For the indefinite outcome, predictions are computed conditional on the presence of a definite article, which reflects the diachronic sequence in which definite articles typically precede indefinite ones (see supplementary Section S2.3 for details). Since the model constrains the case effect to be monotone, the predicted probabilities increase steadily as case inventories decrease. The data determine the direction and magnitude of the effect across case levels. For definite articles, the posterior median predicted probability exceeds 0.5 at four cases. For indefinite articles, the posterior median crosses this threshold at approximately three to four cases. Rather than marking an abrupt threshold, these transition points reflect the gradual increase in the probability of articles as inflectional case marking is reduced. The results are consistent with earlier claims that article systems tend to emerge in languages with reduced case inventories (Hewson & Bubeník 2006:15, 364), but show that the transition occurs at different points for definite and indefinite articles.

6. Discussion

The results support the claim that languages with smaller case inventories are on average more likely to exhibit both definite and indefinite articles. This inverse association challenges accounts that restrict the emergence of articles to languages that have lost case marking entirely. On this view, languages such as Ancient Greek, with a four-case inventory and a definite article, are neither exceptional nor in need of special explanation (pace Martin et al. 2021:240–41, 256–58).

The remainder of this section situates these results within a broader typological and diachronic context. Section 6.1 reinterprets the relationship between case inventories and articles in terms of Blake's

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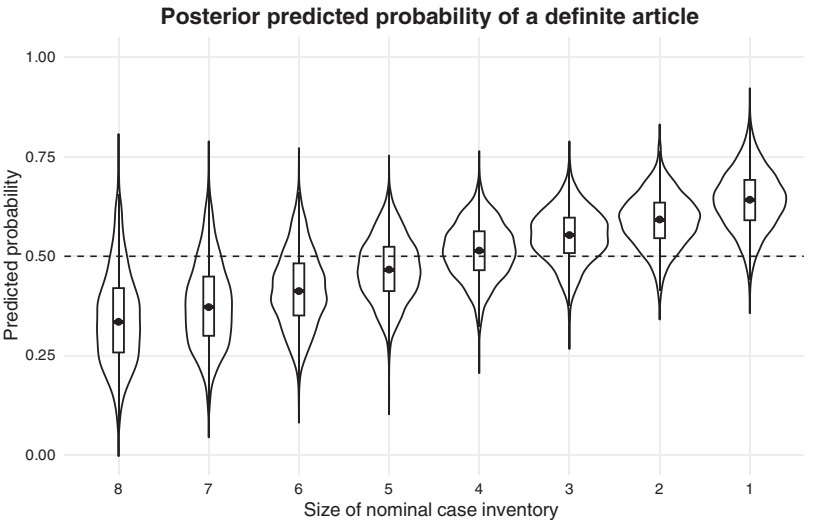

Figure 12. *Posterior predicted probability of a definite article as a function of nominal case-inventory size under the main model. Each violin summarizes the posterior distribution of predicted probabilities for a given inventory size, evaluated using phylogenetic and spatiotemporal latent effects averaged across the languages in the sample. Superimposed boxplots and points indicate the interquartile range and median. Predicted probabilities increase as case inventories decrease, reflecting the monotonic specification of the case effect, with the median exceeding 0.5 at four cases.*

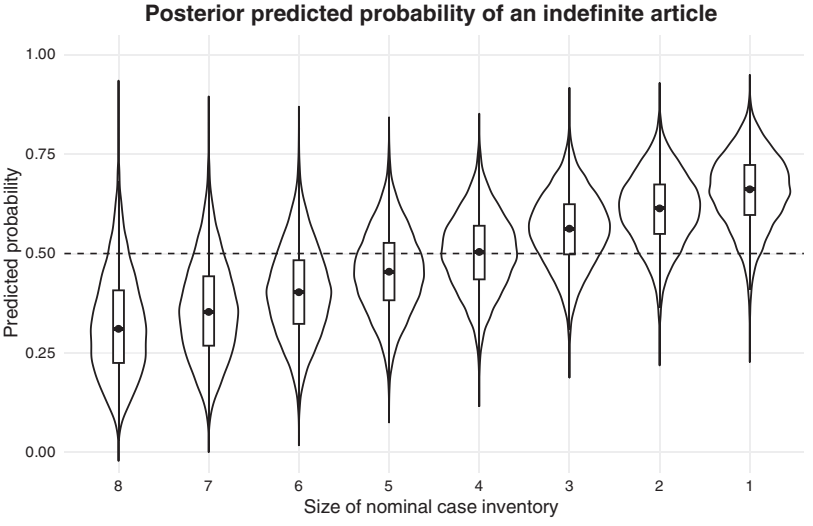

Figure 13. *Posterior predicted probability of an indefinite article as a function of nominal case-inventory size, conditional on the presence of a definite article. Each violin summarizes the posterior distribution of predicted probabilities for a given inventory size, evaluated using phylogenetic and spatiotemporal latent effects averaged across the languages in the sample. Boxplots and points indicate the interquartile range and median. Predicted probabilities increase as inventories decrease, reflecting the monotonic specification of the case effect, with the median exceeding 0.5 at approximately three to four cases. Languages lacking a definite article fall outside the scope of these predictions. Since the model estimates a positive association between definite and indefinite articles, predicted probabilities for languages without a definite article are lower than those shown here. Marginal predictions that average over definite-article status are shown in Figure S1 of the supplementary materials.*

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implicational case hierarchy. Section 6.2 examines apparent exceptions to this inverse association. Section 6.3 then considers whether the observed association between case-inventory size and the presence of articles admits a causal interpretation.

6.1. Reduced case inventories and the case hierarchy

6.1.1. Comparing case inventories across languages

The analysis has focused on the size of case inventories rather than on their composition, that is, the specific cases present in each language. This choice reflects the difficulty of comparing individual cases crosslinguistically (Blake 2001:155, 157). Labels such as *dative* or *ablative* are not semantically consistent from one language to another. Even closely related languages may differ substantially in how a given case is used. For example, although both Ancient Greek and Sanskrit have a dative case, the Greek dative continues a syncretism of earlier dative, locative, and instrumental cases and thus differs markedly from its Sanskrit counterpart in its semantic range (Kühner & Gerth 1898:404–5, Green 1913:18–19, 21–23, Petersen 1918a,b, Luraghi 1987:362, 365, Calabrese 2008:165, Goldstein 2021:10–11). Conversely, the Latin ablative and the Old and Middle High German instrumental are functionally similar but are conventionally assigned different labels. Despite these discrepancies, it is possible to formulate crosslinguistic generalizations about reduced case systems by drawing on Blake's implicational case hierarchy and the distinction between grammatical and semantic cases.

6.1.2. Blake's implicational case hierarchy

The distribution of cases across languages has been argued to follow an implicational hierarchy (Blake 2001:89, 160, Hewson & Bubeník 2006:52).

(7) Implicational hierarchy among cases: Nominative >> Accusative, Ergative >> Genitive >> Dative >> Locative >> Ablative/Instrumental >> Others

Smaller case inventories contain only the higher-ranked cases in the hierarchy. A two-case system includes nominative and accusative (or nominative and ergative), while a three-case system adds genitive, and so on. Although the interpretation of individual cases (e.g. accusative) varies across languages (Arkadiev 2009), there is considerable uniformity in the structure of reduced case systems. Inventories that contrast nominative and instrumental while lacking accusative or ergative, for instance, are not expected.

The hierarchy also predicts a characteristic trajectory of case loss, whereby peripheral cases (such as ablative and instrumental) are typically lost before core cases (such as nominative and accusative). This trajectory is well attested in Indo-European (Rosén 1999:137, Blake 2001:155, Luraghi 2004, Hewson & Bubeník 2006:52, Malchukov & Spencer 2009a:655, Sobolev 2009, Kulikov 2012:291). The long-term effect is convergence toward a shared core inventory (Calabrese 1998:85–86). Languages such as Ancient Greek, Gothic, Old English, Old Irish, and Old Norse exemplify this convergence, as each retains nominative, accusative, genitive, and dative—cases typically classified as grammatical rather than semantic.

6.1.3. Grammatical and semantic cases: a reinterpretation of the results

Grammatical cases encode abstract syntactic relations (e.g. subject, object), whereas semantic cases typically express spatial, instrumental, and related meanings (Blake 2001:31–33, 201), though many cases serve both functions. Following Blake 2001:31 and Hewson & Bubeník 2006:16–17, nominative, accusative/ergative, genitive, and dative are treated here as grammatical cases, with nominative, accusative, and ergative constituting the core and genitive and dative the noncore subset. Viewed in these terms, the results of Section 5 can be reformulated more precisely. In Indo-European, definite articles tend to emerge once case systems have been reduced primarily to grammatical cases, and often to their core subset. Languages that retain larger inventories of semantic or peripheral cases, by contrast, tend not to exhibit definite articles.

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6.2. Exceptions to the inverse association

The inverse association admits two types of exception: languages with small case inventories but no articles, and languages with relatively large case inventories that nonetheless exhibit a definite article. The first group includes languages such as Hindi (two cases), Nepali (one), and the Tocharian languages (three), all of which are predicted to have a relatively high probability of exhibiting a definite article. Their exceptional status admits at least two explanations, one functional and one methodological.

The functional explanation concerns the role of differential object marking (DOM). Both Hindi and Nepali encode distinctions of specificity and definiteness in the object domain through DOM, which potentially reduces the functional pressure for article development. In such cases, DOM may fulfill communicative functions typically associated with articles (Montaut 2018:307, fn. 10, Goldstein 2022:690–91).[6] More generally, the relationship between case inventories and articles may be partially obscured in a model that considers only one type of definiteness marking.

The methodological explanation is that the case inventories of these languages may be underestimated. As noted in Section 3.2, the boundary between inflectional and adpositional marking can be difficult to draw. If one were to include the secondary cases of Tocharian (as in Carling 2019:52, 64) and the postpositional markers of Nepali (Masica 1991:238–39), these languages would exhibit larger inventories. Their lack of articles would then be expected under the model.

The second group of exceptions comprises languages with relatively large case inventories that nonetheless exhibit a definite article, such as Classical Armenian and Romani, both with seven cases. One possible explanation is language contact, which has been proposed for Romani (Matras 2002:19), though it is less clearly applicable to Classical Armenian. A second possible explanation is the U-shaped development of the Romani case system. Like other Indic languages, Romani underwent substantial case reduction before developing so-called layer II cases from postpositions. If the definite article grammaticalized during this earlier stage, when the case system was still reduced, its presence would be consistent with the inverse association identified here. An important question for future research is whether Romani articles indeed emerged prior to the reexpansion of the case system.

6.3. The question of causation

The analysis presented above establishes a robust association between case-inventory size and the presence of definite and indefinite articles, but does not alone demonstrate that case loss[7] **causes** the grammaticalization of articles. Causal inference in historical linguistics remains challenging (e.g. Luraghi 2010, Aitchison 2013:142, Winter-Froemel 2013, Levshina 2021:5), both because of conceptual difficulties (Illari & Russo 2014) and because the available data are sparse and observational. Although formal methods for causal inference, ranging from general frameworks (e.g. Pearl 2009, Pearl et al. 2016) to recent developments in phylogenetic comparative modeling (e.g. Ringen et al. 2021, Sheehan et al. 2023, Ringen et al. 2026), are becoming increasingly sophisticated, their application to linguistic change is still relatively recent (Moscoso del Prado Martín 2014, Levshina 2021, Rosemeyer & Van de Velde 2021, Shcherbakova et al. 2024, Nijs et al. 2025). Given these constraints, I do not attempt to resolve the causal question. Instead, I outline three scenarios consistent with the observed association: direct causation, mediated causation, and a common-cause scenario in which case loss and article emergence are not causally related to each other.

[6] An anonymous referee suggests that the absence of articles in languages such as Nepali and Hindi may reflect areal factors. This view is consistent with the present discussion, which seeks to identify the underlying linguistic mechanisms that give rise to such patterns.

[7] Understood here as encompassing both reduction and complete loss of case marking.

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Figure 14. *Schematic representation of a direct-causation scenario in which case loss increases the likelihood of article emergence, with definite articles preceding indefinite articles.*

6.3.1. Direct causation

Figure 14 represents a simplified causal scenario in which case loss directly promotes the emergence of articles. The diagram is intentionally schematic. It abstracts away from the magnitude and locus of case loss and from the precise sequencing of definite and indefinite article development.

Two general considerations bear on a direct-causation account. First, it is necessary to distinguish between conditions and causes. A reduction in case inventory may constitute a precondition for article emergence (for example, if articles arise only once inflectional marking has been reduced largely to core grammatical cases) without itself being the factor that triggers the change. The proximate cause may instead lie outside the grammatical system itself, in cognitive, sociolinguistic, or usage-based factors, rather than in case loss per se (Labov 1994:5, Sinnemäki 2020:3). Second, article emergence need not follow a single causal pathway. Similar outcomes may arise from different underlying processes across languages.

Nevertheless, several lines of evidence are compatible with a direct causal connection between case and definiteness. Diachronically, König (2011:514) documents a trajectory in which a definiteness marker develops into a nominative and eventually an ergative case marker, which suggests a close relationship between definiteness marking and case morphology. Synchronically, many languages use case to encode definiteness or specificity. Accusative case may mark specific or definite objects (Enç 1991, Paul 1998:21–26, Todd 2008:40), while genitive or partitive case can signal indefiniteness (Giusti 1995:90, Philippi 1997, Kiparsky 1998). In Old Church Slavic, for example, genitive-accusative objects tend to be definite, whereas nominative-accusative objects are typically indefinite (Huntley 1993:137–38). Such patterns suggest that changes in case marking may directly affect how definiteness is encoded and thereby facilitate the emergence of articles.

Some theoretical accounts posit an even tighter connection. Giusti (1995:77, 86, 89) argues that inflectional case and articles are realizations of a single nominal functional head (F). In languages with overt case, F is realized as case morphology. In languages with articles, it surfaces as a determiner. Diachronically, articles emerge as case morphology weakens. She motivates this proposal with detailed syntactic diagnostics and diachronic evidence from Germanic. Giusti and Iovino (2016:221, 243) extend this line of analysis to Latin, arguing that it already projects a split DP layer despite lacking articles. On their account, this structure explains why the Romance languages independently grammaticalized articles as nominal case morphology became less robust. The independence of these developments across the Romance languages is assumed rather than demonstrated, however. While these accounts offer a coherent explanation for article emergence, they do not yield precise predictions about how much case reduction is required, in terms of the number or the type of cases lost. Moreover, the extent to which this mechanism generalizes beyond Romance and Germanic remains an open empirical question.

6.3.2. Mediated causation

A second scenario, illustrated in Figure 15, treats the causal relationship between case loss and article emergence as mediated by the expansion of adpositions. This expansion may involve increases in type frequency, token frequency, semantic range, or some combination thereof (Braune 2004 [1886]:§192a, Hewson & Bubeník 2006:viii, ix, 15, 48, Stilo 2009:712, König 2011:514–15, Ledgeway 2011:720). Among the archaic Indo-European languages, for example, the bare instrumental case often encodes the agent of a passive predicate (Jamison 1979, Hettrich 1990, Melchert 2016). Following the loss of this case, passive agents are typically expressed by adpositional phrases (Goldstein 2019).

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Figure 15. *Schematic representation of a mediated-causation scenario in which case loss results in the expansion of adpositional marking, which in turn facilitates the emergence of articles.*

More generally, article emergence can be viewed as part of the broader rise of configurational syntax accompanying the reduction of nominal case morphology. This perspective is developed by Hewson and Bubenik (2006), who argue that the emergence of the adpositional phrase constitutes the earliest major configurational innovation of this transition and serves as a structural model for the later development of other fixed phrasal configurations, including article-noun configurations.

Alongside the expansion of adpositional marking, case reduction may also increase the grammatical role of constituent order. In several Indo-European languages, flexible word-order systems have been argued to mark definiteness distinctions (Krámsky 1972:42–43, Hewson & Bubeník 2006:364). If case loss increases reliance on constituent order for the expression of grammatical relations, articles may emerge as an alternative or reinforcing marker of definiteness. Some scholars reject the idea that definiteness is systematically encoded in syntax, however (e.g. Hanna 2004:73). In Latin, for instance, where definiteness correlates with certain word-order patterns, the relationship appears to be mediated by information-structural factors such as referentiality and specificity rather than by the grammatical encoding of definiteness itself (cf. Devine & Stephens 2006:62).

6.3.3. Common-cause scenarios and confounds

A third possibility is that case loss and article emergence are not causally related, either because they respond to a shared underlying factor (as represented in Figure 16) or because they unfold through independent processes that nonetheless pattern together crosslinguistically. Börjars, Harries, and Vincent (2016:e30–e31), for instance, argue that in the history of North Germanic, case loss and the grammaticalization of definiteness marking are driven by entirely different forces: phonological change, on the one hand, and discourse-structural reorganization, on the other. Under either scenario, any crosslinguistic association between case loss and article emergence would reflect processes other than direct or mediated causation.

Several potential common causes merit consideration. At the linguistic level, aspect has been argued to play a role in the grammaticalization of articles, either alongside case loss or independently of it (Abraham 1997, Leiss 2000, 2007, Bauer 2007, Lavidas 2017). Word order is another candidate, as discussed in the preceding section. It is also possible that the expansion of adpositional marking contributes both to case loss and to the emergence of articles. More broadly, shifts toward increasingly configurational syntax and greater reliance on syntagmatic cues may simultaneously promote both developments.

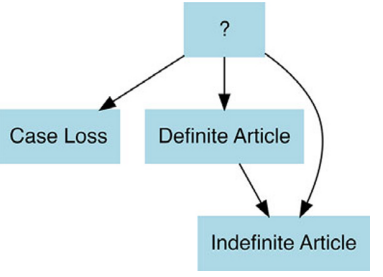

Figure 16. *Schematic representation of a common-cause scenario in which case loss and article emergence are not causally related but arise from a shared underlying factor. Identifying and controlling for such confounding influences is a central challenge in analyzing their association.*

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Potential common causes may also arise from the sociolinguistic context. One influential hypothesis holds that exoteric communicative environments, particularly those involving substantial adult second-language learning, favor greater transparency, regularization, and learnability (Thurston 1987, Wray & Grace 2007). Early large-scale empirical work appeared to support this view (Lupyan & Dale 2010). However, once phylogenetic and spatial nonindependence are taken into account, empirical support for this hypothesis largely disappears. A recent large-scale analysis finds no inverse association between exotericity-related sociodemographic variables and grammatical complexity, and where positive effects are found, they are weak (Shcherbakova et al. 2023).

More direct evidence comes from studies of case inventories themselves. Languages with a higher proportion of adult second-language (L2) speakers tend to exhibit reduced case systems or no case at all (Bentz & Winter 2013). Typological work that jointly models language-internal and sociolinguistic predictors further refines this picture (Sinnemäki 2020). For case-inventory size, the proportion of L2 speakers is a more important predictor than word order, whereas both word order and L2 proportion predict the presence versus absence of case. These findings suggest that the same sociolinguistic pressures that reduce case inventories may also promote article emergence and thus constitute a plausible confound in any attempt to attribute article emergence to case loss.

7. Conclusion

This article has shown that the loss of nominal case in Indo-European is systematically associated with a major reorganization of the nominal domain. The results reveal a robust probabilistic inverse relationship between case marking and article systems that persists even when phylogenetic relationships and spatiotemporal autocorrelation are modeled. Estimated probabilities indicate that lower case-inventory sizes are associated with higher probabilities of definite and indefinite articles. The posterior median for definite articles exceeds 0.5 at four cases, while for indefinite articles, conditional on the presence of a definite article, the corresponding median crosses 0.5 between three and four cases. The presence of a definite article further increases the probability of an indefinite article, over and above the effect of case-inventory size. Recast in terms of grammatical versus semantic case, the results suggest a more precise generalization. Articles tend to grammaticalize once case systems have been reduced to a core set of grammatical cases. This perspective explains why systems such as Ancient Greek, with four cases and a definite article, are not the anomaly they have sometimes been taken to be, since their case inventories fall squarely within the range in which article emergence is predicted.

Several issues remain open. First, the analysis establishes the association but does not identify its causal mechanism. The observed pattern is compatible with direct, mediated, and common-cause accounts. Disentangling these possibilities requires causal models that jointly represent the evolution of linguistic and sociolinguistic variables and the competing causal pathways linking them. Second, the present analysis operates at the level of language-wide properties. A fuller account will require investigation at the level of usage: how speakers distribute definiteness cues across resources such as morphology, aspect, word order, and articles in actual discourse, and how these distributions shift over time (Levshina 2021). Third, it is unclear whether the association identified here is specific to Indo-European or reflects a more general typological tendency. Evidence from Australian languages, where large case inventories are common and articles are rare (Blake 2001:xv–xvi, 158), suggests that the pattern may extend beyond Indo-European.

By demonstrating an inverse association between case-inventory size and article systems in Indo-European, this study sharpens the empirical basis of a long-standing typological debate and identifies the causal and evolutionary questions that remain open.

Supplementary material. The supplementary material for this article can be found at http://doi.org/10.1017/S0097850726000147.

Data availability statement. The data and code used in this study are archived on Zenodo (https://doi.org/10.5281/zenodo.20309293).

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