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Bivalent verb classes across Slavic: areal and genealogical patterns

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Abstract
The Slavic languages, shaped by a complex history of divergence and contact, offer an ideal setting for investigating how genealogical and areal factors influence valency class systems. These systems, marked by diachronic instability, reflect both internal linguistic developments and external pressures. Drawing on data from BivalTyp, a typological database of bivalent verbs and their coding frames (https://bivaltyp.info/), this study analyzes the argument-coding properties of 130 bivalent predicates (e.g., 'hit', 'know', 'be afraid', 'look', 'resemble') across 11 Slavic standard varieties: Belarusian, Bulgarian, Croatian, Czech, Macedonian, Polish, Russian, Serbian, Slovak, Slovenian, and Ukrainian. The dataset is annotated for argument-coding devices, such as cases and adpositions, as well as for cognacy relations between verbs and argument-coding devices. These annotations serve as the basis for constructing distance matrices that reveal patterns of similarity and divergence among Slavic languages in various subsystems of argument coding, with syntactic dimensions partially independent of the cognacy relations of the verbs involved. The findings highlight the significant role of areal factors in shaping valency classes in Slavic languages, often surpassing genealogical influences. This is evident in the systematic convergence between Polish and East Slavic languages and in broader areal trends, where Slavic languages exhibit syntactic convergences with neighboring non-Slavic languages.

Аннотация
Славянские языки, характеризующиеся сложной, но сравнительно хорошо известной историей расщеплений и контактов, представляют исключительные возможности для изучения воздействия генеалогического и ареального факторов на валентностные системы отдельных языков. Эти системы диахронически нестабильны, и их синхронное состояние отражает как внутренние языковые процессы, так и воздействие со стороны других языков. Источником материала для исследования стала типологическая база данных BivalTyp (https://bivaltyp.info/), в которой отражаются сведения о валентностных рамках 130 двухвалентных предикатов (например, 'ударить', 'знать', 'бояться', 'смотреть', 'быть похожим') в выборке языков мира, включающей 11 славянских литературных языков: белорусский, болгарский, македонский, польский, русский, сербский, словацкий, словенский, украинский, хорватский и чешский. В исходных данных

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отражены сведения о морфосинтакскических средствах, используемых для кодирования актантов глаголов; данные славянских языков были дополнительно размечены по признаку этимологического родства между i) глаголами и ii) средствами кодирования актантов (падежными формами и предлогами). На основе всех этих данных были построены матрицы расстояний, отражающие сходства и различия между славянскими языками в отношении различных подсистем кодирования актантов. Распределение валентностных рамок лишь частично коррелирует с этимологическим родством глаголов и отражает значительное влияние ареальных факторов, которое в ряде случаев превосходит влияние генеалогических связей. Это проявляется, в частности, в систематическом сближении польского языка с восточнославянскими, а также в синтаксическом сближении отдельных славянских языков с соседними неславянскими.

1 Setting the stage

Slavic languages display variation in the distribution of verbs across valency classes, as shown by examples (1) from Serbian and (2) from Czech.

(1) *Petar se stidi svoj-e visin-e*
PN[NOM.SG] REFL shame.PRS.3SG one's-GEN.SG.F height(F)-GEN.SG
'Petar is embarrassed about his height.'[1]

(2) *Petr se stydí za svoj-i mal-ou*
PN[NOM.SG] REFL shame.PRS.3SG for one's-ACC.SG.F small-F.ACC.SG
postav-u
stature(F)-ACC.SG
'Petr is embarrassed about his small height.'

The two sentences have nearly identical meanings and use cognate reflexive verbs, but differ in the coding of non-subject arguments: (1) uses the genitive case, while (2) employs the preposition *za* 'for' with the accusative case. Both argument-coding strategies exist in the two languages, but the verbs *stiditi se* 'feel embarrassed' in Serbian and *stydět se* in Czech are assigned to classes involving non-cognate coding devices.

While (1) and (2) illustrate mismatches, Slavic languages often share valency patterns. For instance, the Slovak equivalent of (1) and (2) features *za* and the accusative, aligning with Czech, although the verb *hanbiť sa* is etymologically unrelated. The genitive pattern appears in Slovenian, Polish, and all East Slavic languages, aligning syntactically with Serbian in (1), even when the verbs involved are not cognate with Serbian *stiditi se*, compare Slovenian *sramovati se* and Russian *stesnjat'sja*.

Finally, Bulgarian and Macedonian differ superficially from other Slavic languages, using the prepositions *ot* 'from' (Bulgarian) or *od* (Macedonian), as shown in (3) for Macedonian.

(3) *Petar se srami od svoj-ot rast*
PN[NOM.SG] REFL shame.PRS.3SG from one's-ART.SG.M height(M)
'Petar is embarrassed about his height.'

However, at a higher level of abstraction, Bulgarian and Macedonian align with the genitive pattern: both have lost their nominal case systems, with *ot*/*od* largely filling the genitive's

[1] Throughout this paper, all examples not accompanied by a source reference are taken from the BivalTyp database (Say, 2020-); see Sect. 3 for further details.

functional niche. Thus, the pattern in (3) is the closest functional Macedonian counterpart to the genitive object pattern in other Slavic languages.

This introduction highlights the fact that differences in how verbs are assigned to valency classes in Slavic languages are not fully determined by cognacy relationships among verbs and coding devices. While major morphosyntactic changes, such as the loss of nominal cases in Eastern South Slavic, affect argument coding, they do not automatically alter valency class structure. As demonstrated below, the observed synchronic similarities and differences are not random but reflect genealogical and areal affinities shaped by historical processes. My analysis aims to *quantitatively* assess valency class similarities and differences across Slavic languages and interpret them as evidence of genealogical and areal influences.

The goals outlined above align closely with Seržant et al. (2022), who investigate how cases and adpositions are used to code arguments in clauses expressing 46 meanings across 10 modern Slavic languages and Old Church Slavic (OCS). Their dataset includes 825 entries—well above the expected minimum of 506 (46×11)—since multiple patterns often correspond to a single meaning in a given language. One of their key foci is the variation in argument coding for the same meaning, with OCS shown to exhibit more variation than any modern Slavic language. This suggests that Proto-Slavic (with OCS as its best proxy) employed more semantically driven argument marking. Over time, however, Slavic languages shifted toward more syntactic functions—merely marking subjects and objects—often alongside Differential Object Marking, which is absent in OCS.

Other major findings include:

i) A south-to-north cline in transitivity prominence, with higher transitivity in the south seen as an innovation;

ii) Innovative non-nominative marking of the first argument in East Slavic;

iii) Strong similarities in verb-flagging patterns between Polish and East Slavic languages ("Northeast Slavic"), attributed to language contact and shared retention of archaic features—highlighting a potentially conservative role of contact.

The analysis below builds on the same theoretical premises as Seržant et al. (2022) and shares similar goals and scope. However, it draws on an entirely independent dataset and employs different quantitative methods. Where the two studies yield similar results—including the general claim that the areal dimension, propelled by language contact, plays a significant role in shaping the distribution of argument-coding patterns in Slavic languages—I take this as mutual reinforcement of their validity. At the same time, in what follows, I highlight the findings that are unique to my study or diverge from previous observations.

The remainder of this paper is organized as follows. Section 2 outlines key concepts relevant to cross-linguistic research on valency classes. Section 3 presents the dataset. In Sect. 4, I describe the methods employed to assess (dis)similarities between systems and discuss the main empirical results. Section 5 summarizes the study and offers a brief outlook on broader issues.

2 Definitions and key concepts

The valency of a verb is commonly understood as "the list of its arguments with their coding properties" (Malchukov & Leipzig Valency Classes Project team, 2015, p. 30).[2] Valency

[2]This definition hinges on the distinction between arguments and adjuncts, which is challenging (Helbig & Schenkel, 1983, p. 35ff; Testelec, 2001, pp. 179–187) and likely not very useful for typological purposes (Haspelmath, 2014: 9). Ultimately, this differentiation is not central to my analysis: some patterns may involve adjuncts rather than arguments, but this does not affect the conclusions.

serves as a bridge between the semantic dimension, where the verb's arguments bear semantic roles, and the morphosyntactic dimension, where argument phrases are marked by overt coding devices.

Cross-linguistically, argument-coding devices include flagging (cases and adpositions), indexing (verb agreement), and word order (Malchukov & Leipzig Valency Classes Project team, 2015, p. 31; Sinnemäki, 2008, p. 68). In Slavic languages, *flagging* is the key component of argument-coding systems.[3] For instance, the Polish valency pattern in (4) can be exhaustively described as a combination of arguments in the nominative and instrumental cases, with the verb automatically indexing the nominative argument.

(4) *Paweł* *macha* *chustk-ą*
PN[NOM.SG] wave.PRS.3SG handkerchief-INS.SG
'Paweł is waving a handkerchief.'

Two verbs belong to the same *valency class* if their arguments are coded by the same combination of argument-coding devices. Thus, the Polish verb in (5) belongs to the same valency class as the verb in (4).

(5) *Paweł* *gardzi* *Magd-ą*
PN[NOM.SG] despise.PRS.3SG PN-INS.SG
'Paweł despises Magda.'

Flagging devices in Slavic include cases (4)-(5), prepositions (3), or their combinations (2). Combinations of the same preposition with different cases constitute distinct coding devices. Thus, the Slovenian verbs *uživati* 'enjoy' and *zaljubiti se* 'fall in love' in (6) and (7) belong to different valency classes: although both take the preposition *v* 'in', the former requires the noun in the locative case, while the latter takes the accusative.

(6) *An-a* *uživa* *v* *čaj-u*
PN-NOM.SG enjoy.PRS.3SG in tea-LOC.SG
'Ana enjoys tea.'

(7) *Peter* *se* *je* *zaljubi-l* *v* *An-o*
PN[NOM.SG] REFL AUX.3SG fall_in_love-LPT[M.SG] in PN-ACC.SG
'Peter fell in love with Ana.'

The concept of valency has been central to syntactic research for decades (Apresjan, 1967; Fillmore, 1968; Lazard, 1994; Levin, 1993; Croft, 1998; Malchukov & Comrie, 2015; Ruppenhofer et al., 2016) and has also played a key role in lexicographic work on Slavic languages (Apresjan & Páll, 1982, pp. 42–43; Janda & Clancy, 2002; Zolotova, 2006; Žele, 2008; Ivanová et al., 2014; Przepiórkowski et al., 2014; Lyashevskaya & Kashkin, 2015; Lopatková et al., 2016). Despite differing approaches and terminologies, two points of consensus emerge.

First, verbs with similar meanings often display similar valency behavior (Apresjan, 1965; Fillmore, 1968; Helbig & Schenkel, 1983, pp. 62–63; Jackendoff, 1990, 246–251; Levin, 1993, pp. 1–10; Blume, 1998). This suggests that verbs in the same valency class, as in (4) and (5), may also share semantic similarities.

[3] Word order is primarily used to convey information-structural contrasts. With the exception of certain phenomena in Eastern South Slavic languages, briefly discussed in Sect. 3, indexing is predictable from flagging: the only argument systematically indexed on the verb is the nominative subject.

Second, valency patterns are not *equally* motivated by verb meanings. Case assignment mechanisms range from general rules that produce so-called "structural" cases, such as nominative and accusative, which are often considered default (Lazard, 1994, pp. 134–135; Dowty, 1991) to mid-range mappings between semantic roles (e.g., Recipient) and specific coding devices (e.g., the dative), to idiosyncratic cases linked to individual verbs (Yip et al., 1987; Babby, 1994; Woolford, 2006; Barðdal, 2011, pp. 645–648; Haspelmath, 2014, p. 5).

While default case assignments are crucial for alignment typology (Haspelmath, 2011), cross-linguistic differences in valency class organization are most evident in non-default case assignments (Bickel et al., 2014; Gaszewski, 2020, p. 17). To identify significant differences among Slavic languages, which share the same basic morphosyntactic profile, a large list of verb meanings is required (Seržant et al., 2022; Gaszewski, 2020).

Similarities in valency class organization within genealogical taxa can result from common ancestry and retention (Rostovtsev-Popiel, 2024). In contrast, dissimilarities always arise from diachronic processes affecting valency, as shown for Slavic languages, among others (McAnallen, 2011; Seržant et al., 2022). Various mechanisms of such change have been identified (Pinkster, 1988; Seržant & Kulikov, 2013; Luraghi & Roma, 2021), including studies on Slavic material (Samardžija, 1994; Ovsjannikova, 2011; Milković, 2025). Two scenarios are particularly relevant here: *analogical extension* and *valency-copying*.

Analogical extension is a system-internal process where a verb adopts a new valency pattern based on similar—often more frequent—verbs in the same language (Lazard, 1994, p. 148; Troberg, 2008). For example, in Russian, the instrumental used with *poražat'sja* 'be astonished' is being replaced by the dative, influenced by verbs like *udivljat'sja* 'be surprised'. Ultimately, this change was triggered by a semantic drift from a concrete meaning 'be stricken' to a more abstract meaning; see Ovsjannikova and Say (2020) for details.

Valency-copying is a partially system-external process, driven by language contact, in which a verb in a target language adopts a new valency pattern based on a corresponding verb in the donor language (Grossman & Witzlack-Makarevich, 2019). It is a subtype of pattern replication, a situation when inherited resources are used to copy an external model (Matras & Sakel, 2007). A notable example is the use of the transitive pattern for predicative possession ('to have') in some Slavic languages, often considered a calque from Greek (Isačenko, 1974). McAnallen (2011) offers a detailed reevaluation of this view, but still emphasizes the decisive role of language contact in shaping the distribution of predicative possessive constructions across Slavic languages, see also (Krapova & Dimitrova, 2024, pp. 233–285) for a recent discussion. While valency-copying can occur between both related and unrelated languages, distinguishing it from parallel development is particularly challenging in genealogically related languages.

Changes in a verb's valency pattern can be accompanied by lexical renewal, which may occur either system-internally (when a verb or its derivative acquires a new meaning) or system-externally (when a verb is borrowed). However, lexical and syntactic changes are generally independent. For example, a change in meaning may or may not lead to a change in valency (Samardžija, 1994), and borrowed verbs may either retain the donor language's valency pattern or assimilate themselves to the target system (Grossman & Witzlack-Makarevich, 2019). While verb borrowing is relatively infrequent, valency patterns are highly susceptible to language contact, accounting for the areal distribution of valency phenomena (Say, 2014; Grossman & Witzlack-Makarevich, 2019; Trips, 2020; Kim, 2020; Alfimova, 2024; Khachaturyan et al., 2025; Kozhanov & Say, 2025).

The processes outlined above form the basis for both divergent and convergent changes in valency within closely related languages such as the Slavic languages. While a qualitative, diachronic approach would involve tracing individual verbs in diachronic corpora to

identify specific changes, this paper adopts a quantitative, synchronic approach to systematically measure and analyze similarities and differences in modern Slavic languages' valency behavior, aiming to infer the contributions of various diachronic processes to their valency patterns. To carry out this research, a consistently annotated dataset of valency patterns observed in modern Slavic languages was needed, as discussed in the next section.

3 Dataset

The dataset used in this study, available in the Supplementary materials, is derived from the publicly available BivalTyp database (Say, 2020-) and includes additional annotations.[4] BivalTyp documents bivalent patterns in a large sample of languages and is based on elicited material from a questionnaire. The target clauses focus on meanings that typologically favor non-transitive structures (see Seržant et al., 2022 for a similar approach) and often include contextual information in parentheses, e.g., #13: '(P. and M. played chess.) P. beat M.' (where "P." and "M." are placeholders for person names). The two arguments in the target clauses, such as 'P. beat M.', are labeled as X and Y, with X representing the argument that accumulates more "proto-agent" properties (Dowty, 1991).

Each database entry is based on a language-specific translation of a questionnaire clause. For convenience, I refer to parallel entries using English verbs (e.g., 'win' for #13). However, the 130 questionnaire sentences are probes into an open-ended semantic space rather than a representative verb sample. In other words, patterns observed in a specific entry are not necessarily generalizable to all uses of the same verb. The "sentence-list-based" approach advances the "wordlist-based" typologies (Nedjalkov, 1969; Bossong, 1998; Nichols et al., 2004; Malchukov & Comrie, 2015). By focusing on sentences rather than verbs, BivalTyp sacrifices scope (130 sentences per language cover only a fraction of possible bivalent structures) but enhances comparability, as parallel entries convey the same contextualized meanings.

The analysis below is based on the latest development version of the BivalTyp database, available as of February 12, 2025 and covering 139 languages, primarily from Northern Eurasia. Table 1 lists the 11 Slavic languages included in the BivalTyp sample (data from other languages were used for comparative purposes, as detailed below). Unfortunately, the database does not include Upper and Lower Sorbian, although their data could be highly relevant for the areal-typological assessment of valency patterns in Slavic.

The dataset includes 1,420 Slavic entries, slightly fewer than the expected 1,430 (130 per 11 languages) due to 10 gaps, representing a negligible missing data rate of approximately 0.7%. The gaps result from missing translations or translations that do not meet the inclusion criteria, such as requiring both X and Y arguments to appear as clause-level dependents.

All entries in the dataset are annotated for five parameters: i) verb lemma, ii) valency pattern, iii) locus, iv) verb cognacy set, and v) valency pattern cognacy set. The first three annotation fields are inherent in the BivalTyp database and were used in this study without further modification.

Verb lemma is the citation form of the "valency carrier" (Gaszewski, 2020) used as the predicative head in the entry, which is typically a simplex verb, but may be, e.g., an adjective

[4] The BivalTyp database has been already used in intragenealogical studies on valency classes in Baltic (Alfimova, subm.), Romance (Romanova, 2024), Saami (Blinova & Shagal, 2020), Kartvelian (Rostovtsev-Popiel, 2024), and Mande (Khachaturyan et al., 2025) languages, as well as in a Slavic pilot study (Orestova, 2018).

Table 1 The Slavic languages in the dataset

language	branch	contributor[1]
Belarusian	East Slavic	Volha Harytskaya*
Bulgarian	South Slavic	Krasimira Petrova*
Croatian	South Slavic	Mislav Benić*
Czech	West Slavic	Anastasia Makarova
Macedonian	South Slavic	Vladimir Fedorov, Maria Khazhomia
Polish	West Slavic	George Moroz
Russian	East Slavic	Sergey Say*
Serbian	South Slavic	Anastasia Escher
Slovak	West Slavic	Martin Gális*, Kirill Kozhanov
Slovenian	South Slavic	Andreja Žele*, Mladen Uhlik*
Ukrainian	East Slavic	Natalia Zaika

[1]Contributors who are native speakers and have provided their own translations, rather than eliciting them from others, are marked with asterisks.

or a complex verb. In (8), the Slovak translation of questionnaire sentence #13, the verb lemma is *vyhrať*.

(8) *Peter vyhra-l nad Mark-om*
PN(M)[NOM.SG] win(PFV)-PST[M.SG] above PN(M)-INS.SG
'Peter beat Marek.'

Valency pattern is the main response variable, defined as the ordered combination of coding devices for X and Y. The valency pattern in (8) is schematically represented as "NOM_nadINS", meaning X is coded by the nominative case, and Y by the preposition *nad* 'above' combined with the instrumental case. As discussed in Sect. 2, reference to the preposition alone is not always sufficient to identify the coding device, as different cases can be used with the same preposition. For illustration, the valency patterns observed in (6) and (7) are labeled differently: "NOM_vLOC" and "NOM_vACC", respectively.

A BivalTyp entry is classified as transitive if its two core arguments align morphosyntactically with the 'killer' and 'victim' micro-roles of the verb 'kill' in the same language; see Haspelmath (2015, p. 136) for a similar approach. This class is exceptionally labelled as "TR", regardless of the specific coding devices involved. In most Slavic languages, the X argument in the transitive pattern appears in the nominative case and the Y argument in the accusative case. In Bulgarian and Macedonian, which lack morphological case on nouns, the transitive pattern is defined by i) both X and Y being unflagged by prepositions, ii) the X argument indexed by verb agreement suffixes, and iii) the Y argument optionally doubled by an accusative bound pronoun.[5] Thus, the Macedonian entry in (10) is considered transitive as it matches the morphosyntactic pattern of 'kill' in (9).

(9) *Petar ja ubi Maja*
Petar PRO.3SG.ACC.F kill:PFV.3SG.AOR Maja
'Petar killed Maja.'

[5]The conditions for accusative clitic doubling—the use of accusative bound pronouns alongside unmarked lexical direct objects—in Eastern South Slavic are complex (Tomić, 2008), but they are irrelevant to BivalTyp's definition of transitivity.

(10) *Petar ja pobedi Maja*
Petar PRO.3SG.ACC.F win:PFV.3SG.AOR Maja
'Petar beat Maja.'

Locus (of non-transitivity) is a four-value variable that indicates whether the two predefined arguments are coded by direct or oblique devices, with "direct" referring to the strategies used for the arguments in the transitive pattern. The four possible values of locus are "TR", "X", "Y", and "XY". "TR" is used for transitive entries, where both arguments are coded by direct devices. An entry has Y-locus if X is coded by a direct device (typically the nominative case), and Y is coded by an oblique device. Y-locus patterns are common in the Slavic dataset, see (1)-(8). The less common X-locus, illustrated by the Croatian example (11), occurs when X is coded by an oblique device, and Y by a direct device (typically the nominative case).

(11) *Per-i se sviđa ta košulj-a*
PN-DAT.SG REFL like.PRS.3SG this.NOM.SG.F shirt-NOM.SG
'Pero likes this shirt.'

Finally, XY-locus represents the rarest possibility in the dataset, exemplified in (12), featuring the Polish verb *brakować* 'be short' used in the "DAT_GEN" pattern.

(12) *Ann-ie brakuje jedn-ego dolar-a*
PN-DAT.SG lack:IPFV.PRS.3SG one-M.GEN.SG dollar-GEN.SG
'Anna is one dollar short.'

The notion of *locus* is grounded in two principles. First, it aligns with Malchukov's (2006) "relevance principle", which states that syntactic non-transitivity is overtly coded on the constituent deviating from high semantic transitivity (Hopper & Thompson, 1980). Slavic data generally support this: X-locus is typical of verbs with less agentive X arguments, such as verbs of emotion (11), see also (15) exemplifying an involuntary action, whereas Y-locus is common among verbs with less affected Y arguments, such as 'touch' or 'follow' (Say, 2017, pp. 736–741, see also Sect. 4.3 below). Second, unlike the valency patterns *per se*, which are language-specific descriptive categories (Haspelmath & Hartmann, 2015; Gaszewski, 2020, p. 22), the four-way distinction of locus is a comparative concept in the sense of (Haspelmath, 2010). As such, locus is a suitable tool for comparing how languages map semantic features onto syntactic patterns, even across unrelated languages.

The remaining two annotation parameters are not included in the BivalTyp database and were added specifically for the Slavic dataset in this study.

Verb cognacy sets capture whether the verbs involved in language-specific entries are etymologically related. For example, the 11 Slavic equivalents of entry #25 'think' fall into two sets: 1) Russian *dumat'*, Ukrainian *dumaty*, Belarusian *dumać*; 2) Polish *myśleć*, Czech *přemýšlet*, Slovak *rozmýšľať*, Slovenian *razmišljati*, Croatian *misliti*, Serbian *misliti*, Macedonian *misli*, Bulgarian *mislya*. Cognacy sets are based solely on roots, ignoring affixal differences (see also Orestova, 2018). This broad approach ensures a discrete definition of verb cognacy, avoiding arbitrary decisions in borderline cases.[6]

Finally, *valency pattern cognacy sets* capture whether the language-specific equivalents of a given entry share "the same" valency pattern. While valency patterns are language-specific, in Slavic languages they can usually be equated based on the shared etymologies of

[6] My approach aligns with the analysis of "partial colexifications" in cross-linguistic studies of wordlists (List et al., 2022).

Table 2 Equivalents of entry #37 'make fun' and their valency patterns

language	sentence	valency pattern	cognacy set
Belarusian	*Alieś zdziekujecca z Alieny*	NOM_zGEN	NOM_sGEN
Bulgarian	*Petar izdevatelstva nad Mihail*	SBJ_nad	NOM_nadINS
Croatian	*Pero se ruga Miši*	NOM_DAT	NOM_DAT
Czech	*Petr se vysmívá Michalovi*	NOM_DAT	NOM_DAT
Macedonian	*Petar se potsmeva nad Maja*	SBJ_nad	NOM_nadINS
Polish	*Mefistofeles drwi z Boga*	NOM_zGEN	NOM_sGEN
Russian	*Petja izdevaetsja nad Mašej*	NOM_nadINS	NOM_nadINS
Serbian	*Petar maltretira Mariju*	TR	TR
Slovak	*Peter si z Marka robí žarty*	NOM_zGEN	NOM_sGEN
Slovenian	*Peter se norčuje iz Pavla*	NOM_izGEN	NOM_sGEN
Ukrainian	*Petro znuščajet'sja z Mariji*	NOM_zGEN	NOM_sGEN

case forms and prepositions. For the annotations, I used pan-Slavic tags, assigning different tags only when valency patterns in two languages could not plausibly result from the continuous development of the same Common Slavic pattern (see Khachaturyan et al., 2025 for a similar procedure regarding Mande languages). Table 2 illustrates this principle for the 11 equivalents of entry #37 '(M. did something very stupid. Now,) P. is making fun of M.' The caseless patterns in Bulgarian and Macedonian are nevertheless tagged as "NOM_nadINS" to align them with the corresponding pattern in Russian for the purposes of algorithmic analysis. Phonological differences in cognate prepositions are also disregarded in the annotations.

While Slavic languages with six-term case systems (excluding the vocative, which is irrelevant for my goals)[7] allow for straightforward cognacy set annotations, Bulgarian and Macedonian, the two languages lacking nominal case, pose challenges. I used the following annotation schema for these two languages.

i) The pattern characterized by the lack of flagging and the optional use of the accusative bound pronoun was equated with the nominative plus accusative transitive pattern elsewhere.

ii) Many Bulgarian and Macedonian verbs can combine with a dative bound pronoun and/or a lexical argument noun phrase flagged by the preposition *na* 'on', as in Bulgarian examples (13) and (14). Macedonian differs from Bulgarian in that the dative bound pronoun is obligatorily used in constructions with lexical argument noun phrases as well.

(13) *Petar vyarva na Maria*
PN believe:IPFV.3SG.PRS on PN
'Petar believes Maria'.

(14) *Petar y vyarva*
PN PRO.3SG.DAT.F believe:IPFV.3SG.PRS
'Petar believes her'. (Krasimiria Petrova, p.c.)

[7] Throughout this analysis, I assume that Slavic languages with morphological case on nouns have a system of six cases, as is standard in both pedagogical and typological literature. These are the so-called 'canonical' cases: nominative, genitive, dative, accusative, instrumental, and locative. It is well established that Russian and some other Slavic languages also feature several non-canonical or borderline forms whose status as cases is debated; see Corbett (2008) for an overview.

Table 3 Verb and valency cognacy relations: four equivalents of entry #29 'forget'

language	sentence	cognacy set	
		verb	valency pattern
Russian	*Petja zabyl o drugoj doroge*	*zabyt'*	NOM_oLOC
Polish	*Basia zapomniała o tej drodze*	*zapomnieć*	NOM_oLOC
Czech	*Petr zapomněl na tu druhou cestu*	*zapomnieć*	NOM_naACC
Slovenian	*Peter je pozabil na pot*	*zabyt'*	NOM_naACC

For language-internal purposes, BivalTyp uses complex tags like "SBJ_DAT(na)" for verbs exemplified in (13) and (14), but for this study, I equated these valency patterns with the "NOM_DAT" pattern observed elsewhere.

iii) For all other patterns involving prepositions, the Bulgarian and Macedonian patterns are analyzed using the same labels as other Slavic languages, as discussed for the preposition *nad* based on the data in Table 2.

Valency pattern cognacy sets is logically and empirically independent of verb cognacy sets, as shown by the four equivalents of entry #29 in Table 3. Here, the Polish verb is cognate with the Czech verb, while the Polish valency pattern is cognate with the Russian pattern. Verb cognacy sets are tagged using the form of the verb from the language where the set is first encountered. Thus, the tag "*zapomnieć*" in the third row of Table 3 indicates that Czech uses a verb cognate with the Polish verb *zapomnieć* from the second row.

Two remarks of caution concerning the possible limitations of my dataset are required.

First, BivalTyp focuses on bivalent verbs and does not address argument coding in verbs of other numeric valency types. Bivalent verbs are well-suited for exploring valency class variation, as they often show non-canonical patterns and form relatively stable classes across languages (Bickel et al., 2014).

Second, BivalTyp ignores variability within languages, such as cases where a verb can be used in different valency patterns with or without a clear change in propositional content. While the database provides guidelines for choosing between patterns, much information is lost, and the final choices are sometimes arbitrary. The discrepancy between the Serbian and Croatian patterns in Table 2 likely results from the data-gathering process rather than reflecting a substantial difference between the languages. However, these drawbacks are outweighed by BivalTyp's advantages, such as large lexical coverage and semantic consistency. While some differences may be spurious, cross-linguistic similarities, especially those aligning with genealogical or areal distinctions, are less likely to be so, as discussed in Sect. 4.

4 Distance metrics and results

My main goal was to *measure*, using the dataset outlined in Sect. 3, differences between Slavic languages in verb cognacy (4.1), valency pattern cognacy (4.2), locus distributions (4.3), and lexical distributions of verbs into valency classes (4.4). Despite varying distance metrics, I calculated pairwise distances between languages for all four aspects (0 = maximal similarity, 1 = maximal dissimilarity) and analyzed the resulting matrices. All calculations were performed in R (R Core Team, 2021) using the following packages: `dplyr` (Wickham et al., 2023), `ggpubr` (Kassambara, 2023), `infotheo` (Meyer, 2022), `lingtypology` (Moroz, 2024), `lmerTest` (Kuznetsova et al., 2017), `readxl` (Wickham & Bryan, 2023), and `writexl` (Ooms, 2024). The distance matrices discussed and visualized in the remainder of this section are available in the Supplementary materials.

Table 4 Verb cognacy relations in the Russian and Polish datasets

No	predicate	Russian	Polish	Difference
42	'forfeit'	*lišit'sja*	*stracić*	1
43	'try to catch'	*lovit'*	*łapać*	1
44	'break'	*slomat'*	*złamać*	0
45	'flatter'	*l'stit'*	*pochlebiać*	1
46	'love(1)'	*ljubit'*	*kochać*	1
47	'wave'	*maxat'*	*machać*	0
48	'dream'	*mečtat'*	*marzyć*	1
49	'wash'	*vymyt'*	*umyć*	0
50	'put on'	*nadet'*	*włożyć*	1
51	'be called'	*nazyvat'sja*	*nazywać się*	0

4.1 Verb cognacy

To measure etymological dissimilarities in verb usage between the compared languages, I introduced DistVerbEtym, a metric based on the normalized Hamming distance and verb cognacy annotations. It was calculated for each pair of languages as the ratio of entries with verbs from different cognacy sets. Table 4 illustrates this method with verb lemmas from 10 entry pairs in the Russian and Polish datasets.

In the toy example in Table 4, DistVerbEtym for Russian and Polish is 0.6, calculated as 6 etymological mismatches divided by 10 entries. For the full datasets, DistVerbEtym for this pair is 0.57 (74 mismatches out of 130 entries).

After calculating DistVerbEtym for all pairs of the 11 Slavic languages in my sample, I obtained a distance matrix that largely aligns with the accepted Slavic genealogy, especially at the micro-level. The smallest DistVerbEtym values are observed for Belarusian–Ukrainian (0.22), Serbian–Croatian (0.22), Slovak–Czech (0.28), and Bulgarian–Macedonian (0.34). These pairs represent closely related languages.[8]

However, there are also similarities that cut across established genealogical branches.[9] The fifth and sixth shortest distances are between Polish and Ukrainian (0.37), and Polish and Belarusian (0.38). These relationships are reflected in the dendrogram generated by hierarchical agglomerative clustering algorithm applied to the distance matrix. Clustering was performed using the complete linkage method, which defines the distance between two clusters as the maximum distance between their elements. The resulting visualization (Fig. 1) groups Polish, Belarusian, and Ukrainian into a cluster that excludes the other languages.

[8] I have also performed a Multi-Dimensional Scaling (MDS) analysis of the same distance matrix. The resulting visualization, available in the Supplementary materials, aligns with the three traditional Slavic branches—West, East, and South. Languages within the same branch appear adjacent to one another, forming sectors within the ring-like structure shaped by the 11 languages.

[9] It should be borne in mind that the division of Slavic languages into East, South, and West branches is not entirely unproblematic. At least in the case of the West and South Slavic groups, it is difficult to reconstruct the respective protosystems in their entirety, to identify isoglosses unique to these branches, and to locate their common ancestors as spoken in specific places at specific times (Kortlandt, 2003; Matasović, 2008, pp. 57–67). Despite these uncertainties, I adopt the traditional tripartite division as the basis for the genealogical dimension in my data, as opposed to areal affinities, which may cut across branch boundaries.

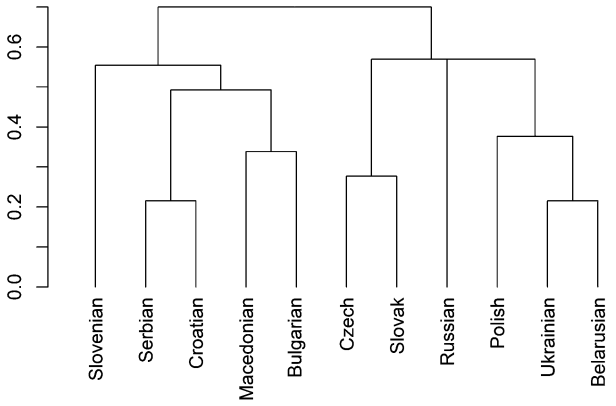

Fig. 1 Dendrogram based on DistVerbEtym

Table 5 Cognate verbs unique to Polish, Ukrainian, and Belarusian

No	predicate	Polish	Ukrainian	Belarusian
2	'have (illness)'	*chorować*	*xvority*	*chvareć*
18	'hold'	*trzymać*	*trymaty*	*trymać*
30	'depend'	*zależeć*	*zależaty*	*zależać*
39	'look for'	*szukać*	*šukaty*	*šukać*
42	'forfeit'	*stracić*	*vtratyty*	*stracić*
48	'dream'	*marzyć*	*mrijaty*	*maryć*
52	'punish'	*ukarać*	*pokaraty*	*pakarać*
58	'like'	*podobać się*	*podobatysja*	*padabacca*
64	'be different'	*odróżniać się*	*vidriznjatysja*	*adroznivacca*
79	'hit (target)'	*trafić*	*potrapyty*	*trapić*
98	'agree'	*zgodzić się*	*zhodytysja*	*pahadzicca*
113	'fall in love'	*zakochać się*	*zakoxatysja*	*zakachacca*
116	'envy'	*zazdrościć*	*zazdryty*	*zajzdroscić*
127	'get upset'	*zasmucić się*	*zasmutytysja*	*zasmucicca*

The empirical basis for the Polish-Ukrainian-Belarusian cluster is evident in the raw data. For instance, 14 entries contain cognate lexical predicates in Polish, Ukrainian, and Belarusian that are not found in other datasets, see Table 5.

The verbs in Table 5 are heterogenous. The equivalents of 'to have (illness)', 'punish', and 'agree' share a common Slavic etymology (Derksen, 2008); their cognates exist in other Slavic languages but are absent from the BivalTyp database due to semantic divergence or stylistic markedness. The equivalents of 'hold' and 'look for'[10] emerged in Old Polish and were later borrowed into Old Ruthenian (Brückner, 1985/1927). Regardless of the specific scenarios for individual verbs, language contact within the Polish-Lithuanian Commonwealth, where the ancestors of modern Polish, Belarusian and Ukrainian were spoken, likely played a key role in shaping the discussed lexical similarities.

[10]Whether the latter is a Germanic loanword is irrelevant to the current discussion.

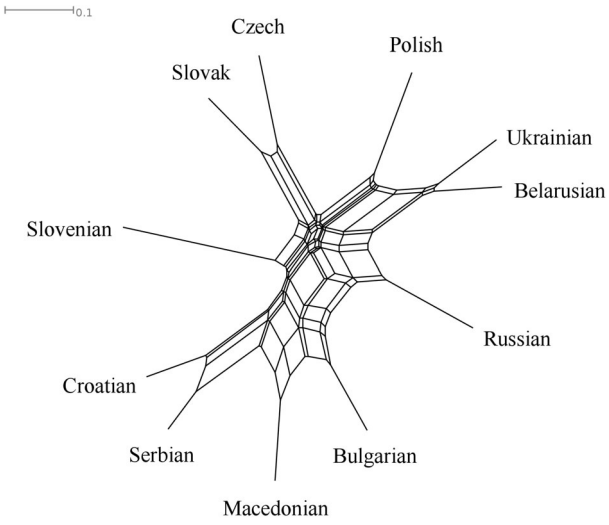

Fig. 2 NeighborNet visualization of the DistVerbEtym distances

The DistVerbEtym metric is based on the lexicostatistic method also used in glottochronological studies, which typically focus on basic vocabulary, which is considered stable and resistant to borrowing. In contrast, the BivalTyp questionnaire includes many non-basic lexical items, likely explaining the deviations in the dendrogram in Fig. 1 compared to the canonical Slavic cladistic tree. However, Polish being grouped with (some) East Slavic languages is not unprecedented (Bouckaert et al., 2012; Rama, 2018). In fact, Kassian (2023) partially attributes the distortions, including the unexpected position of Polish, in the tree presented in Bouckaert et al. (2012) to their misclassifying Polish loanwords in Ukrainian as inherited. While this might be a flaw in a glottochronological study, my goal is different: to explore lexical and syntactic similarities and differences between Slavic languages in the context of their known genealogical relationships. In this regard, the convergence between Polish, Ukrainian, and Belarusian is a reliable finding.

While dendrograms can in principle faithfully represent the internal organization of genealogical taxa, convergences between taxa are better captured by *networks*. One common algorithm for building such networks is NeighborNet, implemented in the SplitsTree4 software (Huson & Bryant, 2006). A NeighborNet visualization of the same distance matrix based on DistVerbEtym is shown in Fig. 2.

An important aspect of interpreting the NeighborNet visualization is identifying *splits*, represented by sets of parallel edges of equal length. In this regard, the inspection of Fig. 2 confirms all the generalizations made from the dendrogram in Fig. 1, while also adding two new ones.

First, although Bulgarian and Macedonian are closely related, Bulgarian displays some lexical convergences with East Slavic languages while Macedonian patterns with Serbian (and, to a slightly lesser extent, Croatian). This split is seen in 8 dataset entries: #17 ‘tell’, #20 ‘milk’, #57 ‘hate’, #76 ‘remember’, #80 ‘cut oneself’, #101 ‘shoot at’, #110 ‘respect’, and #122 ‘have a grudge’ (in two further entries, #42 ‘forfeit’ and #59 ‘need’, Bulgarian patterns with Russian, but not the other two East Slavic languages). The reverse pattern, where Macedonian would share a lexical item with East Slavic languages and Bulgarian with Serbian or other South Slavic languages, is absent.

Second, Slovenian is the most divergent Slavic language, not forming robust clusters with any other Slavic language. This echoes findings from previous lexicostatistic studies, see Kassian (2023) for a discussion.

4.2 Valency pattern cognacy

To measure etymological dissimilarities in valency patterns, I introduced DistValEtym, a metric similar to DistVerbEtym, also based on the normalized Hamming distance. The difference is that DistValEtym calculates the ratio of etymological mismatches in the use of valency patterns (not verbs), as indicated in the "valency pattern cognacy set" annotations in the dataset. For example, there are 26 entry pairs where Polish and Ukrainian use etymologically non-cognate valency patterns, yielding a DistValEtym value of 0.203 (= 26/128[11]).

While the distance matrices based on DistVerbEtym and DistValEtym are similar, the DistValEtym value is consistently smaller than the DistVerbEtym value for every language pair, with average values of 0.32 and 0.55 respectively. This means that when comparing a random entry from language L1 to its counterpart in another Slavic language L2, the likelihood of finding an etymologically unrelated verb is 0.55, whereas for valency patterns it is only 0.32. This suggests that the semantic domains associated with valency patterns are diachronically more stable than the verbs (see Alfimova, subm., for the same conclusion based on the Baltic data). This generalization can be seen as a specific instance of the broader tendency for functional items to be less numerous and more stable diachronically than lexical ones. Apart from this, lexical valency patterns are partly motivated by constructional links, contributing to the relative stability of patterns, while verbs may be largely arbitrary.

The two dimensions of potential diachronic change are not fully independent. The incidence of non-cognate valency patterns for cognate verbs (0.25) is significantly lower than for non-cognate verbs (0.39), as confirmed by a paired t-test ($t = 4.7$, $p = 6.12\times10^{-6}$); see Orestova (2018) for similar calculations based on a smaller dataset.[12] However, these values also suggest that verb cognacy is not the primary factor determining whether Slavic languages exhibit parallel syntactic patterns for a given verb meaning.

In Fig. 3, the distance matrix based on DistValEtym is visualized using the same NeighborNet algorithm introduced in Sect. 4.1.

The network in Fig. 3 resembles the dendrogram in Seržant et al. (2022, p. 323), which was built using similar methods but an independent dataset. This similarity supports the validity of both studies, especially the generalization that genealogical relationships strongly predict similarities in valency patterns, see also Alfimova (2024, p. 293). With this in mind, I will highlight some observations that are not reflected in Seržant et al.'s (2022) findings or in my discussion in Sect. 4.1.

i) The Eastern South Slavic languages form a tightly knit cluster, with neither Bulgarian nor Macedonian exhibiting systematic affinities to languages outside this group. Specifically, unlike in Fig. 2, there are no connections between Macedonian and Serbo-Croatian or between Bulgarian and the East Slavic languages.

ii) While the visualization in Fig. 3 confirms the close resemblance between Polish and East Slavic languages, as discussed by Seržant et al. based on their dendrogram (2022, p. 323–325), it also adds important nuances due to its reticular organization.

[11] The denominator is 128, not 130, because 2 entries have gaps in either Polish or Ukrainian datasets.

[12] Similar quantitative differences have been observed in the BivalTyp data for Romance (Romanova, 2024) and Baltic (Alfimova, subm.), although the differences in the latter case were not statistically significant.

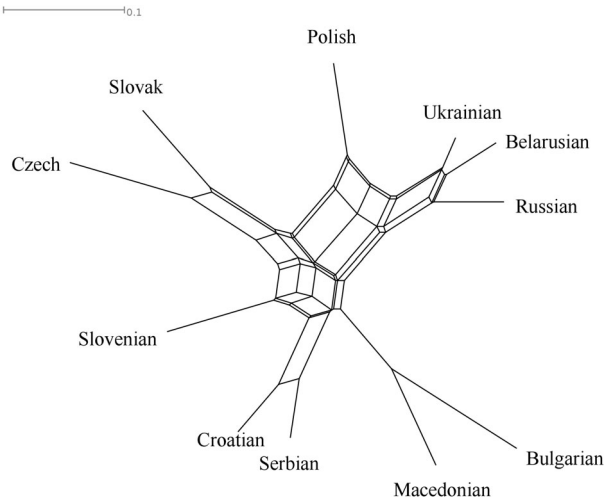

Fig. 3 NeighborNet visualization of the DistValEtym distances

First, the connection between Polish and East Slavic is robust but *layered*, with especially strong similarities between Polish, Ukrainian, and Belarusian; this contrasts with Seržant et al.'s dendrogram (p. 323), where the three East Slavic languages form a cluster, and Polish joins them at a higher level. My raw data yield an almost exceptionless generalization: if Polish shares a valency pattern with Russian (but not Czech), then this pattern is also observed in Ukrainian and Belarusian[13] (the reverse is sometimes not true).

Second, apart from valency pattern similarities with East Slavic languages, Polish also shares similarities with the remaining West Slavic languages, as reflected in Fig. 3. This connection is exemplified by the valency patterns of *dotknąć* 'touch' with the prepositionless genitive case; *czekać* 'wait' with the preposition *na* plus accusative; or *boleć* 'hurt, ache' with the experiencer in the accusative and the body part in the nominative, all of which are not attested in East Slavic datasets.[14]

To summarize, areal convergences across taxa are best captured by networks like the one in Fig. 3, where Ukrainian and Belarusian lie between Russian—the remaining East Slavic language—and Polish; Polish is between the remaining West Slavic languages and East Slavic languages; Slovenian is between the remaining South Slavic languages and West Slavic languages (especially Czech and Slovak), etc.

4.3 Locus distinctions

Compared to specific verbs and valency patterns, the distribution of verb meanings by locus is relatively stable across Slavic languages. For example, equivalents of #1 'feel pain' consistently show the X-locus (with the experiencer in a non-subject position), while #6 'resemble', #7 'believe', and #47 'wave' consistently display the Y-locus. Many entries, such as #9 'see', #18 'hold', and #41 'bite', remain consistently transitive across Slavic languages.

[13] This pattern appears in 23 entries (#35 'avoid', #53 'attack', #87 'govern', etc.). Two partial exceptions include #29 'think', where Ukrainian and Belarusian use *pro*/*pra*, while Russian and Polish use *o*, and #120 'enjoy', where Polish, Ukrainian, and Russian follow the NOM_INS pattern, but Belarusian deviates with NOM_adGEN.

[14] Such patterns do occur in some East Slavic varieties, but they are not sufficiently basic to be included in the database, which records only one translation per context.

Table 6 Slavic equivalents of #97 '(P. sleeps.) P. dreams of M.' and their locus

language	sentence	locus
Russian	*Pete snitsja Maša*	X
Belarusian	*Aliesju snicca Aliena*	X
Ukrainian	*Mariji snyt'sja Petro*	X
Polish	*Romanowi śni się Matka Boska*	X
Czech	*Petrovi se zdá o Michalovi*	XY
Slovak	*Peter sníva o Márii*	Y
Slovenian	*Peter je sanjal Devico Marijo*	TR
Croatian	*Pero sanja Mariju*	TR
Serbian	*Petar sanja Mariju*	TR
Macedonian	*Petar ì se sonuva na Maja*[1]	Y
Bulgarian	*Petar sanuva Maria*	TR

[1] An alternative is *Petar ja sonuva Maja* with the transitive pattern.

Table 7 The prevalence of patterns defined in terms of locus

language	TR	Y	X	XY
Polish	0.41	0.53	0.04	0.02
Russian	0.42	0.52	0.05	0.02
Belarusian	0.43	0.51	0.05	0.02
Ukrainian	0.44	0.50	0.05	0.02
Czech	0.45	0.49	0.05	0.02
Macedonian	0.47	0.48	0.05	0.00
Slovak	0.48	0.49	0.03	0.00
Croatian	0.50	0.43	0.07	0.01
Serbian	0.50	0.42	0.07	0.01
Slovenian	0.50	0.43	0.06	0.01
Bulgarian	0.52	0.43	0.04	0.01

However, locus-based differences exist, as shown in Table 6 with the equivalents of #97 'dream (sleeping)', a rare case where all four locus values are present.

Table 7 summarizes aggregate differences in locus type prevalence across Slavic languages, ordered by increasing ratio of transitive patterns, known as *transitivity prominence* (Haspelmath, 2015).

Transitivity prominence increases from Polish and East Slavic languages to South Slavic languages (see the map in the online version of BivalTyp). This trend, analyzed in detail by Seržant et al. (2022), will not be further discussed here.[15]

Areal studies on valency patterns suggest that Standard Average European (SAE) languages favor uniform subject coding, while Slavic languages, on the SAE's eastern periphery, more commonly feature non-canonical subjects, including experiencers (Faarlund, 1998;

[15] See also Kozhanov and Say (2025) for a similar areal cline observed in Romani dialects spoken primarily in Eastern Europe.

Bossong, 1998; Haspelmath, 2001; Seržant, 2015). As non-canonical subjects broadly correspond to X- and XY-locus patterns, the data in Table 7 align with this well-established generalization, showing these patterns across all Slavic languages.

The systematic differences in the prevalence of non-canonical subjects *among* Slavic languages are less clear. Bossong (1998) introduces a complex index for this prevalence, reporting values for Slavic languages as follows: Russian 2.11, Polish 0.88, Czech 0.76, Serbo-Croatian 0.75, and Bulgarian 0.48. Seržant et al. (2022, pp. 319–322) find the highest prevalence of non-nominative subject-like arguments in East Slavic languages, especially Russian and Ukrainian, and the lowest in South Slavic languages, especially Bulgarian (see Krapova & Dimitrova, 2024, pp. 60–64 for a discussion). My data in Table 7 show the highest prevalence of X- and XY-locus in Serbian and Croatian, followed by Slovenian, Czech, and the East Slavic languages. While all three datasets agree on some points, such as the low prevalence of X- and XY-locus in Bulgarian, they diverge on the placement of other languages, such as Polish and Serbo-Croatian.

Non-canonical coding of X arguments is typologically associated with a small set of predicate meanings, such as experiential (cognition, sensation, and emotion), modal, possessive, and adversity impersonals.[16] However, the extent of non-canonical subjects across these groups varies (Haspelmath, 2001, pp. 63–64; Say, 2014, pp. 144–145).[17] The differences in the results discussed above likely stem from the arbitrary choice of diagnostic contexts used in each study. For instance, Seržant et al. (2022) is the only study among the three to include adversity impersonals, which are primarily found in East Slavic languages (Schlund, 2020), resulting in higher scores for these languages. In contrast, BivalTyp includes an involuntary causative context (#86 'drop'), absent in the other studies. Only three languages in my dataset, Serbian (15), Croatian, and Macedonian, feature the X-locus for this context.[18]

(15) *Petr-u* *je* *ispa-la* *čaš-a*
PN-DAT.SG be.PRS.3SG fall.down-PART.PERF.F.SG glass-NOM.SG
'Petar dropped the glass.'

DistValLoc, another metric based on normalized Hamming distance, captures cross-linguistic differences in the distribution of locus types across datasets. Calculated similarly to DistVerbEtym and DistValEtym, it uses the number of locus mismatches (of any type) as the numerator. For example, the DistValLoc value for Russian and Polish is 0.12 (15 mismatches divided by 129 entry pairs without missing data). DistValLoc focuses on generalized pattern differences and always yields values equal to or smaller than those of DistValEtym. Furthermore, lexical distributions of locus-determined patterns may be diachronically more sta-

[16] Adversity impersonals, sometimes referred to as the "elemental construction", denote events of physical causation in which the (negatively) affected patient is coded as the direct object, while the natural force is expressed peripherally, typically in a position analogous to a demoted agent in a passive construction—for example, Russian *Ego ubilo molniej* 'Lightning killed him', literally '(It) killed him with lightning'.

[17] In this respect, the Slavic data offer additional insight into the proposed universal hierarchies of verb meanings, as reflected in their tendency to display canonical transitive coding or specific types of deviations, such as X- or Y-locus (Tsunoda, 1985; Malchukov 2005, 2006; Haspelmath, 2015; Wichmann, 2016). While some general trends clearly hold—such as the association between action verbs and transitivity, or between interaction verbs (e.g., 'answer', 'follow', 'obey') and Y-locus—the Slavic languages provide counterevidence to strict universality. Despite their relatively shallow divergence, they differ not only in where they draw the cut-off points along the hierarchies, but also in which verbs prefer which type of locus. See also Say (2018, pp. 560–566) for a broader discussion based on BivalTyp data.

[18] Constructions like (15) can be grammatically acceptable in other languages as well, but arguably they are less prominent in East and West Slavic languages.

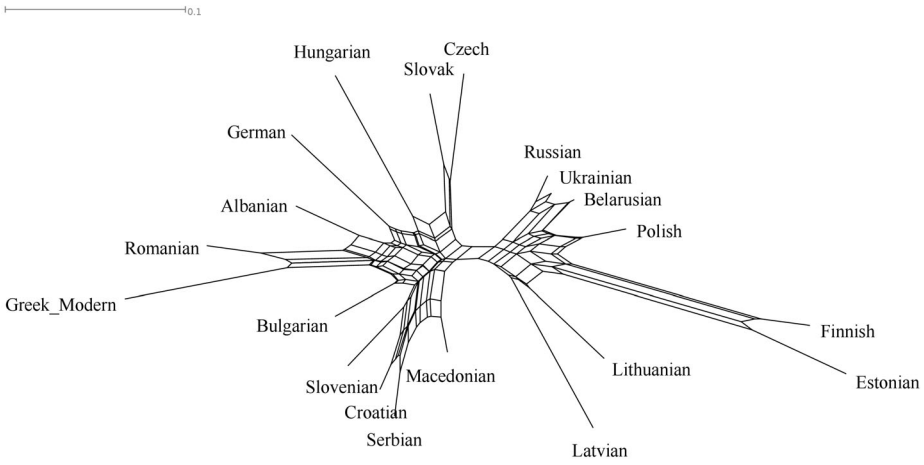

Fig. 4 NeighborNet visualization of DistValLoc distances among Slavic languages and selected neighbors

ble than the specific argument-coding devices instantiating them (Rostovtsev-Popiel, 2024, p. 70).

Unlike the first two metrics, DistValLoc applies to any language pair, regardless of genealogical relation (Kozhanov & Say, 2025). Figure 4 shows a NeighborNet visualization of DistValLoc, comparing Slavic languages with several areally adjacent languages.[19]

The internal structure of Slavic languages as visualized in Fig. 4 is broadly consistent with findings reported in Sect. 4.2 and elsewhere (Seržant et al., 2022), showing Polish in close proximity to East Slavic languages, particularly Belarusian and Ukrainian, etc. Less expected are the connections between individual Slavic and non-Slavic clusters, likely influenced by areal factors. For example, there is a visible split placing Czech and Slovak with their Central European neighbors Hungarian and German, instead of other Slavic languages. This finding supports Alfimova's observation that the Czech valency class system significantly deviates from all other Slavic systems (2024, p. 291).[20] Additionally, East Slavic languages and Polish form part of a prominent cluster with Baltic and Finnic languages, reflecting their complex contact history as part of the Circum-Baltic area; see Alfimova (2024, pp. 291–296) for a similar observation concerning Lithuanian (but not Latvian).[21] Overall, the sensitivity of languages to specific semantic traits as triggers for locus selection appears to be easily transmissible through areal convergence.

[19] When selecting non-Slavic languages for this and the next visualization (Fig. 5), I balanced informativeness and readability. I excluded the many non-Slavic languages spoken in Russia, as their similarities with Russian and other Slavic languages likely result from Russian influence and are less relevant to the analysis of Slavic languages as such.

[20] Alfimova's sample does not include Slovak.

[21] Interestingly, while the (dis)similarities between northeast Slavic languages and their neighbors align well with known contacts in the Circum-Baltic area, there are no clear signs of the Balkan Sprachbund—arguably the most recognized contact zone involving Slavic. The same holds for the results in Sect. 4.4. Why the valency classes in Balkan Slavic languages appear unaffected by non-Slavic Balkan languages such as Albanian, Romanian, and Modern Greek remains unclear.

Table 8 A subset of German and Czech datasets and their joint distribution

No	predicate	German pattern	Czech pattern	joint distribution
23	'fight'	NOM_mitDAT	NOM_sINS	NOM_mitDAT&NOM_sINS
24	'be friends'	NOM_mitDAT	NOM_sINS	NOM_mitDAT&NOM_sINS
25	'think'	NOM_anACC	NOM_oLOC	NOM_anACC&NOM_oLOC
26	'eat'	TR	TR	TR&TR
27	'fry'	TR	TR	TR&TR
28	'wait'	NOM_aufACC	NOM_naACC	NOM_aufACC&NOM_naACC
29	'forget'	TR	NOM_naACC	TR&NOM_naACC
30	'depend'	NOM_vonDAT	NOM_naLOC	NOM_vonDAT&NOM_naLOC
31	'call'	NOM_nachDAT	NOM_naACC	NOM_nachDAT&NOM_naACC
32	'get to know'	TR	NOM_sINS	TR&NOM_sINS

4.4 Lexical composition of valency classes

The two distance metrics discussed in Sects. 4.2 and 4.3 each have their advantages and limitations. DistValEtym reflects subtle differences in the semantic composition of valency classes but relies on etymological equivalence and cannot be applied to unrelated languages. DistValLoc, on the other hand, is applicable to unrelated languages but only captures fundamental syntactic distinctions and collapses distinctions coded by individual cases and adpositions.

Ideally, a metric combining the strengths of DistValEtym and DistValLoc is needed. The challenge is that valency classes in unrelated languages cannot be directly equated, which calls for alternatives to metrics based on normalized Hamming distance. DistValPat, first introduced in Say (2014, p. 156) under a different label ("D"), addresses this by measuring dissimilarity in how two languages distribute verbs into valency classes without equating the classes themselves (see Gaszewski, 2020; Alfimova, 2024 for alternative approaches to this problem). The starting point for calculating DistValPat in a given language pair is a joint distribution, as illustrated for a subset of the Czech and German datasets in Table 8.

As shown in Table 8, less systematic correspondences between valency patterns observed in the two languages result in higher variation in the joint distribution. In a scenario with strict one-to-one correspondences, the joint distribution would mirror both language-specific distributions. Conversely, fully random correspondences would result in maximum variation in the joint distribution. The actual data always show an intermediate case. For example, Czech verbs with the "NOM_sINS" pattern often correspond to German verbs with the "NOM_mitDAT" pattern; however, the correspondences are not perfect, as seen with the Czech "NOM_naACC" pattern. The quality of such matches can be quantified by Mutual Information (MI), a well-known metric based on Shannon entropy (H). The formula for H is given in (16).

$$H(x) = -\sum_{i=1}^{k} p(x_i) \cdot log_e(p(x_i)) \quad (16)$$

In our case, values of x correspond to distinct valency classes observed in a given language (e.g., Czech) or in a joint distribution. Likewise, k is the number of possible patterns in a given language (for example, k equals 24 in the case of Czech). Finally, due to unavailability of actual probabilities of valency classes $p(x_i)$, relative frequencies serve as estimates for

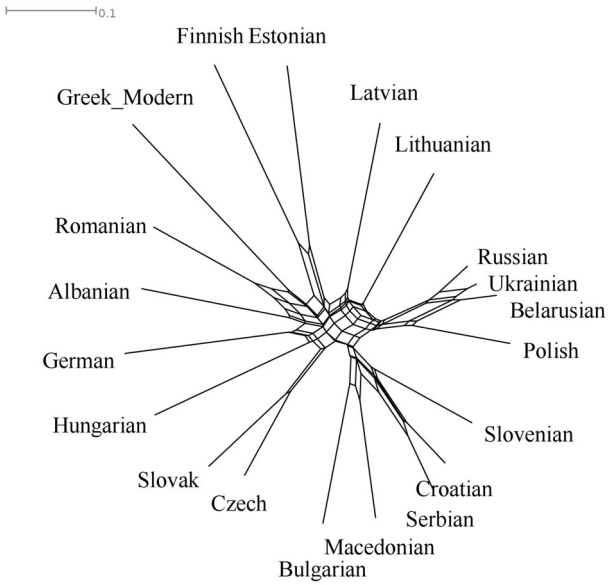

Fig. 5 NeighborNet visualization of DistValPat distances among Slavic languages and selected neighbors

these probabilities, which is a standard step in entropy-based approaches to linguistic phenomena (Ackerman & Malouf, 2013, p. 439; Levshina, 2019). In a nutshell, higher values of H correspond to more variable distributions.

As the next step, the formula for MI is given in (17).

(17) $\mathrm{MI}(X; Y) = \mathrm{H}(X) + \mathrm{H}(Y) - \mathrm{H}(X, Y)$ (Hausser & Strimmer, 2009)

Higher MI values occur when the entropy of the joint distribution is moderate, which happens when the two distributions are well-matched. By contrast, low MI values, with a theoretical minimum of 0, occur when the two distributions show fully random correspondences. As the final step, MI is converted into the distance metric DistValPat using the formula in (18).

(18) $$\mathrm{DistValPat}(L1, L2) = 1 - \frac{\frac{MI(L1,\ L2)}{H(L1)} + \frac{MI(L1,\ L2)}{H(L2)}}{2}$$

Like the previous distance metrics, DistValPat varies between 0 and 1, with higher values indicating greater differences between languages. Figure 5 shows a NeighborNet visualization of DistValPat, featuring the same languages as Fig. 4.

Figure 5 closely resembles Figs. 3 and 4, particularly in its depiction of the internal structure of Slavic languages. This is expected, as all three visualizations reflect the same underlying valency pattern distribution, differing only in how (dis)similarities are measured. However, Fig. 5 also reveals new insights. Notably, unlike Fig. 4, it shows a split separating Slavic and non-Slavic languages. At the same time, local convergences persist, linking specific Slavic and non-Slavic languages. One example is the cluster including Baltic languages, Polish and East Slavic languages, reminiscent of the proposed Circum-Baltic Sprachbund. Another is the cluster with Czech, Slovak, Hungarian, and German. This latter case arguably reflects the so-called Donaubund, a set of languages with multiple specific convergences in argument coding, which however are not strong enough to reshape the whole system of bivalent classes (Gaszewski, 2020).

Overall, the DistValPat metric primarily captures systematic similarities in valency class organization (occasional calques affecting only small parts of the verbal lexicon do not even necessarily decrease DistValPat values). Such systematic similarities are sometimes observed among Slavic languages, typically in small local clusters. Examples include Croatian and Serbian, Czech and Slovak, the Polish–East Slavic cluster (or, more precisely, two overlapping clusters: one with the three East Slavic languages and another with Polish, Ukrainian, and Belarusian), and the Eastern South Slavic cluster. Interestingly, despite shared features like tense organization or the lack of nominal case, Bulgarian and Macedonian still differ significantly in their verb distributions across valency classes, as seen in the long edges associated with these two languages in Fig. 5.

5 Summary and outlook

My analysis aimed to uncover similarities and differences in the distribution of bivalent verbs and their argument-coding patterns across 11 Slavic languages, contextualized within the broader areal background of Eastern and Central Europe.[22] Instead of separating lexical and syntactic dimensions (Gaszewski, 2020, p. 37), I employed an aggregate approach, combining both. This approach assumes that while the lexical-etymological distribution of verb roots is logically independent from the syntactic distribution of valency patterns, empirical correlations may exist. The observed synchronic distributions in the dataset shed light on diachronic processes shaping the Slavic linguistic landscape.

My first overarching finding is summarized in (19).[23]

(19) Different aspects of the organization of bivalent verbs and their valency patterns yield broadly consistent distributions across Slavic languages, revealing recurring areas of similarity and divergence.

Aligning with (19), similarities in valency structures are observed at all levels in pairs like Serbian and Croatian, Ukrainian and Belarusian, Czech and Slovak, and Bulgarian and Macedonian. While these convergences are expected, attributing them to specific mechanisms is complex. The challenge lies in distinguishing between genealogical explanations, which involve shared inheritance and parallel innovations, and areal explanations due to language contact, either among Slavic languages or with non-Slavic neighbors. Genealogical explanations inherently do not exclude areal factors, as closely related languages also tend to be involved in language contacts, including shared contacts with non-Slavic languages. Thus, proving a purely genealogical explanation is difficult. Instead, we can distinguish affinities explained by language contact from those explained by both genealogy and contact (Alfimova, 2024; Khachaturyan et al., 2025). In this context, a key methodological step is the

[22] As noted in Sect. 1, this paper may be seen as a follow-up to Seržant et al. (2022), sharing its theoretical perspective, some goals, and general methodology, while drawing on an independent dataset and employing different analytical techniques. Unsurprisingly, the two studies often reach similar conclusions, which I take as mutually reinforcing.

[23] This claim presupposes meaningful variation among Slavic languages, though the extent and significance of such variation remain open questions. While Seržant et al. (2022: 317–319) emphasize the overall homogeneity of valency class organization in Slavic, they also point to systematic differences beyond random noise. A robust assessment of whether this variation is "high" or "low" requires cross-family comparison using consistent methods—an undertaking yet to be carried out. Kozhanov and Say (2025), however, briefly suggest that Slavic exhibits greater internal diversity than Turkic or Romance, two taxa of comparable genealogical depth.

identification of non-trivial similarities between genealogically unrelated or distantly related languages (Grossman & Witzlack-Makarevich, 2019; Blinova & Shagal, 2020). This approach underlies the "benchmark principle" (see, e.g., Khachaturyan et al., 2025), which is instrumental in diagnosing the effects of language contact. While identifying such similarities is essential for proposing areal explanations, they are not, by themselves, sufficient to prove contact as the cause (Kim, 2020). With these caveats in mind, the following generalization emerges.

(20) In Slavic valency patterns, the areal dimension significantly influences the observed distributions and, in some cases, outweighs the genealogical factor.[24]

The clearest example supporting (20) is the link between Ukrainian, Belarusian, and Polish, which appears at various levels of valency pattern organization, from the lexical-etymological level to the distribution of patterns based on the locus of non-transitivity (i.e., whether oblique devices are involved in coding either of the two arguments in the bivalent construction). These convergences are so strong that in some respects, Polish valency patterns are closer to East Slavic languages than to Czech and Slovak. Despite Polish being a West Slavic language, the Polish – East Slavic connection demonstrates how areal processes can override genealogical distinctions.[25] In this respect, my findings fully align with the conclusions arrived at by Seržant et al. (2022), who also highlight the similarities between Polish and East Slavic systems and show that areal factors can override genealogical distinctions.

The (dis)similarites between Slavic languages revealed in this study lead to the next overarching generalization.

(21) Pathways of lexical renewal[26] may be largely independent of changes in the selection of valency pattern for a given meaning.[27]

The partial independence of lexicon and syntax shown in (21) is asymmetric: it is common for etymologically unrelated verbs to follow the same valency pattern despite lexical renewal (e.g., equivalents of #17 'tell' with the stable NOM_DAT pattern or #99 'have a quarrel' with the stable NOM_sINS pattern). The reverse case—cognate verbs appearing in different patterns due to valency class change—occurs less frequently.

On a more general level, a clear manifestation of (21) is the lexical convergence between Bulgarian and East Slavic languages, discussed in Sect. 4.1, which is not accompanied by significant convergences in valency patterns, as shown in Sects. 4.2-4.4. This may be explained by the fact that cultural influences, often through translations of individual texts, can easily affect lexical phenomena, whereas pattern replication requires deeper contact, such as widespread bilingualism.[28] A further twist, also consistent with (21), comes from comparing

[24] A similar quantitative result was recently obtained using comparable methodology for Romani dialects spoken in Europe (Kozhanov & Say, 2025).

[25] This generalization can be viewed quantitatively: centuries of intense contact with East Slavic languages had a greater impact on Polish valency patterns than the relatively short period of unity within the West Slavic branch.

[26] By "lexical renewal" I mean the replacement of an earlier lexical item with a different one—either borrowed or inherited with a shifted meaning. When two related languages use non-cognate words for the same meaning, this signals at least one event of lexical renewal.

[27] This generalization also echoes findings for Romani dialects (Kozhanov & Say, 2025).

[28] Dmitri Sitchinava (p.c.) notes that lexical similarities between Bulgarian and East Slavic languages, especially Russian, may reflect influence in both directions: the influx of Church Slavonic into Russian and, since 1878, the influence of Russian on Standard Bulgarian.

Bulgarian with Macedonian and with other South Slavic languages. Bulgarian and Macedonian show strong similarities in valency class distributions (see Sect. 4.2). Etymological relations between verbs show a gradient from Bulgarian to Macedonian, and then to Serbian and Croatian and finally to Slovenian (Fig. 2 in Sect. 4.1). Overall, the study supports the generalization that genealogical relationships primarily shape lexical (dis)similarities, while contact configurations play a larger role in syntactic (dis)similarities (Heeringa et al., 2023), including valency related (dis)similarities (Khachaturyan et al., 2025). This study is inherently limited to providing only indirect quantitative evidence for the claim in (21); ideally, it should be complemented by direct qualitative data from historical corpora, a task to be undertaken elsewhere.[29]

The final conclusion is presented in (22).

(22) The development of valency classes in Slavic languages is partially independent of the development of the coding devices involved.

The generalization in (22), supported by quantitative evidence, can be explained by mechanisms shaping the form–meaning mappings of flagging devices, especially during major shifts such as the loss of synthetic case on nouns. Sobolev (2008), for instance, demonstrated that new analytic forms in South Slavic dialects often spread across the same semantic networks once associated with older synthetic cases like the instrumental or genitive. This can lead to the functional reproduction of the original system using new forms. In this sense, the finding in (22) can stem from the historical process known as "renewal", see Reinöhl and Himmelmann (2017) for a critical reassessment.

The partial independence between the development of valency classes and coding devices, as reflected in (22), helps explain why the major morphosyntactic split between Eastern South Slavic (which lacks nominal case) and other Slavic languages (which retain six cases) does not define the primary division in Slavic valency class systems—especially when viewed in a broader areal context that includes other European languages. Deeper valency-related phenomena, such as transitivity, locus, and lexical composition of valency classes, show wide areal effects, positioning Slavic languages within the broader European context, as discussed in Sects. 4.3 and 4.4 and largely in line with the findings of Seržant et al. (2022). For instance, Czech and Slovak, while retaining their six-term case system shared with Polish, East Slavic, and Western South Slavic languages, exhibit areal convergences with non-Slavic languages in the distribution of verbs into specific valency classes (Sect. 4.4). Apart from this, Slavic languages follow a south-to-north decline in transitivity prominence, mirroring patterns in non-Slavic languages of Central and Eastern Europe, including the Balkans.

Supplementary materials The initial dataset used in this study, the distance matrices discussed in Sect. 4, and an additional MDS visualization mentioned in Sect. 4.1 are publicly available in a GitHub repository (https://github.com/serjozhka/Bivalent_verbs_Slavic_RL/tree/main) under the Creative Commons Attribution 4.0 International License (CC BY 4.0).

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[29] It also remains to be explored how genealogical and areal factors interact with lexical borrowing driven by cultural processes—a scenario that does not necessarily require areal proximity.

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Declarations

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