Distance-based approach reveals convergence effects in word order among the languages of the Circum-Baltic linguistic area

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We probe a new approach to linguistic areas. Instead of *similarity* of a feature across languages of the area, we focus on its *adaptation* to the area. Adaptation is a set of changes and/or retentions in a language towards, but not necessarily into, similarity with the other languages of the area. Technically, we estimate adaptation by comparing the distance between the focus language from the area and a geographically and genealogically closely related language outside of the area (its benchmark language) as *tertium comparationis*. If the focus language is closer to the area than its benchmark, we interpret it as evidence for adaptation towards the other languages of the area. Adaptation includes all possible scenarios of change and non-change. We test word order and find that all languages of the CB area show effects of adaptation, with Baltic Romani and both Baltic languages being in the center of the area.

Keywords: areal linguistics, distance-based approach, linguistic area, adaptation

1. Introduction

The **Circum-Baltic (CB) area** — a term coined in Dahl & Koptjevskaja-Tamm (1992), perhaps after *baltischer Sprachbund* in Jakobson (1931[1971]: 137) (for other terms and subareas see Matthiassen 1985; Stolz 1991; Nau 1996), — is an established linguistic area along with the Balkan or Mesoamerican linguistic areas. Although there is no full consensus on which languages should belong to the CB area, the following languages are generally included: Indo-European languages:

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Polish, 'Borderland' Polish (*polszczyzna kresowa*) (West Slavic), Russian, North-Western Russian dialects, Belarusian, the West Russian variant of Church Slavic (East Slavic), Lithuanian, Latvian, Latgalian (East Baltic), Low German, High German, Yiddish (West Germanic), Swedish, Danish (North Germanic), marginally Latin (Romance) as well as the Baltic, Finnish and Scandinavian dialects of Romani (Indo-Aryan); it further includes most languages of the Finnic subfamily, such as Livonian (nearly extinct), Estonian, Finnish, Veps, Karelian, Votic, etc., and the Saami subfamily of the Uralic family. Finally, Karaim (Kipchak, Turkic) belongs here as well. The map in Figure 1 shows the geographical locations of the languages (the languages analyzed in the paper are rendered by black and the other by gray points).[1]

Historically, speakers of East Baltic, East Slavic and West Germanic languages immigrated into the coastal region of the Baltic Sea generally later than speakers of Finnic languages and assimilated some of them. Likewise, speakers of North Germanic immigrated into Scandinavia after speakers of Saami. Other Indo-European tribes (e.g., the now extinct branch of West Baltic) might have predated the arrival of the Finnic population in the area (see Kalio 2015; Lang 2018).

Methodological and conceptual problems such as defining the boundary of an area ("The boundary problem"), establishing the set of languages that should belong to the area ("The language problem") or establishing the set of features of an area in a non-arbitrary way ("The feature problem") (Masica 1976; Dedio et al. 2019: 499; van Gijn 2020; van Gijn & Wahlström 2023: 179–180) hold for the CB area too (see, *inter alia*, Nau 1996; Koptjevskaja-Tamm & Wälchli 2001).

The identification of this area crucially relies on a list of linguistic traits that are in one way or another similar across subsets of the languages of the area and are less or not at all characteristic of the surrounding languages not included in the area (see the overviews of such lists for the CB area in Koptjevskaja-Tamm & Wälchli 2001 or Seržant, forthc.). While such "list approach" provides a good approximation of what may single out the languages of a linguistic area against their broader geographical background, it has a number of limitations, which we discuss in detail in Section 2 below.

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1. The map was created in R (R Core Team 2024) using the packages lingtypology (Moroz 2017), ggplot2 (Wickham 2016), sf (Pebesma & Bivand 2023; Pebesma 2018), rnaturalearth (Massicotte & South 2023), rnaturalearthdata (South et al. 2024), and ggrepel (Slowikowski 2024). The coordinates for the languages, if available, were taken from Glottolog 5.1 (Hammarström et al. 2024), and in other cases assigned to the approximate centers of the spread of the lects in question, as indicated in the code, available at Aktaş et al. (2025). The map indicates that High German as one of the languages analyzed in the paper, standing in this case for standard German.

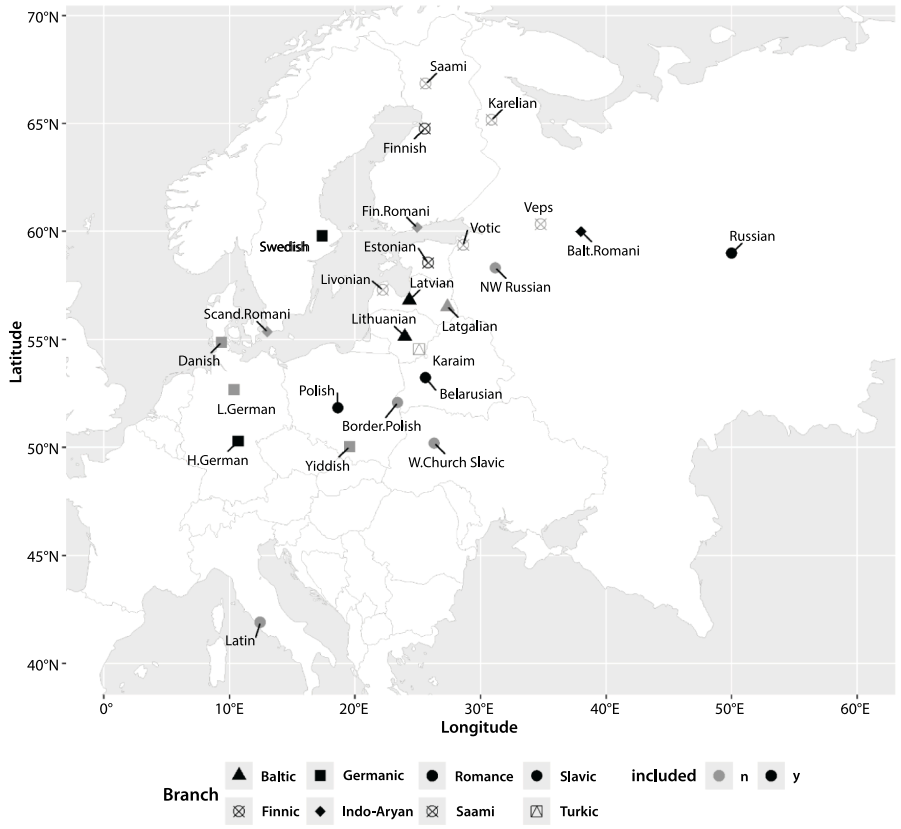

Figure 1. Languages of the Circum-Baltic area

To overcome a set of methodological and theoretical limitations, we put forward a new method that is crucially based on measurable distances between the languages within the area and their related languages outside of it (henceforth the **distance-based approach**) with respect to a specific phenomenon.

We test this method on word order. Word order figures prominently in the discussion of the CB area in Wälchli & Koptjevskaja-Tamm (2001). They show that CB languages — very much like the Caucasus — represent a transitional area in the general European development from Eurasian SOV (Proto-Uralic, Proto-Turkic, Proto-Indo-European) to SVO and from genitive-noun to noun-genitive (Wälchli & Koptjevskaja-Tamm 2001: 709). However, they remain cautious about whether or not there are CB-specific areal effects on word order.

We proceed as follows. In Section 2, we first highlight some of the weaknesses of traditional approaches, which are crucially based on the similarity of the phenomenon in the languages of the area. In Section 3, we present our distance-based approach to linguistic areas. Section 4 gives a brief overview of word order

patterns in the languages of the area. Section 5 presents our sample and the data. Section 6 discusses the specific computational methods used for the study to measure the distances. Finally, Section 7 presents the results of the study. In Section 8, we summarize and contextualize the results.

2. Why do we need a new approach to establishing convergence in linguistic areas?

It is thanks to traditional qualitative approaches that today we know so much about various linguistic areas around the globe. However, traditional approaches face quite a few limitations and methodological hurdles.

Areal linguistics emerged as an explanatory model of similarities across languages that is **complementary** to the explanations provided by the historical-comparative method, based on co-inheritance from the common ancestor language, as well as to the explanations based on universal preferences of languages (since Trubetzkoy 1923, 1928; Jakobson 1931). As a consequence, in areal linguistics, the standard has been to rely solely on those convergent traits that are neither universally preferred (Haspelmath 2001: 1493) nor found in genealogically (closely) related languages. For this reason, linguistic areas are often required to consist of unrelated or distantly related languages (*inter alia*, Emeneau 1956: 124; Campbell 1985; Aikhenvald & Dixon 2001: 11; van Gijn 2020: 164).

However, there is no complementarity between genealogical, areal and universal factors, rather overlap (see recently Seržant 2025). Effects of language contact accumulate and lead to areal convergence in genealogically closely related languages too (Breu 1994: 41). Closely related languages may even be more prone to transfer and thus to convergence than unrelated or remotely related languages because of their high structural similarity prior to contact (cf. the second factor in Matras 2007: 34). Structural similarity of contact languages facilitates diffusibility of patterns (*inter alia*, Haig 2001; Epps et al. 2014 and critically Bowern 2014). It has also been shown that, along with geographical proximity, genealogy ~~channels~~ innovations (sound change across dialects in Heeringa & Nerbonne 2001).

Not only contact-induced innovations are likely to be found in closely related languages in contact. Shared inheritance itself also does not always exclude effects of language contact because such effects may also manifest themselves in a pressure to preserve certain inherited traits, i.e., to contact-induced non-change (see, *inter alia*, Breu 1994; Seržant 2021; Seržant et al. 2022). For example, Seržant (2021) shows that the degree of preservation of the person-number inflection in Slavic languages from Proto-Indo-European was affected by language contact with the neighboring Indo-European and non-Indo-European languages.

An extreme example of a linguistic area consisting of genealogically closely related languages is dialectal areas (cf. van Gijn & Wahlström 2023: 185). Mutual contacts between dialects is the reason why dialects mostly do not drift apart but keep exchanging innovations and exercise contact-induced pressures to preserve of some of their inherited traits (see also Bowern 2013: 413–414). Thus, closely related languages should not be excluded.

Likewise, typologically frequent and universal phenomena may show areal skewing and should, therefore, be part of the descriptions of linguistic areas. For example, the two most frequent word orders — SOV and SVO — show areal skewing in Dryer (2013) such that SVO is typical for Europe and Southeast Asia while SOV for the rest of Eurasia (Dryer 2013).

Generally, universally preferred traits reflect preferences of human processor (or articulation apparatus) and, therefore, may even be more prone to borrowing and, thus, areal convergence than cross-linguistically rare or dispreferred traits. Concededly, it is methodologically difficult to show that a universally preferred trait is affected by language contact against the null hypothesis. For example, even though all languages of the Circum-Baltic area are SVO (Wälchli & Koptjevskaja-Tamm 2001: 704; Siewierska & Uhlířová 1998 on the Slavic languages), this cannot be regarded as a distinguishing feature of the languages of the area, since it is universally the second most frequent word order after SOV (Dryer 2013). However, methodological difficulties should not lead one to a priori exclude universal traits from areal convergence.

Another problem with traditional approaches is **selectiveness**. Since Trubetzkoy (1923, 1928), linguistic areas are traditionally described in terms of lists of areal traits (isoglosses or isopleths), see such lists for the CB area in Koptjevskaja-Tamm & Wälchi (2001) or Seržant (forthc.). Crucially, such traits are picked up by researchers primarily based on methodological considerations, i.e., on how plausible the null hypothesis can be rejected with these traits. The null hypothesis can easily be ruled out with typologically rare traits because they are usually not found outside of the area. However, such lists based on methodological selection may lead to skewed descriptions of linguistic areas, in which many potentially converging traits of the languages of the area remain unmentioned. By contrast, infrequent and marginal traits — or even negative descriptions (e.g. lack of infinitives) — are often included. For example, an established isogloss of the CB area is polytonicity (Jakobson 1931; Koptjevskaja-Tamm & Wälchli 200: 640–646), compare the textbook example *anden* 'duck.DEF' (pronounced with tone 1) vs. *anden* 'spirit.DEF' (pronounced with tone 2) from Swedish, or *tā* (the falling tone) 'DEM.GEN.SG.M' vs. *tā* (the sustained tone) 'DEM.NOM.SG.F' vs. *tā* (broken tone with a glottal stop) 'so' from Latvian. Since European languages outside of the CB area generally do not employ tonemic distinctions (Maddieson 2013), it is likely that an

areal impact must have promoted the retention (or even development) of at least some of the tonemic distinctions in CB. This isogloss is methodologically convenient because it is easy to prove as a property of the area against the null hypothesis. However, the informational contribution of tonemes in the languages of the area is minimal. There are only very few and only marginal minimal pairs and an L2 speaker not mastering distinct tones is never misunderstood. In this respect, the CB languages contrast to, say, languages of Southeast Asia, in which the distinctions of this type are crucial for successful communication.

In effect, the methodological rigor of traditional approaches to rule out the null hypothesis has the consequence that typological rara, cherry-picked, less salient and even negative phenomena become the best candidates for areal isoglosses. This, in effect, leads to inadequate descriptions of linguistic areas. As a consequence, considerable amount of structural parallelism among languages of an area (see Civjan 1979; Bužarovska 2020: 59 for Balkan), sometimes referred to as mutual translatability (Gumperz & Wilson 1971: 154–155) or effects of metatypy (Ross 2007), cannot be explored and described in full despite the intuition that linguistic areas tend to converge towards one grammar, cf. "…roughly the same thing can be said in the same way…" (Campbell 2006: 4).

Finally, another methodological problem of traditional approaches to linguistic areas is that these are crucially **similarity-based**. That is, these approaches rely on similarity of the phenomenon at issue across the languages of the area (since Trubetzkoy 1928; see also Campbell 2006). Methodologically, however, similarity represents a serious problem because linguistic traits never exactly match in any two different languages and are often quite diverse for the following reasons.

First, convergent phenomena often arise via different historical pathways in different languages. This is, for example, the case with tonal distinctions discussed above. This unavoidably leads to somewhat divergent outcomes.

Second, histories of linguistic areas often consist of migrations and complex, layered contact configurations (Nau 1996; Wälchli & Koptjevskaja-Tamm 2001). Since languages often migrate, hardly any linguistic area will attest language contact taking place over many thousands of years and achieving a high degree of convergence. For example, East Baltic and East Slavic languages occupied their current geographical locations in the CB area quite recently, no earlier than ca. 1000 years ago.[2] Yet, unless contacts last thousands of years it is likely that genealogically motivated traits will not only persist but also dominate even under intensive contacts.

2. The earlier population of the Eastern coastal regions of the Baltic Sea was primarily Finnic and probably West Baltic (but see also Kalio 2015; Lang 2018).

Third, languages normally do not arrive in an area all at once. The durations of contacts may strongly vary across the languages of an area and, therefore, their degrees of convergence.

Fourth, the specific historical, political, social and environmental processes may constrain and skew the degree of convergence among subsets of languages in an area (**contact configuration** in Seržant 2021), as has been repeatedly emphasized in the literature (Nichols 1992; Tosco 2000; specifically for CB in Nau 1996; Wälchli & Koptjevskaja Tamm 2001). For example, Livonian speakers must have all been bilingual in Latvian and the contact effects of Latvian on Livonian were accordingly much stronger than the effects of, say, German on Latvian since only a minority of Latvian speakers were bilingual in German.

Fifth, the degree of structural similarity of languages at the time of their arrival into an area may also be different and this may represent another obstacle for convergence despite intensive contacts. For example, German has a typologically rare V2 word order which likely emerged already in Proto-West-Germanic or even earlier, i.e., prior to the arrival of German in the CB area. By contrast, Finnic, East Baltic and East Slavic languages must have all originally been SOV, since Proto-Uralic and Proto-Indo-European were both SOV (Janhunen 1982 for Proto-Uralic and Watkins 1963; Dressler 1971; Lehmann 1974 for Proto-Indo-European). Thus, convergence in word order between East Baltic and Finnic languages required much less restructuring than convergence of these languages with German. We, therefore, *a priori* expect German to perform differently in our study than Baltic and Finnic languages.

Finally, without a clear baseline, similarity is a subjective measure, which is why scholars rarely achieve a general agreement on which linguistic traits are areal and which are not (Campbell 2006: 2; "the feature problem" in van Gijn & Wahlström 2023: 179–180). Eventually, it is up to the researcher to subjectively decide between the two options: (i) the differences between similar traits in the languages of an area are negligible and, therefore, these traits may be claimed to bear areal effects, or (ii) these traits are rather too different from each other for such a claim. For example, while for Jakobson (1931[1971]: 137), polytonicity is one of the defining traits of the CB area, Wälchli & Koptjevskaja-Tamm (2001: 640–646) are much more cautious. They discuss in detail the emergence of polytonicity in Baltic, Livonian (Finnic) and Scandinavian languages of the CB area and come to the conclusion that these systems are quite distinct in terms of time depth and pathways of their emergence in the three branches and cautiously conclude that it is "(~~U~~)nclear whether the three phenomena are related to each other" (Wälchli & Koptjevskaja-Tamm 2001: 729). Jakobson (1931[1971]) was certainly aware of the same facts but his subjective threshold for claiming contact effects was apparently lower than that of Wälchli & Koptjevskaja-Tamm (2001).

To conclude, since there will always remain some variation between similar phenomena across languages of any area, uncertainty and subjectivity as to whether or not the null hypothesis can be safely rejected will persist.

3. The distance-based approach

To avoid these methodological limitations, we propose another approach, namely, the **distance-based approach**. This approach implements a somewhat different concept of areal convergence, which is not based on similarity among languages, but rather on the concept of **adaptation.** Adaptation is any positive diachronic dynamics towards convergence with the other languages of the area. Such dynamics naturally results from any change in a language of an area towards the other languages of the area. It is likewise found if a language of an area does not change and retains its inherited pattern in contrast to its geographically and genealogically closely related languages outside of the area, which change away from the pattern of the area.[3] Adaptation does not need to result in a high degree of similarity. Minimally, adaptation may consist of just a change (or retention) **towards**, but not necessarily **into**, similarity with the other languages of the area. Various adaptation processes accumulate and lead to overall convergence. Convergence too does not often manifest itself in a high degree of similarity of linguistic phenomena across languages of linguistic areas (due to different arrival times of languages into an area, varying structural (dis)similarity prior to contact across subsets of languages in an area and thus the number of changes needed to achieve similarity, the total duration of mutual contacts in an area, the specific contact configuration in an area, etc.).

Accordingly, our method aims at capturing diachronic dynamics of languages and crucially relies on the question whether or not a language may be said to have undergone adaptation. We operationalize the concept of adaptation as follows. We suggest that adaptation is found if it can reasonably be shown that ~~languages undergo~~ (non)-changes away from ~~their~~ close relatives~~s~~ outside the area **towards** the languages of the area (drawing on Di Garbo & Napoleão de Souza 2023). In this respect, the distance-based approach follows more recent approaches such as Ranacher et al. (2021), Di Garbo & Napoleão de Souza (2023) or Sinnemäki et al. (2024), the major differences being that these studies

3. For example, German retains some of the cases of Proto-Germanic as opposed to its closely related language Dutch which loses these. Such a retention — as opposed to change in a closely related language — may indicate that German does undergo adaptation towards the neighbouring Slavic languages in the East in contrast to Dutch.

rely on similarity, categorical features and global sampling, while we work with adaptation and corpus data (Section 5).

We primarily draw on Di Garbo & Napoleão de Souza (2023). Their goal is to approach language contact from a typological perspective in order to explore and produce generalizations about worldwide contact scenarios. For this purpose, they developed a method that we draw on here. The method allows them to estimate the probability of contact effects on the Focus language by the Neighbor language without going into diachronic research and/or research into the specific contact situation. This method crucially relies on the notion of Benchmark language as a baseline. A Benchmark language is genealogically related to the Focus language but has no contact with either the Focus or the Neighbor language and serves as a *tertium comparationis*. Every potential aspect of similarity of a specific grammatical category between the Focus and the Neighbor language is compared to the Benchmark language. If the Benchmark language also exhibits a similar trait, a contact effect is not supported. However, if the Benchmark language deviates from the Focus language but the Focus language correlates with the Neighbor language then a contact effect from the Neighbor language on the Focus language can be safely assumed. In this way contact-induced similarities between languages are identified. This approach requires, accordingly, a special way of sampling, making sure that the dataset would consist of language triples. This, in turn, brings about limitations, some of which are similar to our approach, e.g., isolates or languages with only distant relationships are problematic because a reasonably justified Benchmark language is not available.

While the focus of Di Garbo & Napoleão de Souza (2023) is to put forward a better way to control for areal biases in typological research as well as typologizing over contact situations, our focus is reverse. We seek to explore and better understand linguistic areas, their internal composition, genealogical effects and contact effects on specific linguistic phenomena. We do not rely on similarity judgements and, instead, work with the concept of adaptation. We also adopt a more flexible definition of linguistic areas in (1), which allows for linguistic areas consisting (solely) of closely related languages and even (dia)lects of the same language, provided geographical contiguity.

(1) Definition of a linguistic area
A linguistic area represents an idiosyncratic clustering of linguistic traits in a geographical area (containing more than one lect) as opposed to the wider geographical background.

More specifically, our approach involves three steps.

First (Step 1), on the basis of previous research, we identify the set of languages (Focus languages) that have been claimed to belong to a linguistic area,

i.e., the CB area in this study (see the list of the CB languages above in Section 1). We take a subset of these languages, for which the relevant corpus data is available (see the list below in Table 1). For each language suggested to be part of the area, we establish its Benchmark language. A Benchmark language is a language that is next to the Focus language both genealogically and geographically, but which does not belong to the area. For example, Dutch is outside of the CB area, but it is genealogically and geographically close to German — a language inside the area. Similarly, Ukrainian (non-CB) is a Benchmark language for Belarusian (CB) and Russian (CB), see Table 1 in Section 5. Only Latvian and Lithuanian do not have Benchmark languages, since these languages are the only living Baltic languages. This is a natural limitation to the distance-based approach that applies to small (sub)families and isolates and it is not a constraint on the type of language that may be part of an area. Moreover, if there are only few such languages in the area, these can be tested later in the pipeline (see under Third).

Second (Step 2), we test whether there is a positive distance between the Benchmark language and the Focus language such that the Focus language (e.g., Belarusian) is closer to the languages of the area than its Benchmark language (Ukrainian) with respect to the phenomenon at issue, i.e., word order in this study. If so, then Belarusian can be claimed to have undergone some adaptation processes with respect to its word order. We repeat the procedure subsequently for all languages of the area which have Benchmark languages. We thus identify the set of adapting languages with respect to the specific linguistic phenomenon.

Under the distance-based approach, it is entirely irrelevant whether the areal impact was conservative, i.e. exercising pressure for no change, or innovative, i.e. exercising pressure for change. That is, it is irrelevant whether, say, Belarusian has preserved from Proto-East-Slavic more similarities with the languages of the area than Ukrainian or whether Belarusian developed some innovations towards the patterns of the area which Ukrainian did not. What matters only is that, with the respect to the trait, the difference between Ukrainian and the CB languages is larger than the difference between Belarusian and the CB languages.

Third (Step 3), if there are some Focus languages without a Benchmark language in the sample, such Focus languages can now be tested relative to the other Focus languages by comparing their averaged distances to the other languages of the area. If the distance of such a Focus language (e.g. Latvian) to the other languages of the area is similar or lower than the average distance of the other Focus languages to the area, then such Focus language may also be considered as adapting to the area even though it could not be tested via Benchmark.

Finally (Step 4), once the set of adapting languages has been established, we may explore the internal composition of the area, based on pairwise (dis)similarities between the languages of the area, technically implemented as pairwise distances.

We summarize these steps in (2), indicating sections of the paper where we discuss the respective steps of our study:

(2) The distance-based approach

Step 1:	"Setting up the data" (Section 5) *Identify the linguistic phenomenon; identify the set of languages (Focus languages) to be tested for areal convergence as well as the set of the Benchmark languages outside of the area.*
Step 2:	"Identifying convergent languages" (Section 7) *Explore whether there is a distance between the Focus and its Benchmark such that the Focus is closer to the other languages of the area than its Benchmark.*
Step 3 (optional):	"Comparing Focus languages without Benchmarks to the other Focus languages" (Section 7)
Step 4:	"Exploring internal relations within the convergent languages" (Section 7) *Explore and explain the degree of similarities across the convergent languages.*

4. Word order

We test the order of words in sentences in the running text. While fine-grained categorical data in principle is compatible with the distance-based approach as well, in this paper, we rely on corpus data (Section 5). The reason is that it has been repeatedly emphasized that typological word order types such as SVO vary greatly across languages as to their corpus frequencies (Mithun 1987; Dryer 1989; Downing 1995: 19; Levshina et al. 2023). Languages vary in the exact conditions of the occurrence of their basic word orders and thus in the frequencies with which these word orders are found in corpora. Different factors may affect word order in a language such as the lexical (animacy, part-of-speech) and discourse (giveness, definiteness) factors (Dryer 1997: 73), information-structural profiles the particular word orders may have (Mithun 1987; Dryer 1989), interactional factors affecting word order such as turn-taking (Downing 1995; Du Bois 2014; "intersubjective coordination" in Verhagen 2005; Tanaka 2005; Selting & Couper-Kuhlen 2000: 86–89), specific effects of more efficient sentence processing (e.g. Seržant et al., ~~forthc.,~~ on Russian) and possibly other factors. The combinations and the impact of specific factors and their effect size are obviously language-specific and thus idiosyncratic. Correlations in idiosyncratic traits is a methodological requirement to argue for effects of language contact against the null hypothesis of genealogical effects and/or spread of universally preferred

and common traits, see (1) above (Seržant 2015: 330–331; Seržant, forthc.). Specific corpus frequencies — in contrast to biases (e.g. for OV vs. VO) — can only be language-specific and can neither be universally preferred nor inherited over generations.

Specifically, we explore the frequency and the degree of match in the order of words across sentences on the basis of parallel translations of the same text (Bible) for 10 Circum-Baltic languages. We approach the comparison of the word orders agnostically by comparing the sequences of words in every sentence. We do not directly explore the distribution of typological primitives such as S, V and O as is usually done in large-scale type-based typological works (like Dryer 1989, 1992, 2011). The typological primitives S, V and O are also unlikely to be sufficient for identifying the points of variation and correlations across our languages as they gloss over many different types of syntactic structures such as complex predications, various non-argumental and oblique object NPs, discourse particles, etc. Our approach indirectly captures fine-grained linear differences, which, however, remain to be identified and described in more detail in future work.

5. Data

The study is based on the Parallel Bible Corpus comprising ca. 900 translations into 830 language varieties (Mayer & Cysouw 2014; Plungian 2023; see a collection of papers based on this corpus in Khomchenkova et al., eds., 2023). From this corpus we extracted 16 languages, of which 10 belong to the Circum-Baltic area (Focus languages) and another 6 are CB-external languages which are close to these 10 Focus languages genealogically and geographically and will be used as Benchmark languages.[4] Table 1 summarizes our sample.

4. We relied on previous research that determines which languages are part of the CB area and which are not. However, theoretically our method may be used to provide evidence in favor or against including a language into an area depending on its similarity to the other languages of the area and crucially on its distance to its close relatives that are unequivocally outside of the area, if the evidence from different phenomena would accumulate towards the area. Furthermore, we did not include different dialects and diachronic layers of the same languages for convenience. Thus, Low German is not included into the sample even though this was an important language in the beginning of the Hansa in the region (13–14th c.). This language can easily be added in subsequent research. Low German quite soon ceased to be the main language of Hansa as more and more traders from High German areas became active in Hansa. German trade documents were prevailingly composed in High German since then.

Table 1. Languages of our sample

Language	Branch	Family	Part of the area	Benchmark language	Bible translation, metadata*
Belarusian	East Slavic	Indo-European	yes	Ukrainian	"Belarusian New Testament and Proverbs." Translated by A. Bokun. 2023.
Czech	West Slavic	Indo-European	no	–	"Czech Bible, 21st century translation." Biblion (First edition) 2009.
Dutch	West Germanic	Indo-European	no	–	"The Bible in Dutch." Biblica, Inc. 2007.
Estonian	Finnic	Uralic	yes	Hungarian	"The Bible in Estonian." Estonian Bible Society. Eesti Piibliselts 1997.
Finnish	Finnic	Uralic	yes	Hungarian	"The Bible in Finnish." Version of 1992.
German	West Germanic	Indo-European	yes	Dutch	"The New Testament in German." Abraham Meister Version. 1989.
Hungarian	Ugric	Uralic	no	–	"The New Testament in Hungarian. Simple translation." World Bible Translation Center. 2012.
Latvian	Baltic	Indo-European	yes	absent	"Revised Latvian Bible". Revised translation from 1965. Latvian Bible Society. 1997.
Lithuanian	Baltic	Indo-European	yes	absent	"The Bible in Lithuanian Bible, Ecumenical edition." Bible Society of Lithuania. 1999.
Norwegian	North Germanic	Indo-European	no	Swedish	"The Bible in Norwegian (bokmål)." The Norwegian Bible Society. 2011.
Polish	West Slavic	Indo-European	yes	Czech	"The New Covenant Translation of the Bible in Polish." Evangelical Bible Institute. 2011.
Russian	East Slavic	Indo-European	yes	Ukrainian	"The New Testament — A modern Translation in Russian." Corporation World Bible Translation Center. 2011.
Swedish	North Germanic	Indo-European	yes	Norwegian	"The Bible in Swedish." Swedish Bible Society. 2000.
Ukrainian	East Slavic	Indo-European	no	–	"The Bible in Ukrainian." 2009.

Table 1. *(continued)*

Language	Branch	Family	Part of the area	Benchmark language	Bible translation, metadata*
Baltic Romani	Indo-Aryan	Indo-European	yes	Vlax Romani	"St John's Gospel in Lettish Romani." 1933. British and Foreign Bible Society. 1933, 2016.**
Vlax Romani	Indo-Aryan	Indo-European	no	Baltic Romani	"New Testament in Romani." 1984 — Ruth Modrow. Ramosardya pe rhertia pala International Gypsy Publications Inc, Seattle USA.

* The translations we used are available in the following documents of the corpus: File: pol-x-bible-nowagdansk.txt, Lines: 7958, Tokens: 179804; File: rus-x-bible-modern2011.txt, Lines: 7958, Tokens: 196672; File: lit-x-bible-ecumenical.txt, Lines: 31157, Tokens: 677209; File: bel-x-bible-bokun.txt, Lines: 7958, Tokens: 179454; File: fin-x-bible-1992.txt, Lines: 31170, Tokens: 678920; File: ces-x-bible-bible21.txt, Lines: 31163, Tokens: 704965; File: nob-x-bible-2011.txt, Lines: 7491, Tokens: 194244; File: ukr-x-bible-2009.txt, Lines: 31173, Tokens: 762472; File: eng-x-bible-common.txt, Lines: 7942, Tokens: 210762; File: swe-x-bible-2000.txt, Lines: 35161, Tokens: 878160; File: deu-x-bible-meister.txt, Lines: 7957, Tokens: 209006; File: est-x-bible-1997.txt, Lines: 31173, Tokens: 724525; File: rmy-x-bible-vlax.txt, Lines: 7958, Tokens: 224382; File: nld-x-bible-2007.txt, Lines: 7920, Tokens: 228476; File: lav-x-bible-1997.txt, Lines: 7956, Tokens: 178259; File: pol-x-bible-covenant.txt, Lines: 7956, Tokens: 180128; File: rml-x-bible.txt, Lines: 879, Tokens: 18670; File: hun-x-bible-2012.txt, Lines: 7943, Tokens: 210886.

** This is one of the earliest Bible translations into Romani. It was translated by a native speaker Janis Lejmanis who was a Latvian Rom and a member of the Orthodox Church. His translation was checked both by an educated Rom from Latvia and by the Scottish scholar Sir Donald MacAlister (1854–1934) (van den Heuvel 2020: 461).

Unfortunately, Baltic Romani only includes some parts of the entire Bible text (approx. 10%), which means that the comparison of word order for Romani vs. all other CB languages relies only on this part. We think, nevertheless, that given the amount of the text (~~more than 24.000 verses~~), this did not affect our analysis.

With the other languages we examined, ~~the entire texts~~ available. We did not perform any adjustments of the amounts of texts used across the language and strived for the maximum text lengths available in the Parallel Bible Corpus. Larger text amounts capture more variation in each of the languages, making sure that our results are more robust against potential text-internal variation.

When it comes to the Bible translations chosen for our study, we purposely selected the newest translations, which are presumably less influenced by the translational tradition and closer to the contemporary language. This was important in order to minimize translational effects of one language on the other. Modern translations aim at better comprehensibility of the Bible text and care ~~much~~

less about preserving older styles which themselves are often biased by the original text (i.e. by languages such as Latin, Greek, Biblical Hebrew, Church Slavonic, etc.).

Finally, we considered the modern Bible translations to be a better parallel text than literary translations of, e.g., Harry Potter. While the Bible translator has only one goal, namely, to render the meaning of the original with as few deviations from the original as possible, this is not the case with literary translation. Here, the translator also has other goals such as style issues, finding comparable cultural habits, expressions and objects, etc., and is also much freer in her/his translation. This often leads to the selection of deviating constructions even though, potentially, the same construction would have been available in the language of translation. This, in turn, brings in noise effects that skew the comparability of such parallel texts. While modern Bible translations primarily rely on the originals in the classical languages that are not part of the CB area, literary translations are often done from an intermediate language. Thus, Latvian translations are often done from Russian and not from the original text, which would have brought in a strong bias for Russian in Latvian.

6. Computation

In order to compare word order across all sentences in the 16 languages, first, the words in each language pair were automatically aligned. This was achieved by employing the eflomal application, which is based on the earlier efmaral tool (Östling & Tiedemann 2016). The eflomal tool automatically aligned words[5] for all matching sentences across the 16 languages. Specifically, we utilized Model 3 of the eflomal tool that is the successor to earlier alignment models and has demonstrated superior performance in preliminary evaluations for several language pairs compared to other models. The tool provides every aligned word pair with the word positions in the sentences. An example of the outcome of eflomal for a sentence pair in English and German (taken from the Bible corpus) is given in Figure 2.

5. Eflomal aligns all tokens in the sentences, including punctuation marks in addition to words. However, for the sake of simplicity, we will refer to the 'word' as the minimal unit in the sentence. Note that punctuation or orthography does not influence the results. In the languages under analysis, in order for the punctuation signs to mismatch there needs to be mismatch in word order. We additionally checked whether the distances calculated based on words only and not taking into account punctuation marks differ from those we use in the paper. We found only no differences and a perfect correlation of 1 between the two matrices, using Mantel test from the package vegan (Oksanen et al. 2025).

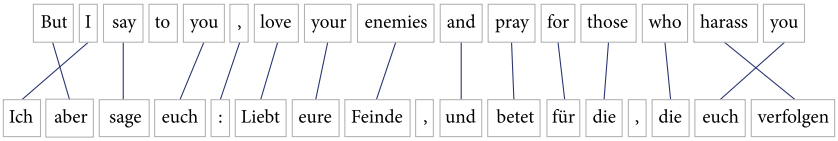

Figure 2. An example for the world alignment in the German and English Bible translations

In this sentence, there is a word pair *I-Ich*, with the positions 1–0, meaning that *I* is the second word in the English sentence and *Ich* is the first word in the German sentence (with numbering starting from 0). The crossing lines in Figure 2 indicate that two words in the English sentence (i.e., *But* and *harass*) are not in the same linear order as their correspondences in German. However, all other words maintain the same linear order. In this case, the distance for this sentence between German and English would be calculated by dividing 13 (the number of words in the same linear order) by 15 (the total number of words in the English sentence that are aligned with words in the German sentence) and then subtracting the result from one. Thus, the distance between German and English for this sentence pair is 1–0.87 = 0.13. Once we computed distances for all aligned sentences ~~and language pairs~~, we calculated the average distances for each language pair. These average distances represent mutual word-order distances between each pair of languages.

In case of periphrastic constructions in which, for example, a preposition plus a lexical noun, say *mit* 'with' plus NP in German correspond to one word in the other language, say, the noun in the instrumental case in Belarusian, the algorithm aligns only the lexical correspondence and ignores the function word. This is found with *to* in the English sentence in Figure 2 which is rendered in the dative-marked pronoun in German and has, therefore, no alignment pair. In this way the distinction between periphrastic vs. synthetic forms does not influence the alignment and, thus, the differences between more synthetic languages like Estonian vs. more analytic languages like German cannot affect our results.

7. Results[6]

As the first step in our analysis, we estimated whether each Focus language of the CB area is closer to the other CB languages than its Benchmark language, with respect to the order of words in sentences. Then, we tested whether these

6. The data and the code for the analysis and visualizations discussed in this section are available at Aktaş et al. 2025.

differences, technically distances, between each CB language and its Benchmark language are statistically significant. This allowed us to estimate whether the languages of the Circum-Baltic area form a cluster as opposed to the surrounding languages, cf. (1) above.

As an example, consider the pair of Polish, which belongs to the CB area, and Czech, which is its Benchmark language. Czech is close to Polish both genealogically (both belong to West Slavic) and geographically, but Czech does not belong to the CB area. Table 2 shows the distances between each of these two languages and the other languages of the area.

Table 2. Distances of Polish and its Benchmark language Czech to the languages of the Circum-Baltic area (except Polish)

	Baltic Romani	Belarusian	Estonian	Finnish	German	Latvian	Lithuanian	Russian	Swedish
Polish	0.08	0.11	0.14	0.15	0.13	0.13	0.12	0.12	0.14
Czech	0.15	0.15	0.17	0.18	0.17	0.13	0.16	0.14	0.17

Except for Latvian, Polish is consistently closer to the languages of the CB area than its Benchmark language Czech. To check the statistical significance of these differences, for each pair of the CB languages and their Benchmarks, we used Wilcoxon signed-rank test. Table 3 shows the mean distance of each language of the area to the remaining languages of the area and the mean distance of its Benchmark language to the same set of languages. It also shows the *p*-values and the effect size[7] obtained as a result of the tests for each pair under comparison (the sample size, i.e., the number of paired distances under comparison, always equaled eight). Two of the languages outside of the area, Hungarian and Ukrainian, are used as Benchmark languages twice, and have two mean values, depending on which language of the area they are compared with. Baltic languages do not have a Benchmark language outside of the area, but the mean distance to the remaining languages of the area is also given for them.

Table 3 shows that all languages of the CB-area have smaller distances to the other CB-languages under comparison as compared to their Benchmark languages. The differences for all pairs are statistically significant with a large effect size, with the exception of Swedish and Norwegian, where the difference does not reach significance.

7. The effect sizes for the Wilcoxon signed-rank tests were calculated using the finction wilcox_effsize of the R package rstatix (Kassambara 2023).

Table 3. Mean distances of the languages of the area and their Benchmark languages (if available) to the other languages of the area and the results of Wilcoxon signed-rank test (p-values and the effect size) for each pair of languages of the Circum-Baltic area and their Benchmark languages

Language of the Circum-Baltic area	Mean distance to the other CB-languages	Benchmark language	Mean distance to the other CB-languages	p-value	Effect size
Baltic Romani	0.08	Vlax Romani	0.17	0.009	0.89
Belarusian	0.12	Ukrainian	0.16	0.009	0.89
Estonian	0.12	Hungarian	0.21	0.009	0.89
Finnish	0.13	Hungarian	0.21	0.009	0.89
German	0.14	Dutch	0.26	0.004	0.89
Polish	0.12	Czech	0.16	0.01	0.87
Russian	0.12	Ukrainian	0.16	0.01	0.85
Swedish	0.13	Norwegian	0.14	0.3	
Latvian	0.11	*	*	*	*
Lithuanian	0.11	*	*	*	*

The only likely explanation of these non-accidental and substantial differences between the Focus and Benchmark languages is that the Focus languages underwent adaptation with the other languages of the area (Step 2 in (2) above). From this it follows that the CB languages have undergone historical changes (or non-changes) which resulted in them being closer to each other in contrast to their Benchmark languages. At the same time, this approach allows the CB languages to be distinct from each other; what matters only is that the CB languages show a statistically significant difference from their Benchmarks towards the other languages of the area.

Moreover, given that the average distances of the two Baltic languages, which lack Benchmarks, are below the respective distances of the other CB languages (with a Benchmark), we can safely assume that both Baltic languages are also likely to have adapted their word orders to the area (Step 3 in (2) above).

The mean distances given in Table 3 are visualized in Figure 3, which represents the difference between the CB-languages and the Benchmark languages graphically.

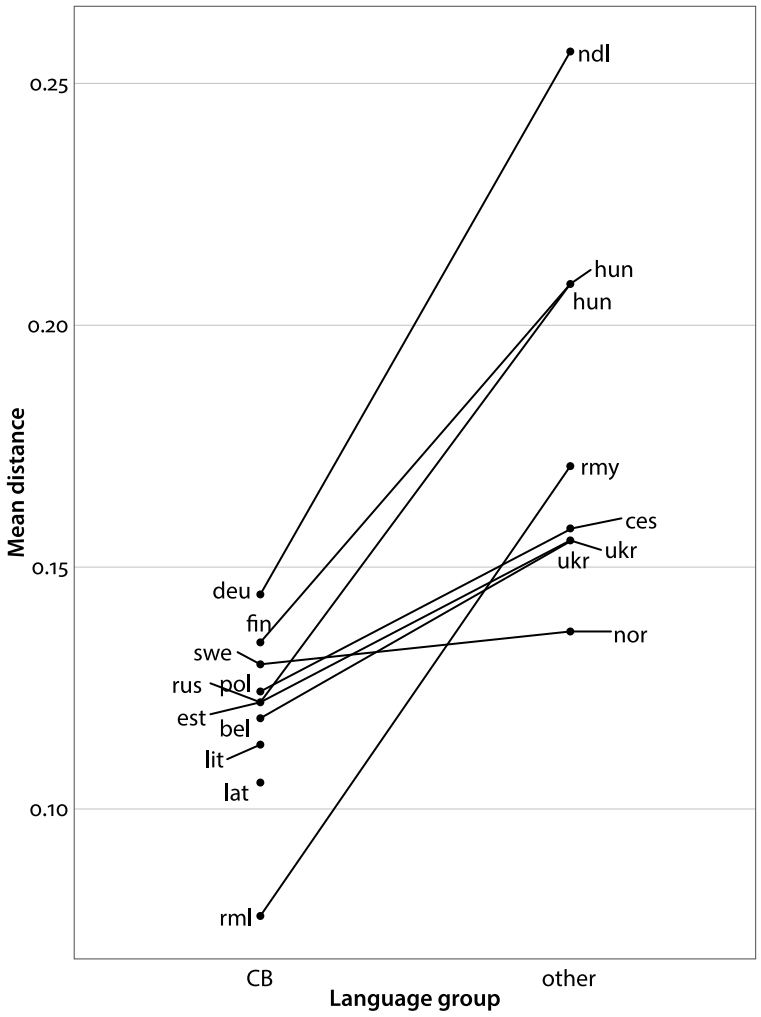

Figure 3. Mean distances between the languages of the sample to the CB languages[8]

The steepness of the lines in Figure 3 can also be interpreted in terms of the amount of adaptation of each of the languages to the other members of the CB area as well as the effect of the genealogical and geographical distance between Focus and Benchmark languages. It is not easy to disentangle these two effects.

8. In Figure 3, as well as in Table 4 and Figures 4 and 5 below, we use the ISO 639–3 abbreviations for the languages: *bel* — Belarusian, *ces* — Czech, *deu* — German, *est* — Estonian, *fin* — Finnish, *hun* — Hungarian, *lat* — Latvian, *lit* — Lithuanian, *nld* — Dutch, *nor* — Norwegian, *pol* — Polish, *rml* — Baltic Romani, *rmy* — Vlax Romani, *rus* — Russian, *swe* — Swedish, *ukr* — Ukrainian.

Thus, Hungarian — as opposed to more closely related languages such as Erzya or Moksha (not according to Glottolog) — is more distant from both Finnic CB languages Finnish and Estonian, both geographically and genealogically. These languages also have the largest distance between Focus and Benchmark. However, Dutch and German are closely related both genealogically and geographically but nevertheless show a large distance between Focus and Benchmark, which indicates that German is highly adapting. Even though being highly adapting, it is, nevertheless, as predicted above in Section 2, a language that is still the most distant from the other languages in the area (average distance is 0.14). This is an effect that might be explained by quite a special word order of German prior to contact.

Swedish is the least adapting language as it deviates from its Benchmark language Norwegian towards the languages of the CB area only very slightly. This evidence supports previous claims about the CB area that the Eastern part thereof is subject to more intensive contact effects than the entire area, which also includes Scandinavia.

Given that Baltic Romani shows the least distance to all the other CB languages (0.08) and that it has one of the highest distance to its Benchmark, we may conclude that Baltic Romani quite intensively developed towards the CB area and it is one of the most adapting languages in the area. One of the reasons why Baltic Romani is highly adapting might be sought in the fact that Romani dialects are not standardized languages and are subject to language ideology and prescriptivism to a much lesser extent than the other languages of our sample, which are official languages in the respective states. Thus, Romani dialects seem to be generally more flexible in adapting word order traits of their contact languages. Matras (2002: 167–169) lists a number of innovations in word order Romani dialects adopted from their neighbors. For example, Matras (2002: 168) notes that, under Slavic influence, some Romani dialects acquired a new "tendency to place the object, and especially the pronominal object, before the verb."[9] By contrast, Sinti varieties have adopted the German word order to a different extent; Romani dialects in Azerbaijan and Turkey tend towards verb-final order, as in Western-Oghuz Turkic (Matras 2002: 168).

Now we turn to Step 4 of our approach, as described in (2), and explore the internal composition of the CB languages with respect to the order of words. Here, we no longer focus on the dissimilarity of the Focus languages with their Benchmark languages but rather highlight the similarities among the CB languages since

9. Pronominal objects prefer OV in Russian, for example, despite the fact that this language is generally VO (Seržant et al., ~~forthc.~~).

they have been shown to be adapting to the area with respect to word order in Step 2.

First, we explore the structure of the area by looking at the mean distances of the CB languages to each other. The overall picture of word-order distances in the CB and non-CB languages under scrutiny is found in Table 4. This table shows one half of the distance matrix only, as it is symmetrical about the diagonal. The darkness of the shading corresponds to the distance value. The Circum-Baltic languages are grouped in the left part of the table.

Table 4. Distances between the languages

	CB											Other				
	bel	**deu**	**est**	**fin**	**lav**	**lit**	**pol**	**rml**	**rus**	**swe**	**Cgs**	**hun**	**nid**	**nob**	**rmy**	**ukr**
bel	0	0,14	0,15	0,15	0,14	0,11	0,11	0,04	0,09	0,14	0,15	0,22	0,30	0,15	0,17	0,11
deu		0	0,14	0,20	0,12	0,15	0,13	0,09	0,17	0,16	0,17	0,25	0,26	0,17	0,19	0,16
est			0	0,11	0,08	0,11	0,14	0,09	0,14	0,14	0,17	0,20	0,29	0,13	0,20	0,18
fin				0	0,09	0,14	0,15	0,09	0,13	0,15	0,18	0,20	0,31	0,13	0,21	0,20
lav					0	0,08	0,13	0,08	0,13	0,10	0,13	0,20	0,18	0,12	0,11	0,15
lit						0	0,12	0,07	0,10	0,14	0,16	0,21	0,30	0,14	0,20	0,18
pol							0	0,08	0,12	0,14	0,11	0,23	0,21	0,14	0,13	0,14
rml								0	0,09	0,07	0,15	0,12	0,16	0,10	0,08	0,11
rus									0	0,13	0,14	0,22	0,29	0,15	0,17	0,13
swe										0	0,17	0,23	0,27	0,07	0,16	0,17
ces											0	0,24	0,28	0,16	0,22	0,19
hun												0	0,29	0,22	0,22	0,23
nld													0	0,25	0,26	0,32
nob														0	0,16	0,16
rmy															0	0,20
ukr																0

Here, we also see that Baltic Romani is generally very close to the other languages of the CB area. Furthermore, Latvian (Indo-European, Baltic) is as close to its close relative Lithuanian (0.08) as to Estonian (0.08) (Finnich, Uralic). This specific contact configuration of Latvian is motivated historically. This language was closely affiliated with Estonian for political reasons both during the time of Livonia (founded by the Teutonic Order by the end of the 12th c.) as well as later under the Swedish reign (up until 1721). In turn, Lithuanian was part of the Polish-Lithuanian Commonwealth (up until 1795) together with Belarusian and Polish and it, indeed, shows lower distances to these languages. German is on average

more distant to the languages of CB area than the other languages, which is also expected given that this language was only dialectally and as a superlect present in the CB area. Languages that are the closest to German (within CB) are: Latvian (0.12), Estonian (0.14), Polish (0.13) and Baltic Romani (0.09).[10] These results lend support to our approach as we find smaller distances between those languages for which we independently know about their more intensive contacts. In turn, large and dominant languages such as German, Russian or Swedish extend beyond the CB area and are, therefore, likely to be more distant from the other CB languages of the area. Indeed, this is what we find in Figure 5 below, thus lending support to our method.

To visualize these distances, we used a Multidimensional Scaling algorithm, as implemented in the package smacof (Mair et al. 2022) in R (R Core Team 2024). This dimensionality-reduction method is used to represent distances between objects in a 2- or 3-dimensional space, aiming at a minimal distortion of the distances. The degree of distortion is expressed in a value called stress, with the acceptable values of stress being lower than 0.20 (Levshina 2015: 341). The 2-dimensional visualization of our distance matrix in Figure 4 has the stress value 0.24, which is above the acceptable threshold. However, the 3-dimensional visualization in Figure 5, which has an acceptable stress value of 0.17, shows basically the same picture, with the languages of the Circum-Baltic area being closer to each other, and the other languages at the periphery of the graph.

What we see in Table 4, Figures 4 and 5 is that the languages of the Circum-Baltic area (marked with black dots) generally cluster closer to each other than to their Benchmark languages (crossed circles in Figure 4, grey dots in Figure 5). MDS thus likewise provides evidence for adaptation of word orders in the CB area.

Alongside the adaptation, the genealogical signal is very strong, since many closely related languages are found next to each other in Figure 5: the three East Slavic languages (Ukrainian, Belarusian, Russian), and, not far from them, Polish (which is a West Slavic language) are placed next to each other.[11] Likewise, Scandinavian languages (Norwegian and Swedish), and the two Finnic languages

10. Interestingly, we do not see much of the effect of written Estonian being largely also V2 like German (Vihman & Walkden 2023) in our data. This might have many different explanations. For example, the verb-second position is natural in any SVO language and might be the most frequent one in any of the languages of the area and, at the same time, Estonian is not yet strictly a V2 language like German. This is probably why Estonian does not perform as the most closely associated language with German but is rather just one of the subset of the languages more similar to German, among Latvian, Polish and Baltic Romani.

11. Note that Polish — in contrast to the other West Slavic languages such as Czech — patterns with East Slavic also in other traits, for example, in argument marking (see Seržant et al. 2022) or aspect (Dickey 2000).

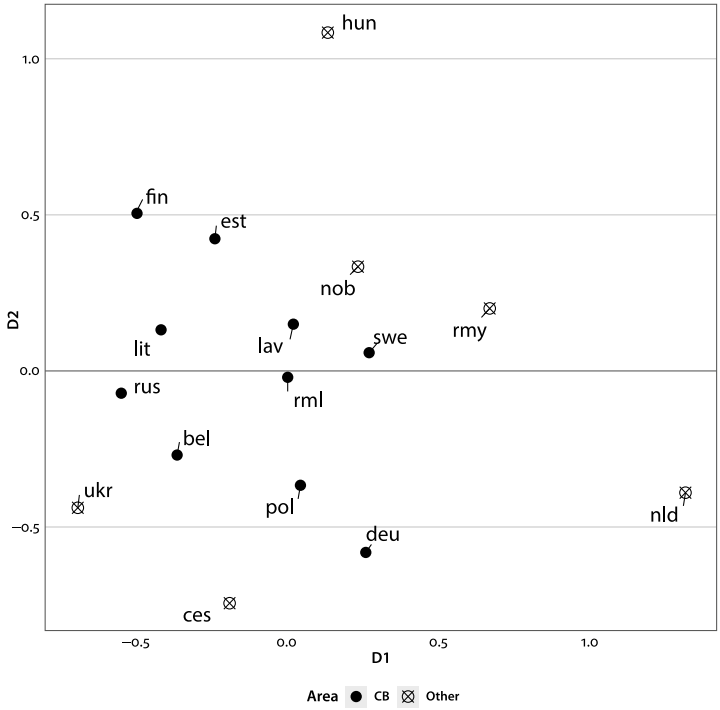

Figure 4. The 2-dimensional MDS-plot visualizing word-order distances between the languages

(Finnish and Estonian) pattern close to each other. The two Baltic languages Latvian and Lithuanian are very close to each other as well.[12] The row numbers in Table 4 above also indicate this: the distance between Lithuanian and Latvian is the smallest (0.08) for Lithuanian. It is also the smallest for Latvian, which, however, in addition, has the same minimal distance with Baltic Romani and Estonian.

To support our observations on adaptation of the CB languages to each other, we tested for the correlation between the distances based on word order and the membership in the CB area, controlling for the genealogical affiliation. To do this, we used partial Mantel test, which checks for the presence of correlation between two matrices (in our case, word-order distances and membership in the area), controlling for the factor given in the third matrix (genealogical "distance"). We encoded the membership in the area as 1 for the pairs of CB languages and 2

12. Recall that MDS is a 3-dimensional representation of an originally multidimensional space so some information might be lost in the visualization. This is the case in two-dimensional Figure 4 as opposed to three-dimensional Figure 5 where both languages are close to each other on a dimension that disappears from Figure 4.

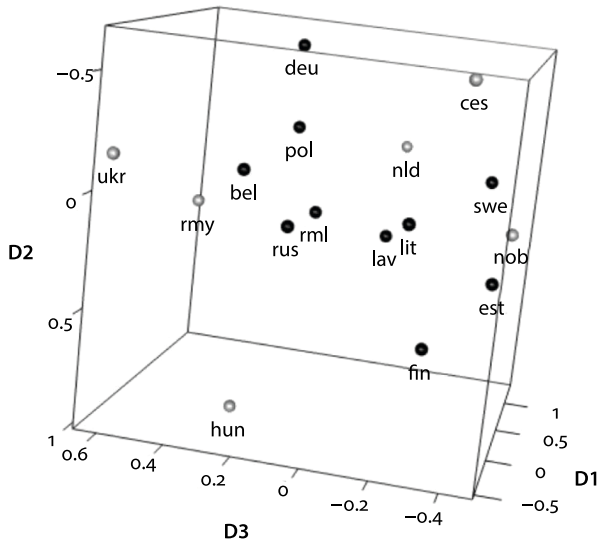

Figure 5. The 3-dimensional MDS-plot visualizing the word-order distances between the languages

for all other pairs, and the genealogical relations as 1 for pairs belonging to the same subfamily (such as Slavic or Finnic), 2 for the pairs of languages from different subfamilies within the same family, and 3 for the languages from different families. The test showed a significant correlation between the word-order distances and the membership in the area (Mantel statistic $r = 0.57$, $p = 0.002$). We also tested for the significance of the correlation between the distance matrix and the matrix encoding genealogical relations, controlling for the areal factor, i.e., for the membership in the Circum-Baltic area. In this case, the partial Mantel test shows a weaker correlation between the matrices, which is only marginally significant (Mantel statistic $r = 0.27$, $p = 0.06$). Thus, within our language sample, we see strong evidence for the areal adaptation of Circum-Baltic languages, accompanied by a more moderate genealogical effect.

However, as we argued in Section 2 above, it is doubtful that within an area of intensive language contact, the genealogical signal is solely conditioned by independent preservation of commonly co-inherited traits. We suggest that **genealogical pressure** and **genealogical signal** should not be equated (Seržant 2025). The latter is just a statistical effect in the data that has to be interpreted by a researcher. It may be rooted not only in the genealogical pressure per se but also in a universal or areal pressure enforcing retention of a specific pattern or even in a contact-induced innovation that historically spread across structurally similar languages which coincided with the genealogical proximity.

While we do not have a specific example from the domain of word order given the quantitative nature of our study, there are several contact-induced innovations in the area which expanded along genealogical nodes, thus boosting the genealogical signal. For example, in the East Slavic languages, the new perfect construction based on the invariant active past participles in *-vši* (and its phonetic variations) is found in both Russian (3) and Belarusian (4) dialects (Trubinskij 1984; Erker 2014; Pozharickaja 2014).

Western Russian dialects

(3) *Rebenok prosnu-**vši.***
child.NOM.SG wake_up-PRF
'The child is awaken.' (Pozharickaja 2014: 112)

Belarusian dialects

(4) *fs'a úlica bylá zγaré-**ušy***
all.NOM.F street.NOM.F AUX.PST.F.SG burn-PRF
'the entire street was burned down' (Erker 2014: 138)

However, this construction has demonstrably appeared much later than the split of Proto-East-Slavic into Belarusian, Ukrainian and Russian and thus cannot represent an instance of inheritance from the common proto-language (Proto-East-Slavic) (Trubinskij 1984: 171). Another example is the expansion of the prepositional phrase *u* 'at' plus the genitive with the function of **free affectee** in all the three East Slavic languages (traditionally labeled **external possessors**, see, however, Seržant 2016). This is not a phenomenon that one would find in early Old Rusian documents and, therefore, cannot be claimed to be inherited either. This innovation spread via language contact among closely related East Slavic languages and dialects. Thus, contact-induced innovations channeled by the genealogical tree boost the genealogical signal but do not represent genealogical pressure. In turn, genealogical pressure is a concept that applies to retention mechanisms other than areal or universal pressures, for example independent drift/inertia (Seržant 2025).

To conclude, we see a strong areal effect. Even though we detect a genealogical signal in our data too, it cannot be directly "translated" into genealogical pressure and may also result from the areal effect.

8. Conclusions

We have argued that traditional similarity-based approaches to linguistic areas have limitations. There are methodological difficulties with genealogically more homogenous linguistic areas, with borrowing of universally preferred traits and

with the subjective degree of similarity that would be sufficient to claim an areal trait. Such approaches do not allow for more holistic descriptions of linguistic areas and ~~mostly~~ describe areas in negative terms (e.g. lack of infinitives)~~,~~ via typological and areal rara, which are often rara in the corpora of the language as well. These limitations are primarily rooted in the methodological difficulty in providing strong evidence against the null hypothesis as well as in the history of areal linguistics. Similarity-based approaches introduce ~~a lot of~~ uncertainty and subjectivity into areal linguistics and research on language contact by requiring that a specific trait in different languages of an area be very similar without a clearly defined baseline. Less similar but still adapting traits cannot be taken into account in these approaches.

Our goal is to shift the focus from comparing similarities in the languages of an area to exploring their dynamics. Our concept of adaptation is dynamic and not dependent on a high degree of similarity of comparable traits across languages of an area. Instead, adaptation is understood here as any historical process towards, but not necessarily into, similarity with the other languages in an area. While we cannot access the specific historical (non-)changes that a language in an area underwent, we approach adaptation indirectly. Technically, we estimate adaptation based on the positive distances between the Benchmark and Focus language with respect to the other languages of the area. We define the Benchmark language as a language that is geographically and genealogically close to the Focus language but is outside of the area. When comparing Focus and Benchmark languages, we draw on the approach put forward in Di Garbo & Napoleão de Souza (2023). However, in contrast to this approach, we work with distances and not with similarities.

Our distance-based approach departs from the assumption that an exact match of two similar traits in two languages is never found and, therefore, what only matters is whether or not the languages of the area exhibit adaptation. An exact threshold for the degree of adaptation or let alone for high similarity across the languages of the area are not required here at all. Finally, our approach is independent of whether the languages of the area are closely genealogically related or not.

We exemplified our approach by exploring the order of words in the languages of the CB area. All languages of the CB area enjoy quite lax constraints on word order. Even the most constrained language German allows for a whole set of word order variants within its V2 and other rules.

We have shown that all languages of the CB area indeed show adaptation effects (Step 2). In the next step (Step 3), we compared the two Focus languages without a Benchmark, namely, Latvian and Lithuanian, with the Focus languages with a Benchmark and demonstrated that these two languages likewise adapt to

the area. Finally, we explored the degree of adaptation across the CB languages (Step 4) and found that Baltic Romani and both Baltic languages are in the center of the area by exhibiting the smallest distances to the other languages of the CB area. Baltic Romani is the most adapted language in the CB area given its high distance to its Benchmark Vlach Romani. By contrast, German, Finnish, Swedish and, to some extent, Russian are the least integrated languages. These findings, and thus our method, are independently supported by what we know about the history of the CB area and the role these languages play in the area.

While the specific ways to measure the distance and dissimilarity may vary (see, for example, different approaches in the contributions in Borin & Saxena 2013), the approach we exemplified is designed to be more resistant to differences among languages of an area than similarity-based approaches. The distance-based approach combined with corpus data is fine-grained enough to handle even closely related languages in an area. It can also handle varying degrees of similarities across the languages of the area.

When it comes specifically to word order in the CB area, our approach does not allow us to identify which specific constructions and discourse strategies were adapted through contact. We only see the overall effect. Our study is just the first step to holistically analyze similarities in word order across the languages of the CB area. The next step in the future would be identifying specific discourse moves, properties of the input, interactional and other effects, which affect the choice of constructions, to pin down the specific constructions that these languages share, e.g. topicalization constructions, animacy and/or definiteness-driven placement of arguments, position of discourse particles, turn-taking effects on word order, etc. This will certainly first require explorative manual analysis and preprocessing of the aligned sentences we have produced for this study. Such an approach would allow aggregating over different types of syntactic and discourse variables in our pre-processed corpus data but would also be very time consuming, since most of such variables would have to be tagged manually. It would also require more difficult computation given that our parallel data are neither syntactically nor part-of-speech-wise tagged. Finally, we also remain agnostic as to the exact diachronic mechanisms that led to adaptations in word order. Language external reasons such as social and political history of the region would suggest that it is the Baltic languages that have adapted more to the dominant languages such as German or Russian than vice versa. The same applies to Baltic Romani.

Another aspect that we did not discuss in detail is varying degree of genealogical relatedness between the Focus and the Benchmark languages. Benchmark languages will often be subject to convenience sampling due to lack of specific data. Some languages do not have very close relatives at all (like Baltic in our

case), yet other languages do have close relatives but there is no parallel corpus data available for these (like Erzya and Moksha which would have been better Benchmark languages for Finnish and Estonian). This is an issue that Di Garbo & Napoleão de Souza (2023: 581–582) also address and suggest including a measure of relatedness into the computation. For example, one way to do so might be by means of building a model that would incorporate genealogical distance (cf. Jaeger et al. 2011). Additionally, one might balance the effect of sampling and take more than one Benchmark language to rule out language-specific noise.

Languages with no Benchmark languages may be included in Step 3 in (2) by comparing their distances to the mean of the languages of the area with such distances of the languages that have been shown to belong to the area on the basis of the distance-based approach. We applied this procedure with respect to both Baltic languages and were thus able to include languages with no Benchmarks.

In addition to the "pure" adaptation effects for the languages for which genealogical pressure can be excluded due to their distinct genealogies (such as Polish-Lithuanian or Latvian-Estonian adaptation), we also observe a strong genealogical signal. However, we argued that the genealogical signal should not be oversimplified and equated with genealogical pressure (cf. Seržant 2025). To the contrary, genealogical relationship may channel areal and even universal effects.

Finally, although we provided evidence for areal adaptation in the domain of word order in the languages of the CB area, our study has no bearing on the more general questions of whether or not a linguistic area is a phenomenon *sui generis* that is distinct from just a set of binary contact effects between ~~the~~ neighboring languages (see Dedio et al. 2019; Ranacher et al. 2021 on further discussion). In other words, it remains to be an empirical question whether there is something like linguistic areas with statistical peaks that would distort larger macroareal clines or whether any random set of contiguous languages on macroclines would show an areal effect similar to the one we found in word order in the CB area. This is certainly something that can only be meaningfully explored on the basis of a set of mutually independent phenomena and on a large scale such as Western Eurasia.

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List of abbreviations

AUX	auxiliary
bel	Belarusian
BL	benchmark language
CB	Circum–Baltic
ces	Czech
DEF	definite
DEM	demonstrative
deu	German
est	Estonian
F	feminine
fin	Finnish
FL	focus language
GEN	genitive
hun	Hungarian
L2	second language
lat	Latvian
lit	Lithuanian
M	masculine
MDS	multi–dimensional space
nld	Dutch
NOM	nominative
nor	Norwegian
NP	noun phrase
O	object
OV	object verb
pol	Polish
PRF	perfect
PST	past
rml	Baltic Romani
rmy	Vlax Romani
rus	Russian
S	subject
SG	singular
SOV	subject object verb
SVO	subject verb object
swe	Swedish
ukr	Ukrainian
V	verb
V2	verb–second
VO	verb object

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