Word order flexibility: a typometric study

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Abstract

This paper describes the distribution of languages according to the head-dependent direction in a set of constructions. A typometric measure, called flexibility, is introduced and compared with Bakker's (1998) categorical flexibility index. It is shown that the typometric flexibility is a good measure to characterize the distribution of languages for a given construction and to estimate whether a construction can predict the global behavior of word order in a language.

1 Introduction

For half a century, research in typology centers on the discussion of word order parameters, pioneered by Greenberg (1963, 1966), and elaborated by such authors as Hawkins (1983), Dryer (1992) and Nichols (1992). Bakker (1998) proposes a seminal study on word order flexibility, which we pursue here. First off, it is clear that languages differ in the flexibility of word order: Greek or Russian are more flexible than English or Chinese. Secondly, constructions differ in their flexibility across the diversity of languages: The relation between an adposition and its complement is less flexible than the relation between a verb and its direct object. How can we measure the flexibility of languages and constructions? What are the properties of flexibility across languages and constructions?

Most classical approaches to typology, including Bakker (1998) and previous works, are categorical in the sense that languages are grouped into categories based on their order constraints, and often only one basic word order is assumed per language from which other word orders are derived by movement, dislocation, or similar operations.

We propose a typometric approach: With the availability of a wide range of uniformly annotated treebanks in the Universal Dependencies (UD) project, it has become possible to approach these questions empirically. Syntactic typology outgrows the need for ad hoc categories and measures of distribution of languages across empirical observations become the center of interest (Futtrell et al. 2020). In Gerdes et al. (2021), quantitative universals describe empty or sparsely populated spaces in unidimensional or multidimensional spaces instead of qualitative universals that are claiming rare or impossible combinations of language features based on categories.

Tesnière (1959) proposed a classification of languages based on the dependency direction referring to Steinthal (1850) and Schmidt (1926). He opposes strict word order, when head-daughter relations mostly go in one direction, to *mitigated* when the head is amidst its dependents going out in both directions.

In this paper we propose measures of flexibility that can be applied to dependency treebanks and discuss the distributions of these measures compared to other observations on dependency treebanks.

We try to characterize the distribution of all languages of our sample in terms of word order direction for each construction C: We compute for each language L, the number of head-initial realization of the construction C in L, what we call the head-initiality of language L under C (Section 3). We deduce from head-initiality a second measure we call flexibility and study the relation between head-initiality and flexibility for all languages in our sample, distinguishing flexible languages from mixed word order languages (Section 4). Our typometric measure of flexibility we introduce is compared with Bakker's (1998) categorical measure of flexibility, as well as a more typometric measure à la Bakker (Section 5). We show that the distribution of head-initiality for every construction C can be characterized by the average head-initiality of C and the flexibility of C (Section 6). In Section 7, we explore the question of the predictability of word order distribution from one construction to another.

2 Dependency syntax and word order

Dependency syntax encodes constructions by relations between words representing combinations between larger units (Tesnière 1959, Hudson 1984). A dependency relation goes from one word to another, from governor to dependent. There is no a priori assumption on locality of a relation, which makes dependency treebanks the obvious choice when attempting to measure tendencies in word order across languages (Liu 2008).

A syntactic relation is a class of combinations of the same type, having similar properties. Dependency syntax makes the assumption that most constructions are asymmetric, with a head element controlling the distribution of the combination. In some languages, constructions are very rigid and combinations of a certain type tend to always have the same word order between the governor and the dependent. Examples of such rigid relations are the *subject* and the *object* relation in English.[1] Subject and Object are different constructions and therefore are annotated as different relations.

Although the main criteria of distinguishing one relation from another is valency and morphology based (for example an accusative case can be the main criterion for delimiting the direct object relation), in some cases the definition of a dependency relation relies on the word order itself and thus the relations have by definition a strict word order.[2]

Just as in the initial typometrics paper Gerdes et al. (2021), we rely for our measures on the Surface Syntactic Dependency (SUD) version of UD (Gerdes et al. 2018), in order to make our work comparable with previous work on word order typology, thus avoiding complications in particular concerning adpositions and auxiliary verbs that are analyzed in an unusual manner in the original UD annotation scheme, see Note 5 for details. We base our work on the latest SUD version 2.10 which includes 228 treebanks in 130 languages in total. For our study, treebanks of the same language are combined and taken as one data point.

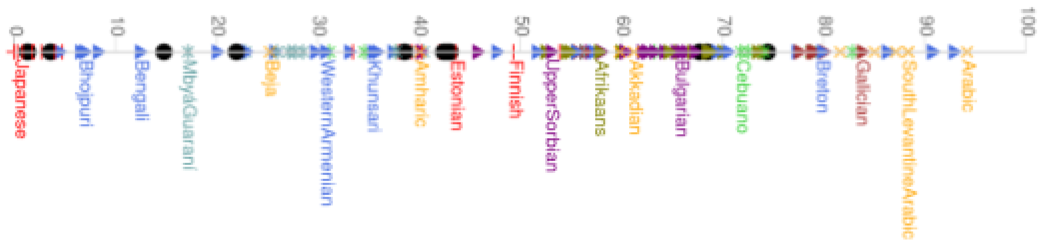

Figure 1: Head-initiality of core relations across SUD 2.10

3 Typometrics and scatter plots

A typometric analysis does not assume a basic word order or any threshold for categorizing languages or construction. Our basic observation is the measure of *head-initiality* defined for a language L and a construction C as follows:[3]

```
head-initiality(L, C) =
% of occurrences of C in L that are
head-initial (governor < dependent)
```

In most cases the construction C is defined as a *gov-rel-dep* triple (governor's POS, dependency relation, dependent's POS). In some cases the construction is defined as the sum of a series of *gov-rel-dep* triples. Note that any variable of the triplet (*gov*, *rel* or *dep*) can be equal to *all*, denoting no restriction on this variable.

[1] Widely discussed exceptions include the relative pronoun (*a person who I never met*) and marginal cases of dislocation such as *Chocolate I adore!* As in other typological studies, we restrict our object measures to nominal objects, thus excluding the first case. The measures that we obtain for the dislocation case depend on the corresponding annotation choices.

[2] As an example, consider the annotation choices for Cantonese and Mandarin reported in Wong et al. (2017): Any element to the left of the verb is considered as "dislocated" even if it fills the verb's object slot.

[3] Head-initiality is introduced in Gerdes et al. (2019, 2021), where it is called *direction*.

A head-initiality of 0 for a given language and construction shows a strictly head-final construction, a head-intitiality of 100 indicates a strictly head-initial construction. Measuring head-initiality across the UD languages for the combination of core dependency relations (to be defined in the next section) gives the unidimensional scatter plot of Figure 1, where, unsurprisingly, Japanese is the most head-final language, and Arabic the most head-initial language of our language sample set.[4]

We can further compare the head-initiality of two constructions. As an example, consider the measures of the nominal object of adpositions vs. the nominal object of verbs (Figure 2).

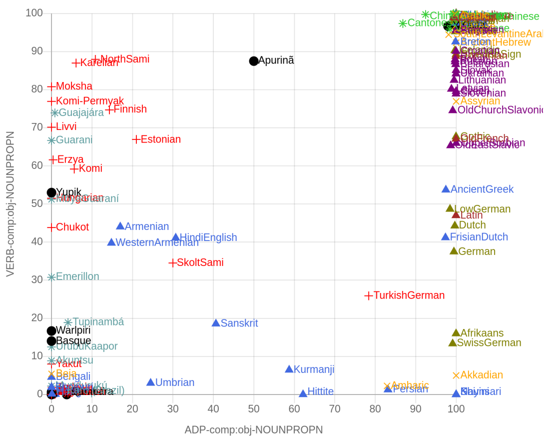

Figure 2: Two-dimensional scatter plots with ADP-comp:obj-NOUN in the x-axis and VERB-comp:obj-NOUN in the y-axis.

As a first observation, note that a large majority of languages have x=0 or x=100 in Fig. 2: Languages that mix prepositions and postpositions equally are rare. Nonetheless, the postpositional languages on the left appear to be less strictly postpositional than the prepositional languages on the right are prepositional. This motivates the definition of flexibility in the next section.

A second observation is the clustering around (0,0) and (100,100), indicating that postpositional languages tend to have their verbal object to the left, and prepositional languages have their verbal object to the right of the verbal governor. This is a well-established observation in typology since Greenberg (1963), and is at the base of our choice of SUD treebanks (see Note 5 for details).

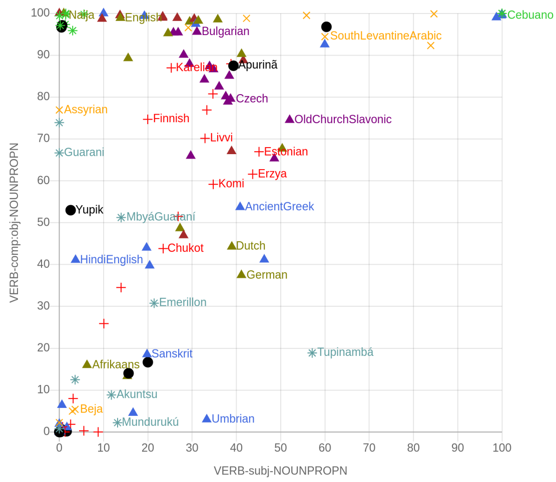

Figure 3: Two-dimensional scatter plots with verbal subjects and objects.

A second scatter plot (Fig. 3) opposes the head-initiality of nominal subjects in the X-axis (VERB-subj-NOUN) and nominal direct objects in the y-axis (VERB-comp:obj-NOUN). We allow both the UD POS noun and proper noun as arguments. We observe a typical triangular shape of the resulting distribution indicating that nearly all languages have the tendency to have direct objects more to the right than subjects. Put differently, hardly any language has a higher head-initiality on subjects than on direct objects. See Gerdes et al. (2021) for a discussion of how this observation generalizes to the well-known absence of OVS languages.

4 Flexibility of languages

For a language L, *flexibility* measures the distance of a construction C from a rigid construction, i.e. strictly head-initial or head-final:

```
flexibility(L, C)
= 2 × min( head-initiality(L,C),
           100-head-initiality(L,C) )
= twice the smallest distance of head-
       initiality(L,C) to 0 or to 100
```

The value of flexibility(L, C) ranges from 0 to 100. We decide to consider the relations of type *comp*, *mod*, *udep*, *subj*, *dislocated*, *det*,

4 Colors and shapes of the language points follow the original typometrics paper with colored triangles for the different subgroups of Indo-European languages, plus signs for agglutinating languages, orange x signs for Afroasiatic and Semitic languages, and circles and stars for other groups. Data, scatterplots and detailed captions are on https://submission.xxx.

and *clf*.[5] Other SUD/UD relations are of little interest for our study as their direction is fixed in the UD annotation guidelines. This includes *conj*, *fixed*, *goeswith*, etc.

We further combine our relations into the following groups:

udep+ = mod + comp + udep

core = subj + udep+ + dislocated

any = core + det + clf

For a given language L, we can compute the weighted average of flexibility(L, C) for a certain partition P of constructions C of the considered data set D. The weight of each construction is equal to its frequency. We can define the head-initiality of a language as well as its flexibility:

`head-initiality(L)` `=`
`weighted average of head-initiality(L, C) on the core constructions C.`

`flexibility(L)` `=`
`weighted average of flexibility(L, C) on the core constructions C.`

This gives us the unidimensional flexibility scatter plots for *udep+*, *core*, and *any*, respectively in Figure 4.

For treebanks with at least 100 core relations, we observe that Ancient Greek, Turkish-German (code switching corpus), Tupinambá, Old East Slavic, and Low German are the most flexible languages (with flexibilities 59, 54, 54, 51, and 50 respectively), while Japanese, Korean, Hindi, Kazakh, and Xibe (flexibilities of around 1, 1, 2, 2, and 2 respectively) are the least flexible languages.

The computation of head-initiality(L) and flexibility(L) is sensitive to the considered data set D. We have chosen not to keep the *det* relation among the core relations because the question to know which of the determiner or the noun is the head has not been settled (see discussion in Hudson 1984 or Abney 1987).[6]

Figure 4: Flexibility of *udep+*, *core*, and *any* relations

We have included the *dislocated* relation, because the boundary between governed and dislocated elements is not always well defined.[7] It should also be noted that we have not considered the relations between co-dependents at all. Yet some languages with a very strict head-final order, like Japanese or Korean, can have a much greater freedom in the placement of co-dependents, which is not taken into account in the present study.

In addition to being sensitive to the considered data set D, the computation of flexibility(L) is also sensitive to the granularity of the partition P of D into constructions: the finer the partitioning P, the higher the yield of flexibility(L). In our case, we have adopted a

[5] SUD's *comp* relation corresponds to UD's *aux*, *ccomp*, *iobj*, *obj*, *obl:arg*, *xcomp*, *cop*, *mark*, and *case*; *mod* corresponds to UD's *advcl*, *advmod*, *obl:mod*; SUD's *umod* unites UD's *acl*, *amod*, *nmod*, *nummod*, and *obl*. SUD's *subj* combines UD's *csubj* and *nsubj*. The relations *dislocated*, *det*, and *clf* remain unchanged between SUD and UD. Note also that many UD treebanks do not distinguish the valency status of prepositional phrases that depend on verbs, i.e. they do not distinguish *obl:mod* and *obl:arg*, the unspecified *obl* relation being rendered as *udep* in SUD.

[6] The calculation of head-initiality(L) is obviously very dependent on the choice made for the head of each construction. It is this question that motivated us not to work with UD, but to choose the SUD variant where adpositions, subordinating conjunctions, and auxiliaries are chosen as heads. For auxiliaries, the question is delicate, because while for Indo-European languages, they are clearly heads, this is less obvious in languages where they are particles. On the other hand, the wh-words of Indo-European languages are treated as pronouns in both UD and SUD, even though they also have a head role, which explains in part their peculiar placement.

[7] For instance, in a pro-drop language such as Chinese, it is difficult to decide if preverbal objects are dislocated or not. See Note 2.

rather fine granularity, as we consider any *gov-rel-dep* triplet as a different construction, where *gov* is the POS of the governor, *dep* is the POS of the dependent, and *rel* is the relationship between them.[8,9]

Lastly, we have chosen to give each construction a weight equivalent to its frequency in the corpora, unlike Bakker (1998) who gives the same weight to each of the 10 constructions he considers.

Figure 5 shows the head-initiality of SUD 2.10 languages in the x-axis and the flexibility in the y-axis. Languages with head-initiality equal to 0 or 100 have flexibility 0 and the closer to 50 the more likely they are to be flexible. But there are languages L with head-initiality(L) close to 50 and flexibility(L) close to 0, such as Bambara: these are *mixed order languages*. Languages with high flexibility(L), such as Ancient Greek, are *free order languages*.[10]

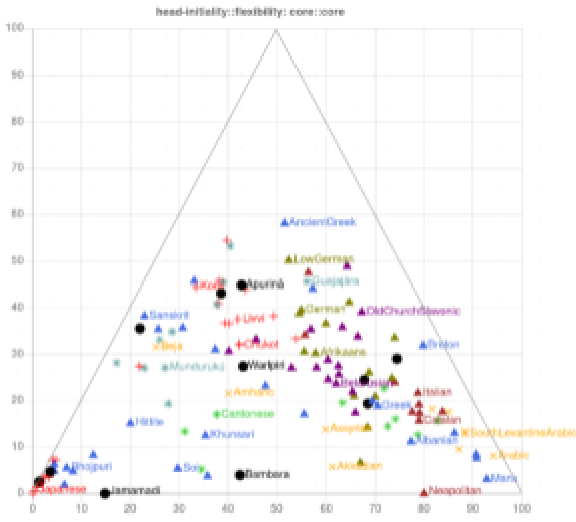

Figure 5: Head-initiality vs flexibility

5 Comparison with Bakker's flexibility

Bakker (1998) proposes a computation of flexibility based on the same principles but does not take into account the greater or lesser flexibility of each construction for each language. In Bakker's computation, a language is either flexible or completely rigid.

```
flexibility[Bakker](C,L) =
0 if the language is completely rigid,
1 if it is flexible
flexibility[Bakker](L)=
(equal-weighted) average over 10
constructions C of
flexibility[Bakker](C,L)
```

Bakker gives the flexibility values for a sample of 86 European languages. We propose to compare Bakker's values with a typometric index of the same type. Some of Bakker's constructions can be directly translated into SUD corpus queries, others can be approximated. For example his "Adj/N" translates directly into the typometric measure NOUN-mod-ADJ. The Verb-Recipient relation (V/R) can only be approximated by

[8] We could have taken an even greater granularity, by taking into account certain features, for example by distinguishing relative pronouns (PronType=Rel) from personal pronouns (PronType=Prs) or by isolating demonstratives (PronType=Dem). Moreover, when we have a direct complement of the verb, we will distinguish nominal complement (dep=NOUN) and pronominal complement (dep=PRON), but not when it is a prepositional complement (dep=ADP). Sometimes the granularity can be excessive, as when UD/SUD distinguishes proper nouns (PROPN) and common nouns (NOUN). On the other hand, UD does not usually distinguish prepositional dependents of the verb, which are all rel=*obl*, whether they are arguments or modifiers. This distinction is made only in a few treebanks, notably the native SUD treebanks (with the *comp* and *mod* labels). SUD uses the *udep* relation, for underspecified dependencies when the distinction in argument and modifier is not encoded, see Note 4.

[9] Bakker (1998: 393ff) introduces another measure which he calls *consistency* and which is very dependent on the set of considered constructions, which are still the 10 same constructions (see Section 5):

```
consistency[Bakker](L)  =
| #{ C / C is head-initial for L }
- #{ C / C is head-final for L } |.
```

It seems to us that the consistency of a language L is well captured by our head-initiality(L), which is not dependent on the partitioning P into constructions undertaken by the linguist. Moreover, Bakker (1998: 401-2) notes that flexibility[Bakker] and consistency[Bakker] are correlated, but this is obvious as soon as there are languages whose head-initiality is close to 0 or 100. Likewise, our flexibility and head-initiality are related, since flexibility(L) ≤ 2 × min (head-initiality(L), 100 – head-initiality(L)), which we have visualized as a triangle in Figure 5.

[10] Our measures are also dependent on the corpus chosen for the calculus and its genre. The flexibility measure of Ancient Greek is certainly increased by the fact that the corpus contains poetry and theater.

VERB-comp:obl-ADP|NOUN. The complete list of Bakker's constructions and their translation into typometric measures are provided in the construction flexibility Table A2 of the Annex.

As Bakker's flexibility measure is categorical per construction, we have to arbitrarily set a threshold at 5% considering that languages with less than 5% variation for a given construction C are inflexible for C.

We can compare those 3 measures across the languages that we also find in UD: 1. Bakker's flexibility, 2. our recomputation of the flexibility à la Bakker, as a non-weighted average over Bakker's 10 constructions, with the 5% threshold as indicated above, and 3. our typometric flexibility.[11]

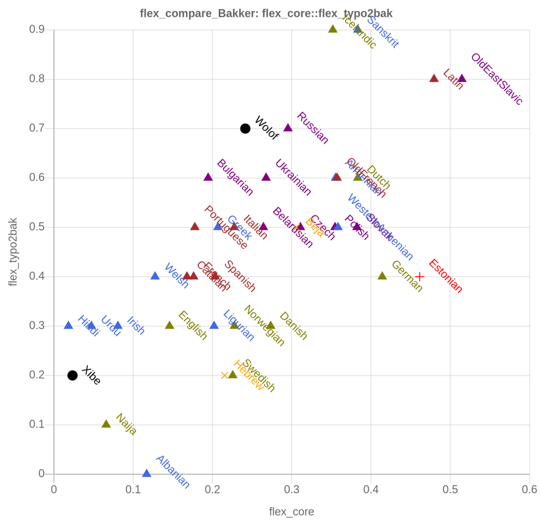

Figure 6: Typometric vs Bakker-like flexibility

The scatterplot of Figure 6 shows the strong correlation between the Bakker-like measure of flexibility and the typometric flexibility. The Bakker-like flexibility is also significatively correlated with Bakker's flexibility (Fig. B2), while there is only a weak correlation between the typometric flexibility and Bakker's flexibility (Fig. B1). See complete results in Tables B1 and B2 in the Annex.

6 Flexibility of constructions

We have compared the overall flexibility of the languages, we can now see how the languages in a given sample S are distributed for each construction C and compare the constructions. Specifically, we are interested in how the head-initiality of the languages in our sample (the 130 languages in UD2.10) is distributed for the different constructions C. Our hypothesis is that this distribution is reasonably well described by the following two values:

average-head-initiality$_S$(C) = average of head-initiality(L,C) over the Ls in S.

average-flexibility$_S$(C) = average of flexibility(L,C) over the Ls in S.

The less flexible C is on average, the more languages are attracted to 0 and 100. The average-head-initiality indicates whether 0 or 100 attracts more to one than the other. We propose two other values that will help us to better understand this attraction towards 0 and 100.

head-initial-weight$_S$(C) = average-head-initiality$_S$(C) / average-flexibility$_S$(C)

head-final-weight$_S$(C) = (100 – average-head-initiality$_S$(C)) / average-flexibility$_S$(C)

For a uniform distribution, flexibility = 50, head-initiality = 50, head-initial-weight = 1, head-final-weight = 1. When head-final-weight > 1, the distribution is drawn towards 0 and when head-final-weight < 1, it is pushed away. The reverse holds for head-initial-weight.

We observe that for all the most frequent C constructions, both head-initial-weight$_S$(C) > 1 and head-final-weight$_S$(C) > 1 (see Table A2 in Annex where all the weights for the 10 Bakker constructions are greater than 1 except one). In other words, these distributions, when compared to a uniform distribution, are as if stretched toward the ends.

To give an idea of the different distributions we encounter, the three scatter plots below show three head-initiality distributions on the treebanks: 1. Num/N (NOUN-any-NUM), 2. aux-v (AUX-comp:aux-VERB), and 3. Adj/N (NOUN-mod-ADJ). The tendency of the first (Num/N) distribution to tend towards 0 and is pushed away from 100 (weights 3.6 and 0.7), while the two other distributions are attracted both by 0 and 100, with a bigger attraction to 0 for Adj/N (weights 4.2 and 2.4) and to 100 for Aux/V (weights 1.7 and 2.8).

[11] Some of Bakker's constructions, such as Dem/N or Pro/N, involve features that are not present in all UD treebanks (PronType=Dem and Poss=Yes in these two cases). Our computation is restrained to languages with all the required features.

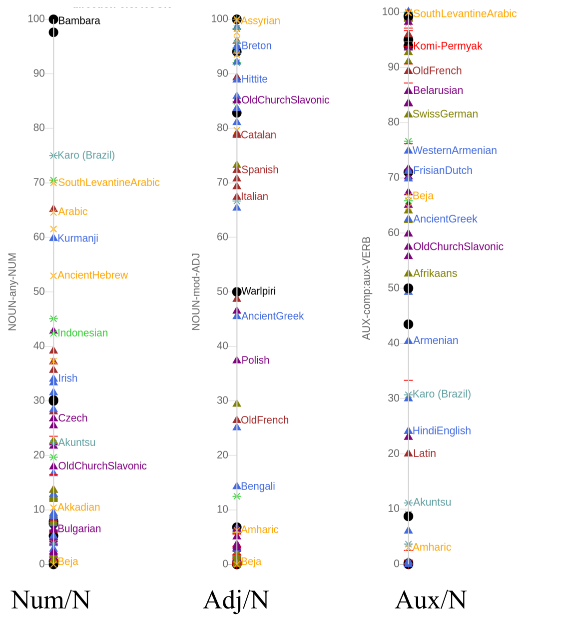

Figure 7: Head-initiality language distribution for three constructions.

Again, we can compare our flexibility results with two measures: the flexibility measure proposed by Bakker (1998) and a Bakker-like measure that we calculate from our sample.

flexibility[Bakker]$_S$(C)=

`% of languages in S that are flexible for C.`

flexibility[Bakker-like]$_S$(C) =

`% of Ls in S with flexibility(L,C) >5.`

We find that V/O is the most flexible construction, followed by V/R and Adj/N. Two constructions do not behave at all as in Bakker's sample: Aux/V appears as the most flexible construction after V/O, while Rel/N appears as extremely inflexible.

Bakker also compares the flexibility languages with head-initial and head-final basic order. Again we can introduce typometric Bakker-like measures. We consider that a language has head-initial basic order if more than 50% of core dependencies are head-initial.

head-initial flexibility[Bakker-like]$_S$(C) =

`% of Ls in S with head-initiality(L,C)>50 that have flexibility(L,C) > 5.`

head-final flexibility[Bakker-like]$_S$(C) =

`% of Ls in S with head-initiality(L,C)<50 that have flexibility(L,C) > 5.`

Bakker (1998: 392) "observed that head-modifier orders are, on the whole, more flexible than modifier-head orders." We have completely different results with our measures (see Table A2 in the Annex): Only for adpositions, languages with head-initial core order are more flexible than languages with head-final core order.

7 Predictivity

With these notions in place, it is now possible to measure which construction predicts best the overall core flexibility of a given language. For this, we measure the Spearman correlation between the distribution of flexibility(L,C) for various couples of construction C (Figure 8). We are particularly interested in the correlation with the *core* construction. Among the 10 Bakker constructions, the best predictors of the *core* flexibility is the *V/O* construction, unlike V/R. Note also some notable correlations: *Aux/V* and *V/O* that have a correlation of 0.59 as well as *subj* and *comp* that have a correlation of 0.53.

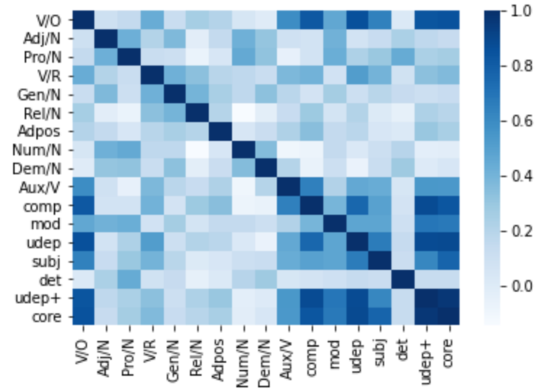

Figure 8: Heatmap of Spearman correlation between the distributions of flexibility(L,C) for various couples of construction C. See Table D of the Annex for detailed values.

Bakker (1998: 392) however states that "the best predictors of overall flexibility are the flexibility of the recipient, genitive, numeral and relative clause. On the other hand, no prediction whatsoever can be drawn from the behavior of adpositions and articles." This is not backed up by our data with our weighted flexibility measure: The typometric genitive flexibility has a correlation of only 0.19 with the core flexibility, numerals have a correlation of 0.05, and relatives of 0.20.

Nonetheless, our data agrees with a common typologist view, most notably Dryer (1992), that sees V/O as a good predictor for word order constraints on other constructions.

Note also that the constructions with the biggest flexibility are the best predictors. This was expected because constructions with low flexibility tend to gather all languages around 0 and 100.

8 Conclusion

We have introduced a first measure, head-initiality, which measures the variable head-dependent word order on a language's treebank or on specific constructions. Based on this, we develop an operational notion of flexibility that renders the intuition that the average head-initiality can be far from 0 or 100 while the languages are strict per given construction.
We then show that our empirical notion of flexibility can be compared to previous definitions of flexibility of word order, notably to Bakker's work. Our notion of flexibility has the advantage that it can directly be computed from treebanks, that it does not require ad-hoc thresholds to categorize languages or constructions, and that it can be applied with any granularity of constructions.
Finally, we show which construction predicts overall word order flexibility of a language. For this, we rely on Spearman's rank correlation coefficient, which allows us to calculate a correlation between two distributions. We show that over UD's language sample, the highest correlation is obtained for nominal objects (V/O construction).
Since the Spearman correlation is a symmetric measure, we would like to continue our study by proposing an asymmetric measure that allows us to decide if one distribution can predict another. Our hypothesis, to be confirmed, is that constructions with the most uniform distribution, thus being flexible and well-balanced, provide better predictions of the behavior of other constructions. The V/O construction, which many authors take as a basic construction (see in particular the study of Dryer 1992) is thus an excellent candidate.

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Annex

Language	Bakker's flexibility	Bakker-like flexibility measured on SUD	Typometric flexibility
Albanian	50	**0**	12
Armenian	40	60	36
Beja	-	50	31
Belarusian	-	50	26
Bulgarian	60	60	20
Catalan	40	40	17
Czech	-	50	31
Danish	40	30	27
Dutch	10	60	38
English	40	30	15
Estonian	40	40	**46**
French	10	40	18
German	40	40	**41**
Greek	60	50	21
Hebrew	-	20	22
Hindi	-	30	2
Icelandic	40	**90**	35
Irish	20	30	8
Italian	30	50	23
Latin	**90**	**80**	**48**
Ligurian	-	30	20
Naija	-	10	**7**
Norwegian	40	30	23
OldEastSlavic	-	**80**	**52**
OldFrench	-	60	36
Polish	60	50	36
Portuguese	30	50	18
Russian	70	70	30
Sanskrit	-	**90**	38
Slovak	50	50	38
Spanish	30	40	20
Swedish	40	20	23
Ukrainian	-	60	27
Urdu	-	30	**5**
Welsh	-	40	13
WesternArmenian	-	50	36
Wolof	-	70	24
Xibe	-	20	**2**

Table A1. Various flexibility measures for languages where a treebank-based verification of Bakker's measures is available.

Bakker's constructions Translation into treebank queries	Average frequency %	Number of concerned languages	Typometric flexibility %	Bakker's flexibility %	Bakker-like flexibility	head-initial flexibility [Bakker-like]	head-final flexibility [Bakker-like]	Head-initiality %	Head-initial weight	Head-final weight
V/O VERB-comp:obj-NOUNPROPN	3.5	129	25	53	47	43	50	57	2.3	1.8
Adj/N NOUN-mod-ADJ	2.7	120	15	50	35	23	56	36	2.4	4.2
Pro/N NOUN-any-[Poss=Yes]	0.3	63	13	34	25	13	59	25	1.9	5.7
V/R VERB-comp:obl-ADP|NOUN	0.4	103	21	66	40	27	55	48	2.3	2.5
Gen/N NOUN-mod-ADP, NOUN-mod-NOUN[Case=Gen]	0.9	106	16	57	33	25	47	43	2.7	3.6
Rel/N NOUN-mod@relcl-VERB	0.2	66	4	11	10	12	12	87	20.9	3
Adpos ADP-comp-NOUN	4.3	127	8	11	15	24	11	62	8.2	5
Num/N NOUN-any-NUM	0.8	120	24	82	55	53	80	15	0.7	3.6
Dem/N NOUN-any[PronType=Dem]	0.4	89	12	50	31	27	57	17	1.4	6.8
Aux/V AUX-comp:aux-VERB	1.9	116	22	47	43	36	47	62	2.8	1.7

Table A2. Measures for the 10 constructions considered by Bakker (1998)

Spearman correlation	Bakker's flexibility	Bakker-like flexibility measured on SUD	Typometric flexibility
Bakker's flexibility	1.000	0.324	0.079
Bakker-like flexibility measured on SUD	0.324	1.000	0.674
Typometric flexibility	0.079	0.674	1.000

Table B1. Spearman correlation between Bakker's flexibility, Bakker-like flexibility and typometrics flexibility

Pearson correlation	Bakker's flexibility	Bakker-like flexibility measured on SUD	Typometric flexibility
Bakker's flexibility	1.000	0.397	0.174
Bakker-like flexibility measured on SUD	0.397	1.000	0.675
Typometric flexibility	0.174	0.675	1.000

Table B2. Pearson correlation between Bakker's flexibility, Bakker-like flexibility and typometrics flexibility

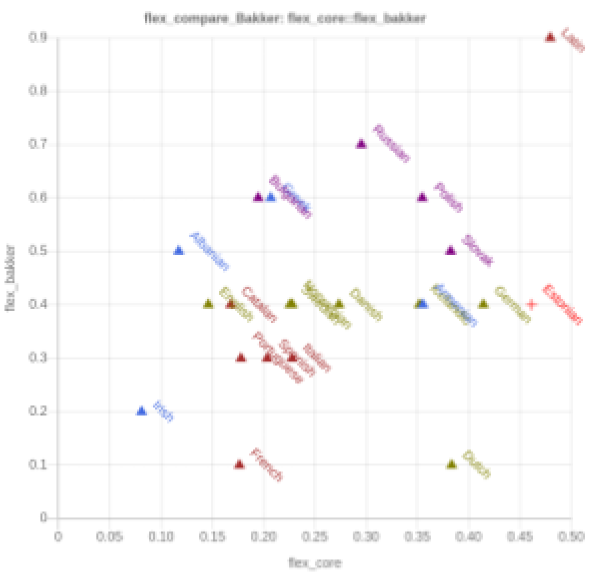

Figure C1. Typometric vs Bakker- flexibility.

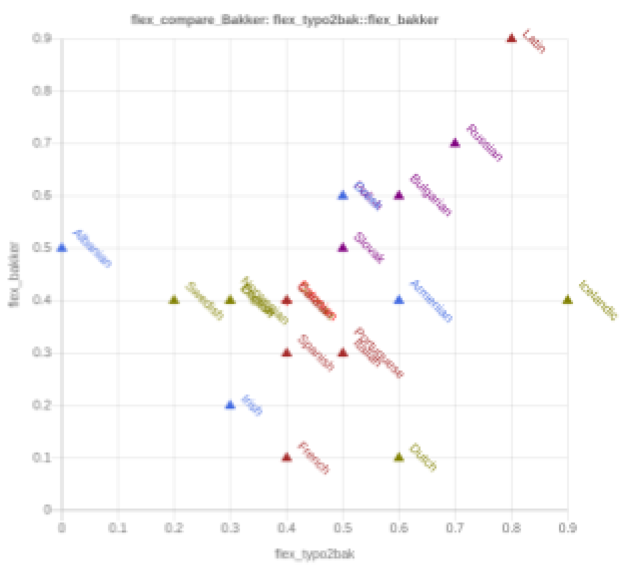

Figure C2. Bakker-like flexibility vs Bakker- flexibility

	V/O	Adj/N	Pro/N	V/R	Gen/N	Rel/N	Adpos	Num/N	Dem/N	Aux/V	comp	mod	udep	subj	det	udep+	core
V/O	1.000	0.099	0.146	0.439	0.124	0.253	0.207	0.046	-0.007	0.589	0.821	0.462	0.858	0.644	0.018	0.836	0.849
Adj/N	0.099	1.000	0.422	0.208	0.371	-0.022	0.149	0.414	0.310	0.090	0.069	0.413	0.071	0.129	0.236	0.165	0.140
Pro/N	0.146	0.422	1.000	0.125	0.108	-0.072	0.040	0.453	0.323	-0.049	0.069	0.430	0.229	0.294	0.442	0.237	0.258
V/R	0.439	0.208	0.125	1.000	0.417	0.335	0.193	0.163	0.126	0.376	0.406	0.076	0.514	0.403	0.080	0.334	0.366
Gen/N	0.124	0.371	0.108	0.417	1.000	0.400	0.245	0.165	0.331	0.181	0.068	0.261	0.106	0.189	0.137	0.105	0.129
Rel/N	0.253	-0.022	-0.072	0.335	0.400	1.000	0.203	-0.146	-0.029	0.128	0.285	0.064	0.211	0.008	-0.046	0.226	0.191
Adpos	0.207	0.149	0.040	0.193	0.245	0.203	1.000	0.038	0.119	0.222	0.346	0.145	0.182	0.039	0.018	0.301	0.244
Num/N	0.046	0.414	0.453	0.163	0.165	-0.146	0.038	1.000	0.359	-0.098	-0.082	0.147	0.024	0.105	0.197	-0.031	-0.024
Dem/N	-0.007	0.310	0.323	0.126	0.331	-0.029	0.119	0.359	1.000	0.202	-0.062	0.108	-0.068	0.125	0.280	0.003	0.040
Aux/V	0.589	0.090	-0.049	0.376	0.181	0.128	0.222	-0.098	0.202	1.000	0.649	0.216	0.458	0.439	0.046	0.542	0.535
comp	0.821	0.069	0.069	0.406	0.068	0.285	0.346	-0.082	-0.062	0.649	1.000	0.393	0.755	0.494	0.065	0.881	0.830
mod	0.462	0.413	0.430	0.076	0.261	0.064	0.145	0.147	0.108	0.216	0.393	1.000	0.474	0.476	0.093	0.689	0.682
udep	0.858	0.071	0.229	0.514	0.106	0.211	0.182	0.024	-0.068	0.458	0.755	0.474	1.000	0.665	0.141	0.882	0.885
subj	0.644	0.129	0.294	0.403	0.189	0.008	0.039	0.105	0.125	0.439	0.494	0.476	0.665	1.000	0.119	0.617	0.771
det	0.018	0.236	0.442	0.080	0.137	-0.046	0.018	0.197	0.280	0.046	0.065	0.093	0.141	0.119	1.000	0.133	0.134
udep+	0.836	0.165	0.237	0.334	0.105	0.226	0.301	-0.031	0.003	0.542	0.881	0.689	0.882	0.617	0.133	1.000	0.967
core	0.849	0.140	0.258	0.366	0.129	0.191	0.244	-0.024	0.040	0.535	0.830	0.682	0.885	0.771	0.134	0.967	1.000

Table D. Spearman correlation between the distributions of flexibility(L,C) for various constructions