GRK 2839 – Winter School 2023

Corpus linguistics: Fundamentals, corpus compilation & annotation

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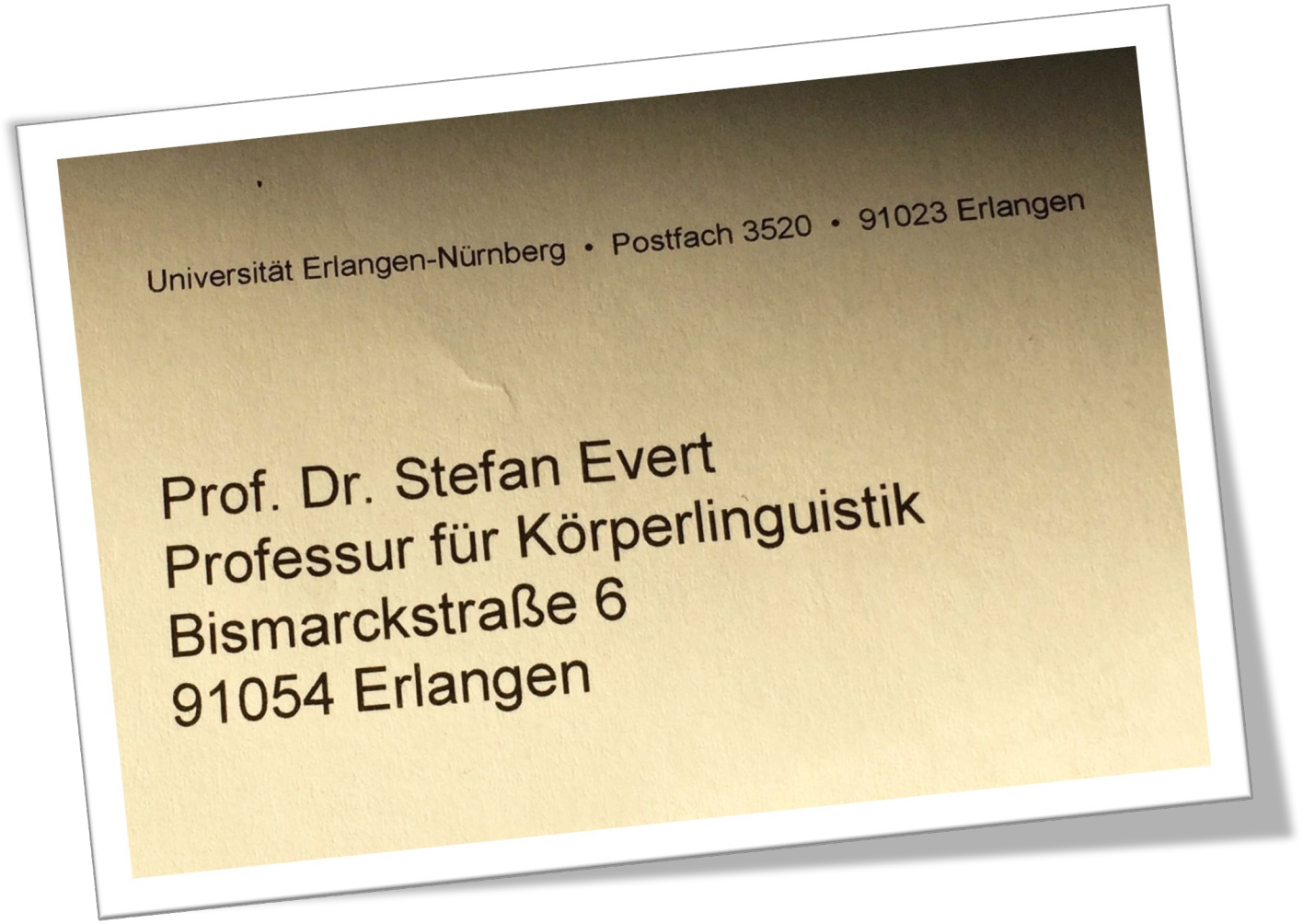
What is a corpus?



What is a corpus?

corpus | ˈkɔːpəs |

noun (pl. **corpora** | ˈkɔːpərə | or **corpuses**)

1 a collection of written texts, especially the entire works of a particular author or a body of writing on a particular subject: *the Darwinian corpus*.

• a collection of written or spoken material in machine-readable form, assembled for the purpose of linguistic research.

2 Anatomy the main body or mass of a structure.

• the central part of the stomach, between the fundus and the antrum.

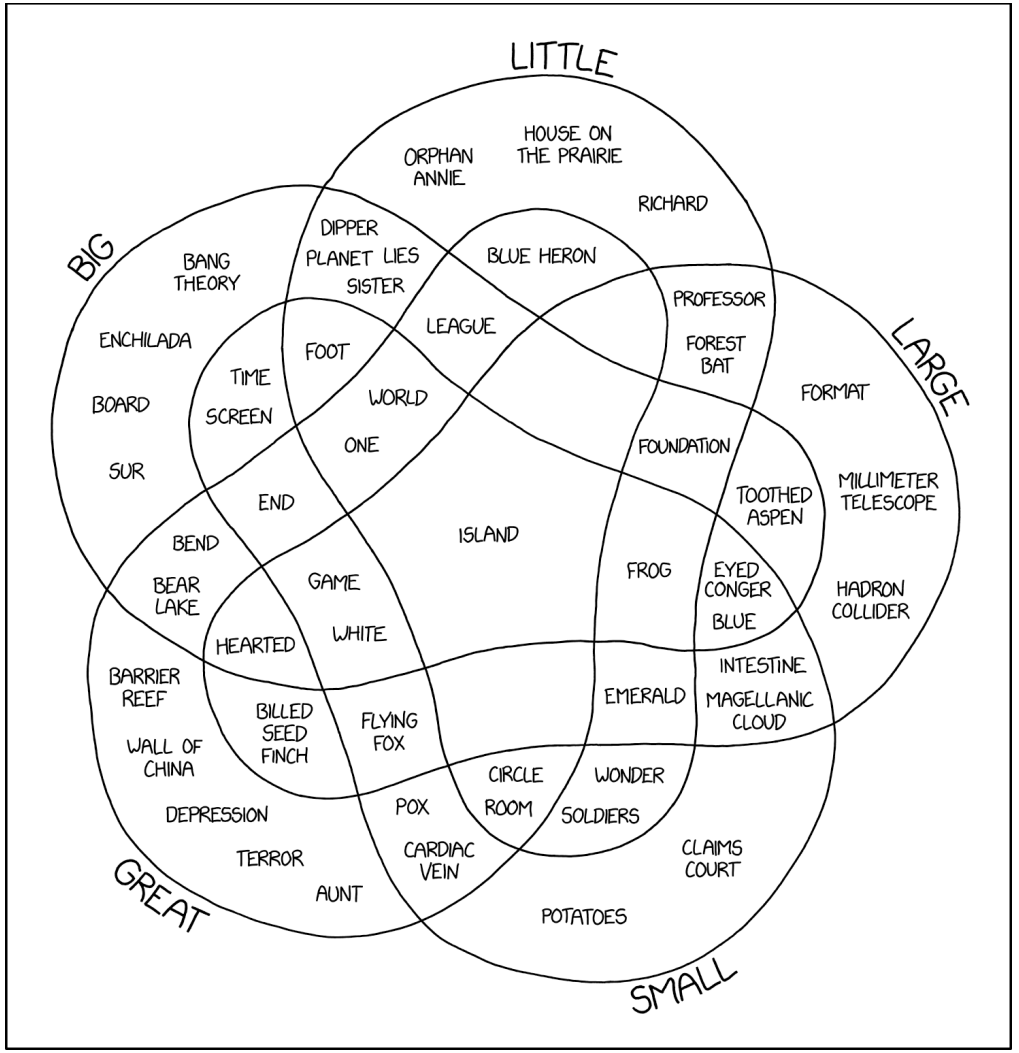
ORIGIN late Middle English (denoting a human or animal body): from Latin, literally ***'body'***. SENSE 1 dates from the early 18th cent.

- Corpus as electronic text collection (archive / database)
  - wide sense: common in computational linguistics & digital humanities
- Corpus as representative sample of language
  - narrow sense: dominant in corpus linguistics (in narrow sense)

What is corpus linguistics?

In a nutshell …

The empirical scientific study of language based on authentic samples of language use



https://xkcd.com/2122/

What is corpus linguistics?

- Corpus linguistics as a methodology
  - (one form of) empirical evidence for linguistic research
  - corpus design & practical aspects
  - development of software tools
  - quantitative analysis techniques, often in terms of frequency comparison

- Corpus linguistics as discipline
  - concordance, collocations, keywords
  - language in use, not language as system
  - language as a medium → applied CL
  - typical research topics

- Corpus-based research
  - verification of hypotheses and theoretical predictions
  - compilation of specialised corpora
  - exploration of specific constructions
  - statistical significance of differences, data analysis as discovery procedure

- Corpus-driven research
  - "trust the text" (Sinclair 2004)
  - purely empirical, inductive, contextualised
  - socio-political discourses & rhetoric
  - sociolinguistic & functional aspects
    language variation
    computational lexicography
    language pedagogy (→ CALL)
    …

Corpus linguistics vs. Theoretical linguistics

Corpus linguistics

- long tradition in esp. British linguistics since 1950s (Quirk, Firth, Sinclair, Leech, …)
- based on corpus data, i.e. authentic language use
- empiricist / inductive
- patterns & preferences
- frequency
- “ordinary” language in use
- empirical validation of theory, induction of new hypotheses
- goals: language use, language as medium

Generative linguistics

- mainstream of theoretical linguistics since early 1960s (Chomsky 1957)
- based on introspection and grammaticality judgements
- rationalist / deductive
- rules
- yes / no (grammaticality)
- language system, border cases
- theory developed on basis of individual (invented) examples
- goal: cognitive account of language faculty

Pre-history of corpus linguistics

- First corpus-based quantitative studies in late 19th century
- Orthography and frequency lists
  - Käding (1897): German frequency dictionary based on corpus of ca. 11 million words (manual work!)
- Language acquisition
  - first longitudinal studies ca. 1876–1926 (parent diaries)
  - large cross-sectional studies ca. 1927–1957
- Lexicography
  - Murray: several million index cards for OED (1879–1928)
- Foreign language teaching
  - basic vocabulary, vocabulary levels, collocations (e.g. Palmer 1933)
- Strucuralist language documentation
  - Boas (1940), J.R. Firth (1930–1955), …
- Comparative philology
  - Eaton (1940): semantic frequency lists for English, French, German, Spanish

Chomsky (1957)

- Rationalism (introspection) vs. empiricism (data-oriented)
  - corpus linguistics: empirical description of language patterns
  - Chomsky: explanatory theory, must be cognitively plausible
- Competence vs. performance
  - Chomsky: corpus reflects speaker performance (with mistakes), empirical frequency data irrelevant for language competence
  - counter-argument: *armchair linguistics* based on invented examples
- Representativity
  - human speakers can produce infinitely many well-formed utterances; even a large corpus only contains a small subset → not representative
  - Chomsky: "Any natural corpus will be skewed. Some sentences won't occur because they are obvious, others because they are false, …"
- Learnability: the poverty of stimulus argument
  - corpus data insufficient for language acquisition: no negative examples

Recent history of corpus linguistics

- Since 1950: Humanities Computing (→ Digital Humanities)
- 1950–1960: Mechanolinguistics (Juilland: contrastive corpora)
  → quantitative / mathematical linguistics (Harris 1968)
- 1960–1980: Corpus linguistics as European counter-movement against mainstream of generative linguistics (→ Chomsky)
- Corpus-based grammars (e.g. Quirk/Greenbaum)
  - Survey of English Usage (SEU) since 1960
  - Brown Corpus 1961–1963
- British contextualism (Firth & Sinclair)
  - Firth (1957) building on Malinowski & Jones, Sinclair (1991), computational lexicography (COBUILD)
  - principles of collocation & colligation, "trust the text"
- Since 1990: Corpus linguistics established as subdiscipline of linguistics, begins to accept methodological innovations from other subdisciplines
- Since 2010: Corpus evidence has become an essential part of linguistic research

Applications of corpus linguistics (I)

- Dialectology & contrastive linguistics
- Historical linguistics & language change
- Language description (e.g. endangered languages)
- Language teaching, language acquisition, CALL
- Language variation, register studies (→ Biber's MDA)
- Lexical semantics (e.g. semantic prosodies)
- Lexicography & lexicology (→ COBUILD, collocation dictionaries)
- Morphology (→ quantitative productivity)
- Phonology (esp. studies of phonological variation)

See McEnery, Xiao & Tono (2006, Unit A10)
for examples and references

Applications of corpus linguistics (II)

- Pragmatics & discourse analysis (→ rhetoric, ideology, politics)
- Psycholinguistics & psychology (e.g. frequency & association norms)
- Sociolinguistics (e.g. gender studies, language ideology, power relations)
- Stylometry & literary studies (e.g. authorship attribution, literary stylistics)
- Syntax & grammar (→ Quirk/Greenbaum, LGSWE)
- Theoretical linguistics (→ validation of theoretical predictions)
- Translation studies (→ "translationese", CAT)
- Usage-based linguistics (→ cognitive linguistics, construction grammar)

See McEnery, Xiao & Tono (2006, Unit A10) for examples and references

The stages of a typical corpus study

1. Operationalization
   - research question → quantitative hypothesis, definition of population (*sampling frame*)

2. Corpus compilation
   - selection of texts (from sampling frame), digitization / format conversion
   - collection of metadata, legal & ethical issues
   - shortcut: reuse existing corpus (often by selecting a suitable subcorpus)

3. Linguistic annotation
   - manual annotation, GUI, annotator agreement
   - automatic annotation with NLP tools for larger corpora

today

4. Representation format
   - standards: Unicode, XML, TEI, XCES, … important for archiving and data exchange
   - efficient binary index formats (e.g. CWB) for corpus search & quantitative analysis

The stages of a typical corpus study

5. Indexing & search

- search for keyword, phrase, linguistic pattern, …
- view results as concordance (“kwic” = keyword in context)
- analysis = grouping & structuring of concordance in order to identify recurrent patterns
- efficient search based on binary index form

Your query “[word="what"%c & !lbound(s)] "a"%c [pos="JJ.*"]+ "night"%c” returned 18 matches in 15 different texts (in 98,511,777 words [9,802 texts]; frequency: 0.18 instances per million words)

[4.616 seconds]

Solution 1 to 18 Page 1 / 1

My dearJarmila ,	what a great night	for you .
oes crazy on a hot night , and maybe that 's	what a hot night	is for .
Wow ,	what a miserable night	.
tee that you 'll have a ball Come one and all	What a great night	you 've got in store You 'll wanna keep comi
e Hey , everyone , let 's go on with the show	What a great night	you 've got in store I 'll bet you 'll wanna kee
I am glad on ` t.	What a fearful night	is this !
Oh , dear ,	what a terrible night	.
oes on and on Oh , Robin ,	what a beautiful night	.
norning skyline Whoa oh	What a weird night	, huh ?
It 's a wonder	what a good night	's sleep will do for you .
ink it 's sunset and see	what a nice night	it is , they 'll muster in the lobby .
God ,	what a beautiful night	, Jack .
God ,	what a beautiful night	, huh ?

tomorrow

6. Quantitative analysis

- many insights based on systematic analysis of frequency data (esp. for large corpora)
- frequency comparison, keywords, co-occurrence
- statistical hypothesis tests, data analysis, visualisation

Friday

7. Interpretation

Types of corpora

- written vs. spoken vs. multimodal/multi-media
- reference corpus vs. specialized corpus
- synchronic vs. diachronic (discrete, continuous)
- closed corpus vs. monitor corpus
- monolingual vs. multilingual (parallel, comparable)
- unannotated (raw text) vs. annotated
  - metadata = information about texts & speakers/authors
  - linguistic annotation = systematically coded interpretation
- corpus size: small & clean vs. large & messy
  - measured in M = million (or G = billion) running words

Some corpora everybody should know

- Brown Corpus (Francis & Kucera 1964)
  - American English, written (edited), texts published in 1961
  - 500 samples @ 2000 words from 15 text genres (*categories*)
- Brown Family
  - Brown (AmE, 1961), LOB (BrE, 1961) – Frown (AmE, 1991), FLOB (BrE, 1991) – BLOB (BrE, 1931), BE2006 (BrE, 2006)
- Penn Treebank (Marcus, Santorini & Marcinkiewicz, 1993)
  - ca. 3 million words of AmE with syntactic analyses (*parse trees*)
- British National Corpus (Aston & Burnard 1998)
  - British English, 90% written / 10% spoken, collected ca. 1991
  - approx. 100 million words in 4048 files (= texts / collections)
- Web as Corpus: WaCky (Baroni et al. 2009)
  - ca. 2 billion words of text from automatically crawled Web pages for each of DE, EN, FR, IT
  - many other Web as Corpus projects: larger corpora, additional languages (Arachnea, COW, SkE 10^{10})

Recommended textbooks

- McEnery, Tony and Wilson, Andrew (2001). *Corpus Linguistics*. Edinburgh University Press, 2nd ed.
- McEnery, Tony; Xiao, Richard; Tono, Yukio (2006). *Corpus-Based Language Studies: An advanced resource book*. Routledge, London/New York. https://www.lancaster.ac.uk/fass/projects/corpus/ZJU/xCBLS/CBLS.htm
- McEnery, Tony and Hardie, Andrew (2012). *Corpus Linguistics: Method, Theory and Practice*. Cambridge University Press, Cambridge.
- Lüdeling, Anke and Kytö, Merja (eds.) (2008). *Corpus Linguistics. An International Handbook*. Mouton de Gruyter, Berlin.
- Kennedy, Graeme D. (1998). *An Introduction to Corpus Linguistics*. Longman (Pearson Education Ltd), London and New York.
- Hoffmann, Sebastian *et al.* (2008). *Corpus Linguistics with BNCweb – a Practical Guide*, vol. 6 of English Corpus Linguistics. Peter Lang, Frankfurt.
- Lemnitzer, Lothar and Zinsmeister, Heike (2015). *Korpuslinguistik: Eine Einführung*. Narr, Tübingen, 3rd edition.

Research community

- Important conferences
  - Corpus Linguistics (Lancaster / Birmingham / UK)
  - ICAME = International Computer Archive of Modern and Medieval English
  - AACL = American Association for Corpus Linguistics
  - CILC = International Conference on Corpus Linguistics

- Scientific journals
  - *International Journal of Corpus Linguistics* (IJCL)
  - *Corpora*
  - *ICAME Journal*
  - *Corpus Linguistics and Linguistic Theory* (CLLT)

- Web resources
  - David Lee's bookmarks (maintained by Martin Weisser): http://tiny.cc/corpora (navigation: CBL Links)
  - Linguistics Web (Sabine Bartsch): http://www.linguisticsweb.org/

Corpus design

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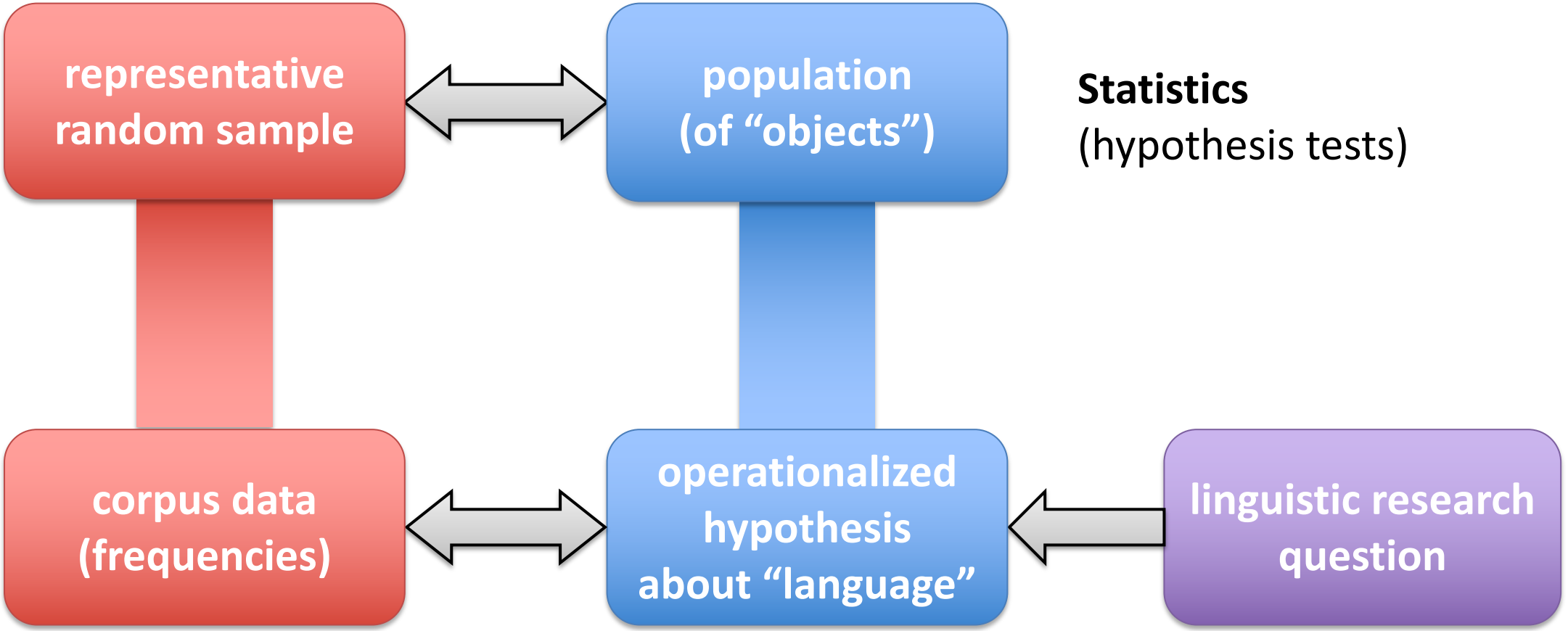
What is representativeness?



Statistics
(hypothesis tests)

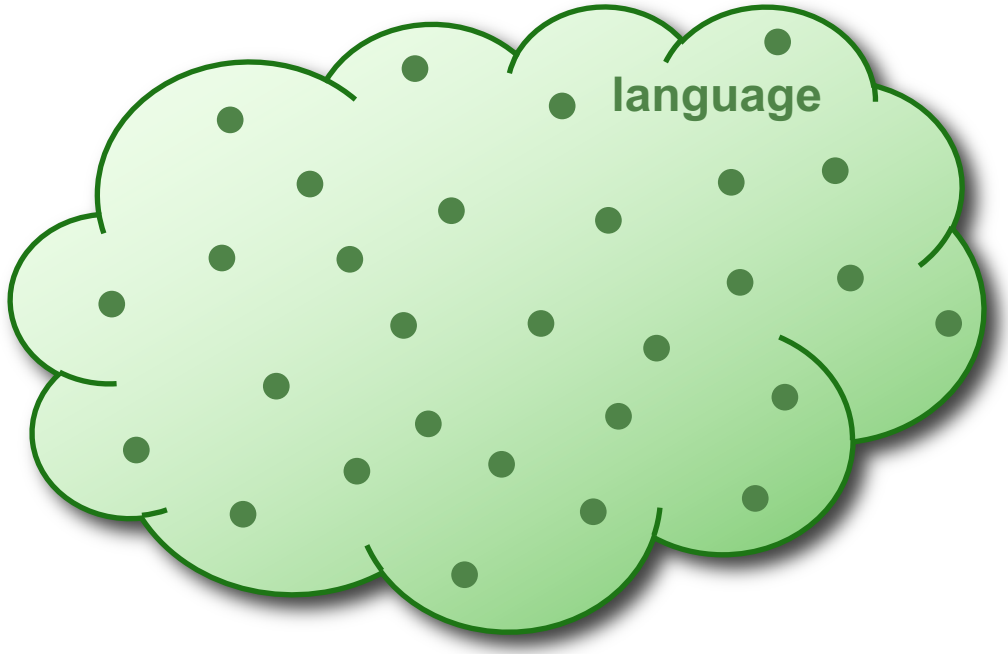
Goals of corpus design

- **Representativeness**
  - a corpus should be representative of the (sub-)language to be studied
  - statistics: random sample
  - full representativeness difficult to achieve
  - must at least be **balanced** (= good coverage of different registers, speakers, …)
  - and avoid **bias** or **skew** towards any particular group of speakers, text type, topic, …

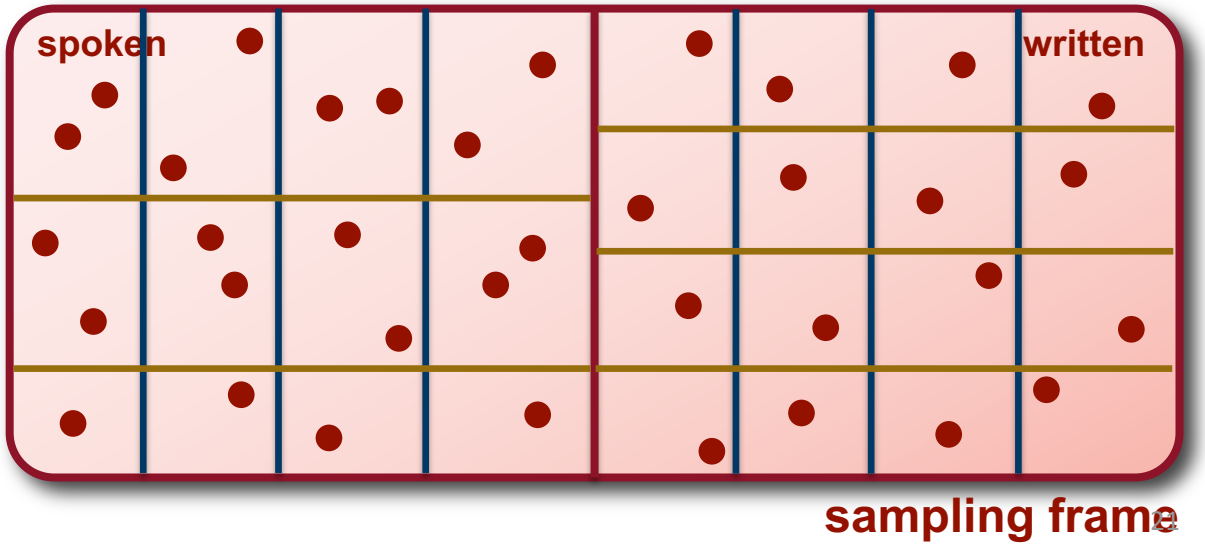
- **Comparability**
  - corpus linguistic analysis often builds on frequency comparison between different corpora or sub-corpora
  - prerequisite: comparable corpora

Representativeness & sampling

- Statistics: completely **random sample**
  - extensional population of interest, i.e. a (possibly infinite) collection of objects
  - randomly select *n* objects from population
- But what about language?



- Design criteria → **sampling frame**
  - dices up and defines linguistic population → make relevant texts **identifiable**
  - "A sampling frame is an operational definition of the population, an itemized listing of population members from which a representative corpus can be chosen." (Biber 1993, 244)
  - pick specified number of items from each cell (related to stratified sampling)



Representativeness & sampling

- Definition of a sampling frame
  - fundamental distinctions: mode (spoken/written/written-to-be-spoken), medium
  - text characteristics: (publication) date, author (single/multi/anon), region, target audience, …
  - function of text: genre / text type (factuality, purpose, situation, …), topic domain, …
  - properties of author/speaker: sex, age, dialect, social class, …
  - see Atkins et al. (1992) for a comprehensive system of categories

- Balance
  - include texts from all (combinations of) categories in the sampling frame = grid cells
  - avoids bias/skew → balanced coverage of the “language” population

- Representativeness
  - sampling frame makes population identifiable (for each combination of categories)
    → random selection of texts for each cell
  - must specifiy **proportion of texts** to be sampled from each category = prevalence in language

Further reading

- Atkins, Sue; Clear, Jeremy; Ostler, Nicholas (1992). Corpus design criteria. *Literary and Linguistic Computing*, **7**(1), 1–16.

- Biber, Douglas (1993). Representativeness in corpus design. *Literary and Linguistic Computing*, **8**(4), 243– 257.

- HSK 29.1 *Corpus Linguistics*, Art. 9

- HSK 5.4 *Dictionaries: Computational Lexicography*, Art. 96 (Ch. XVIII)

Brainstorming

How would you design a corpus for a study of evaluative language in music reviews?

… or another research question?

Annotation & indexing

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A corpus consists of …

- Object data = texts
  - primary data, main object of analysis

- Metadata = information about the texts
  - title, author, publication date, text type, medium, …
  - age, sex, education, region, dialect, … of authors
  - always include all variables used to define sampling frame

- Typographic markup & text structure
  - paragraphs, headings, bold/italics, typeface, itemized lists, footnotes, …

- Annotation = linguistic interpretation
  - simple (token level) vs. structured (e.g. syntax tree)
  - essential for querying and analyzing large corpora

Corpus annotation:
raw text + metadata

It seemed a day much as any other until I happened to look out of the back window. There was a little garden behind the house; a well-mown lawn surrounded by a neatly cut hedge, a few bushes and colourful flowers.

metadata

title:	The Garden
author:	Stefan Evert
author sex:	male
date:	05.08.1991

Corpus annotation: tokenization

It seemed a day much as any other until I happened to look out of the back window . There was a little garden behind the house ; a well-mown lawn surrounded by a neatly cut hedge , a few bushes and colourful flowers .

Corpus annotation:
sentence segmentation

<s> It seemed a day much as any other until I happened to look out of the back window . </s>

<s> There was a little garden behind the house ; a well-mown lawn surrounded by a neatly cut hedge , a few bushes and colourful flowers . </s>

Corpus annotation:
part-of-speech (POS) tagging

<S> It$_{PP}$ seemed$_{VBD}$ a$_{DT}$ day$_{NN}$ much$_{RB}$ as$_{IN}$ any$_{DT}$ other$_{JJ}$ until$_{IN}$ I$_{PP}$ happened$_{VBD}$ to$_{TO}$ look$_{VB}$ out$_{RP}$ of$_{IN}$ the$_{DT}$ back$_{JJ}$ window$_{NN}$.$_{SENT}$ </S>

<S> There$_{EX}$ was$_{VBD}$ a$_{DT}$ little$_{JJ}$ garden$_{NN}$ behind$_{IN}$ the$_{DT}$ house$_{NN}$;$_{:}$ a$_{DT}$ well-mown$_{VBN}$ lawn$_{NN}$ surrounded$_{VBN}$ by$_{IN}$ a$_{DT}$ neatly$_{RB}$ cut$_{VBN}$ hedge$_{NN}$,$_{,}$ a$_{DT}$ few$_{JJ}$ bushes$_{NNS}$ and$_{CC}$ colourful$_{JJ}$ flowers$_{NNS}$.$_{SENT}$ </S>

English: Penn tagset

* with TreeTagger-internal modifications

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CC	Coordinating conjunction	
CD	Cardinal number	
DT	Determiner	
EX	Existential *there*	
FW	Foreign word	
IN	Preposition / subordinating conjuction	
* IN/that	Subordinating conjunction *that*	
JJ	Adjective (positive)	
JJR	Adjective (comparative)	
JJS	Adjective (superlative)	
LS	List item marker	
MD	Modal verb	
NN	Noun, singular or mass	
NNS	Noun, plural	
NP	Proper noun, singular	
NPS	Proper noun, plural	
PDT	Predeterminer	
POS	Possessive ending (*'s*)	
PP	Personal pronoun	
PP$	Possessive pronoun	
RB	Adverb	
RP	Particle	
SYM	Symbol (mathemathical/scientific)	
TO	*to* (any usage)	*fly to Paris, ready to go, …*
UH	Interjection	
#	Pound sign	*£*
$	Dollar sign	*$*

VB	Verb *be*, base form	
VBD	Verb *be*, past tense	
VBG	Verb *be*, gerund/progressive	
VBN	Verb *be*, past participle	
VBP	Verb *be*, non-3rd pers. sg. present	
VBZ	Verb *be*, 3rd pers. sg. present tense	
* VH	Verb *have*, base form	
* VHD	Verb *have*, past tense	
* VHG	Verb *have*, gerund/progressive	
* VHN	Verb *have*, past participle	
* VHP	Verb *have*, non-3rd pers. sg. present	
* VHZ	Verb *have*, 3rd pers. sg. present tense	
* VV	Lexical verb, base form	
* VVD	Lexical verb, past tense	
* VVG	Lexical verb, gerund/progressive	
* VVN	Lexical verb, past participle	
* VVP	Lexical verb, non-3rd pers. sg. present	
* VVZ	Lexical verb, 3rd pers. sg. present tense	
WDT	Wh-determiner	
WP	Wh-pronoun	
WP$	Possessive wh-pronoun	
WRB	Wh-adverb	
SENT	Sentence-final punctuation	*. ! ?*
,	Comma	*,*
:	Colon, semi-colon	*: ;*
( )	Comma	*([ ])*
`` ''	Comma	*“…” ‘…’ "*

German: STTS tagset

ADJA	attributives Adjektiv	
ADJD	adverbiales / prädikatives Adjektiv	
ADV	Adverb	*schon, bald, doch*
APPR	Präposition / Zirkumposition links	
APPRART	Präposition mit Artikel fusioniert	*zum*
APPO	Postposition	*zufolge, wegen*
APZR	Zirkumposition rechts	*von ... an*
ART	bestimmter oder unbestimmter Artikel	
CARD	Kardinalzahlen (Ordinalzahl = ADJA)	
FM	Fremdsprachliches Material	
ITJ	Interjektion	*mhm, ach, tja*
KOUI	unterordnende Konj. mit *zu* + Inf	
KOUS	unterordnende Konjunktion mit Satz	
KON	nebenordnende Konjunktion	*und, oder*
KOKOM	Vergleichskonjunktion	*als, wie*
NN	normales Nomen	
NE	Eigenname	
PDS	substituierendes Demonstrativpron.	
PDAT	attribuierendes Demonstrativpron.	
PIS	substituierendes Indefinitpron.	
PIAT	attrib. Indefinitpron. ohne Determiner	
PIDAT	attrib. Indefinitpron. mit Determiner	
PPER	Personalpronomen (nicht reflexiv)	
PPOSS	substituierendes Possessivpronomen	
PPOSAT	attribuierendes Possessivpronomen	
PRELS	substituierendes Relativpronomen	
PRELAT	attribuierendes Relativpronomen	

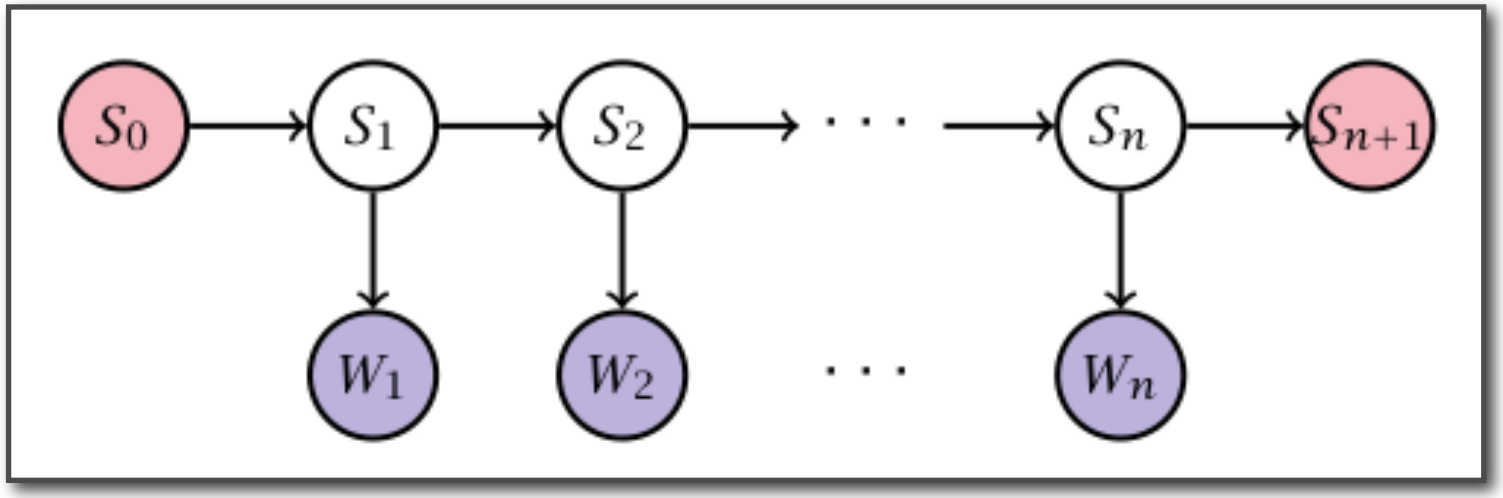
PRF	reflexives Personalpronomen	
PWS	substituierendes Interrogativpron.	
PWAT	attribuierendes Interrogativpronomen	
PWAV	adverbiales Interrogativ-/Relativpron.	
PAV	Pronominaladverb	*dafür, deswegen*
PTKZU	*zu* vor Infinitiv	
PTKNEG	Negationspartikel	*nicht*
PTKVZ	abgetrennter Verbzusatz	*kommt ... an*
PTKANT	Antwortpartikel	*ja, nein, danke*
PTKA	Partikel bei Adjektiv/Adverb	*am, zu*
TRUNC	Kompositions-Erstglied	*Unter- und ...*
VVFIN	finites Verb, voll (= lexikalisch)	
VVIMP	Imperativ, voll	
VVINF	Infinitiv, voll	
VVIZU	Infinitiv mit *zu*, voll	
VVPP	Partizip Perfekt, voll	
VAFIN	finites Hilfsverb	
VAIMP	Imperativ, Hilfsverb	
VAINF	Infinitiv, Hilfsverb	
VAPP	Partizip Perfekt, Hilfsverb	
VMFIN	Finites Modalverb	
VMINF	Infinitiv, Modalverb	
VMPP	Partizip Perfekt, Modalverb	
XY	Nichtwort mit Sonderzeichen	*3:7, H2O*
$,	Komma	,
$.	Satzbeendende Interpunktion	*. ? ! ; :*
$(	sonstige Satzzeichen (intern)	*– [ ] ( )*

Manual annotation

- Manual annotation for small, high-quality corpora
  - e.g. digital edition, political speeches, poetry/song texts, …
- Annotation schema and categories
- Guidelines = detailed instructions for annotators
  - plus collection of examples for unclear / difficult cases
- Annotation tools (usually Web-based)
  - e.g. INCEpTION (https://inception-project.github.io), Prodigy (https://prodi.gy)
- Inter-Annotator Agreement (IAA)
  - reliability and validity of the annotation
  - annotator mistakes vs. systematic differences

Automatic annotation

- Most successful approach: machine learning
- Need to cast annotation as classification task
- Gold standard = corpus with manual annotation
  - annotation must be consistent, errors seem unproblematic
  - separate into training, development and test data
- Example: tagging with Hidden Markov Model (HMM)
  - see e.g. Brants (2000), Schmid (1995)



(Evert et al. 2009)

Corpus annotation: lemmatization

<S> It$_{PP}$ seemed$_{VBD}$ a$_{DT}$ day$_{NN}$ much$_{RB}$ as$_{IN}$ any$_{DT}$ other$_{JJ}$ until$_{IN}$ I$_{PP}$ happened$_{VBD}$ to$_{TO}$ look$_{VB}$ out$_{RP}$ of$_{IN}$ the$_{DT}$ back$_{JJ}$ window$_{NN}$.$_{SENT}$ </S>

<S> There$_{EX}$ was$_{VBD}$ a$_{DT}$ little$_{JJ}$ garden$_{NN}$ behind$_{IN}$ the$_{DT}$ house$_{NN}$;$_{:}$ a$_{DT}$ well-mown$_{VBN}$ lawn$_{NN}$ surrounded$_{VBN}$ by$_{IN}$ a$_{DT}$ neatly$_{RB}$ cut$_{VBN}$ hedge$_{NN}$,$_{,}$ a$_{DT}$ few$_{JJ}$ bushes$_{NNS}$ and$_{CC}$ colourful$_{JJ}$ flowers$_{NNS}$.$_{SENT}$ </S>

Corpus annotation: lemmatization

<s> It$_{PP}^{it}$ seemed$_{VBD}^{seem}$ a$_{DT}^{a}$ day$_{NN}^{day}$ much$_{RB}^{much}$ as$_{IN}^{as}$ any$_{DT}^{any}$ other$_{JJ}^{other}$ until$_{IN}^{until}$ I$_{PP}^{I}$ happened$_{VBD}^{happen}$ to$_{TO}^{to}$ look$_{VB}^{look}$ out$_{RP}^{out}$ of$_{IN}^{of}$ the$_{DT}^{the}$ back$_{JJ}^{back}$ window$_{NN}^{window}$.$_{SENT}^{.}$ </s>

<s> There$_{EX}^{there}$ was$_{VBD}^{be}$ a$_{DT}^{a}$ little$_{JJ}^{little}$ garden$_{NN}^{garden}$ behind$_{IN}^{behind}$ the$_{DT}^{the}$ house$_{NN}^{house}$;$_{:}^{;}$ a$_{DT}^{a}$ well-mown$_{VBN}^{???}$ lawn$_{NN}^{lawn}$ surrounded$_{VBN}^{surround}$ by$_{IN}^{by}$ a$_{DT}^{a}$ neatly$_{RB}^{neatly}$ cut$_{VBN}^{cut}$ hedge$_{NN}^{hedge}$,$_{,}^{,}$ a$_{DT}^{a}$ few$_{JJ}^{few}$ bushes$_{NNS}^{bush}$ and$_{CC}^{and}$ colourful$_{JJ}^{colorful}$ flowers$_{NNS}^{flower}$.$_{SENT}^{.}$ </s>

need better representation format

XML markup of annotation

Standard for data interchange & archiving

root element

element annotated with attributes

start tag of XML element

```
<corpus>
  <story num="6" title="The Garden">
    <p>
      <s>
        <token pos="PP"  lemma="it">It</token>
        <token pos="VBD" lemma="seem">seemed</token>
        <token pos="DT"  lemma="a">a</token>
        <token pos="NN"  lemma="day">day</token>
        <token pos="RB"  lemma="much">much</token>
        <token pos="IN"  lemma="as">as</token>
        <token pos="DT"  lemma="any">any</token>
        <token pos="JJ"  lemma="other">other</token>
        <token pos="IN"  lemma="until">until</token>
        <token pos="PP"  lemma="I">I</token>
      </s>
    </p>
  </story>
</corpus>
```

corresponding end tag

XML markup of annotation
Standard for data interchange & archiving

XML declaration

```
<?xml version="1.0" encoding="UTF-8"?>
<corpus>
  <story num="6" title="The Garden">
    <p>
      <s>
        <token pos="PP"  lemma="it">It</token>
        <token pos="VBD" lemma="seem">seemed</token>
        <token pos="DT"  lemma="a">a</token>
        <token pos="NN"  lemma="day">day</token>
        <token pos="RB"  lemma="much">much</token>
        <token pos="IN"  lemma="as">as</token>
        <token pos="DT"  lemma="any">any</token>
        <token pos="JJ"  lemma="other">other</token>
        <token pos="IN"  lemma="until">until</token>
        <token pos="PP"  lemma="I">I</token>
        ...
      </s>
    </p>
  </story>
</corpus>
```

XML markup of annotation

Standard for data interchange & archiving

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```
<?xml version="1.0" encoding="UTF-8"?>
<corpus>
 <metadata>
    <author>
      <name>Stefan Evert</name>
      <sex>male</sex>
    </author>
    <publication>
      <title>Very Short Stories</title>
      <type>collection</type>
      <genre>fiction</genre>
    </publication>
  </metadata>
  <story num="6" title="The Garden">
    <p>
      <s>
        <token pos="PP"  lemma="it">It</token>
        <token pos="VBD" lemma="seem">seemed</token>
        <token pos="DT"  lemma="a">a</token>
        <token pos="NN"  lemma="day">day</token>
        ...
```

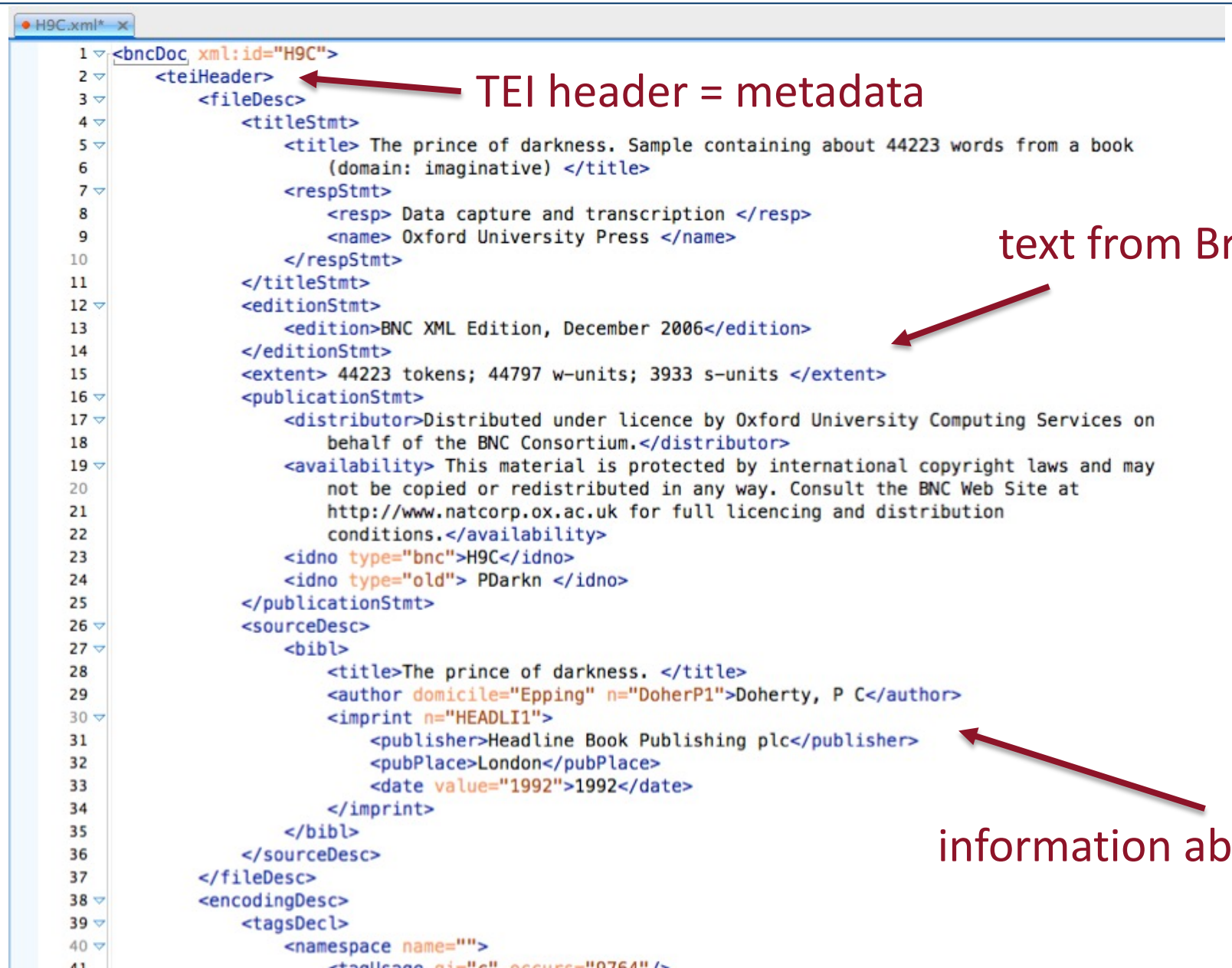
metadata header

XML standards

- XML (Extensible Markup Language) is a widely-used standard for structured annotation
- A well-formed XML document only specifies the structure of annotation, not its semantics
- DTD (document type declaration) or XML Schema specify valid element & attribute names
  - still doesn't explain semantics without documentation!

- Exchange formats for text corpora:
  TEI (Text Encoding Initiative), XCES (Corpus Encoding Standard),
  ISO 24612: LAF (Linguistic Annotation Framework)
  - but more efficient representation requiredd for corpus search etc.

TEI standard (BNC)



TEI standard (BNC)

```
<wtext type="FICTION">
    <pb n="69"/>
    <div level="1">
        <head>
            <s n="2">
                <w c5="NN1" hw="chapter" pos="SUBST">Chapter </w>
                <w c5="CRD" hw="5" pos="ADJ">5</w>
            </s>
        </head>
        <p>
            <s n="3">
                <w c5="VVB-NN1" hw="ranulf" pos="VERB">Ranulf </w>
                <w c5="CJC" hw="and" pos="CONJ">and </w>
                <w c5="NP0" hw="dame" pos="SUBST">Dame </w>
                <w c5="NP0" hw="agatha" pos="SUBST">Agatha </w>
                <w c5="VBD" hw="be" pos="VERB">were </w>
                <w c5="VVG" hw="wait" pos="VERB">waiting </w>
                <w c5="PRP" hw="for" pos="PREP">for </w>
                <w c5="PNP" hw="he" pos="PRON">him </w>
                <w c5="PRP" hw="near" pos="PREP">near </w>
                <w c5="AT0" hw="the" pos="ART">the </w>
                <w c5="NN1-NP0" hw="galilee" pos="SUBST">Galilee </w>
                <w c5="NN1" hw="gate" pos="SUBST">Gate</w>
                <c c5="PUN">, </c>
                <w c5="AT0" hw="the" pos="ART">the </w>
                <w c5="AJ0" hw="young" pos="ADJ">young </w>
                <w c5="NN1" hw="nun" pos="SUBST">nun </w>
                <w c5="AV0" hw="apparently" pos="ADV">apparently </w>
                <w c5="VVG" hw="enjoy" pos="VERB">enjoying </w>
                <w c5="AT0" hw="an" pos="ART">an </w>
                <w c5="NN1" hw="account" pos="SUBST">account </w>
                <w c5="PRF" hw="of" pos="PREP">of </w>
                <w c5="CRD" hw="one" pos="ADJ">one </w>
                <w c5="PRF" hw="of" pos="PREP">of </w>
                <w c5="DPS" hw="he" pos="PRON">his </w>
                <w c5="NN1" hw="manservant" pos="SUBST">manservant</w>
                <w c5="POS" hw="'s" pos="UNC">'s </w>
                <w c5="DT0" hw="many" pos="ADJ">many </w>
                <w c5="NN2" hw="escapade" pos="SUBST">escapades </w>
                <w c5="PRP" hw="in" pos="PREP">in </w>
                <w c5="NP0" hw="london" pos="SUBST">London</w>
                <c c5="PUN">.</c>
```

TEI body = object data + annotation

structure & typographic markup

tokens + token-level annotations

principle:
raw text (= object data)
can be reconstructed by
deleting all XML tags

Vertical text format (.vrt)

Simpler, more efficient format → used by CWB & NLP tools


```
<corpus>
<story title="The Garden">
<p>
<s>
It        PP    it
seemed    VBD   seem
a         DT    a
day       NN    day
much      RB    much
as        IN    as
any       DT    any
other     JJ    other
until     IN    until
I         PP    I
...
</s>
</p>
</story>
</corpus>
```

TAB characters (\t, \x09)

metadata

title:	The Garden
author:	Stefan Evert
author sex:	male
date:	05.08.1991

Vertical text format (.vrt)

Text metadata encoded in XML start tags (not in header!)

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```
<corpus>
<text title="The Garden" author="Stefan Evert" author_sex="male"
      date="1991-08-05">
<p num="1">
<s>
It        PP    it
seemed    VBD   seem
a         DT    a
day       NN    day
much      RB    much
as        IN    as
any       DT    any
other     JJ    other
until     IN    until
I         PP    I
...
</s>
</p>
</text>
</corpus>
```

CQPweb requires **<text>**,
SketchEngine prefers **<doc>**

sub-text level metadata

CoNLL format

Vertical text without the metadata

http://universaldependencies.org/docs/format.html

```
# story: "The Garden"
# paragraph #1
1   It       PP   it
2   seemed   VBD  seem
3   a        DT   a
4   fine     JJ   fine
5   day      NN   day
6   .        SENT .

1   There    EX   there
2   was      VBD  be
3   an       DT   a
4   elephant NN   elephant
5   .        SENT .

# this is the end of the file
```

these are just comments

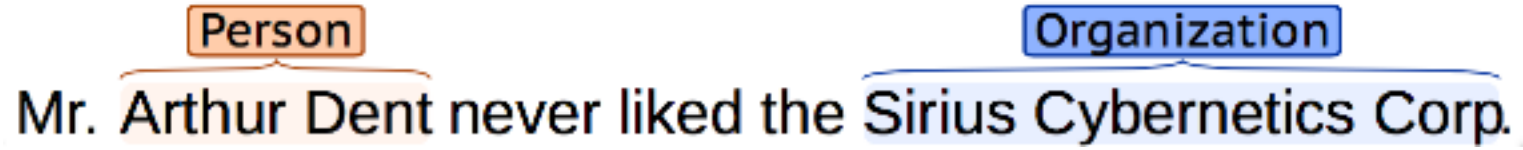
blank lines = sentence boundaries

token numbers (within sentence)

Corpus annotation: segments and structures

- Automatic recognition and categorization of particular word sequences (segments)

- e.g. named entities (NER = named entity recognition)



- e.g. time and place expressions: last week, the day after tomorrow, September 15th, in Paris, on the lawn in front of their house, …
- e.g. text spans that need to be masked for anonymization purposes

Corpus annotation: segments and structures

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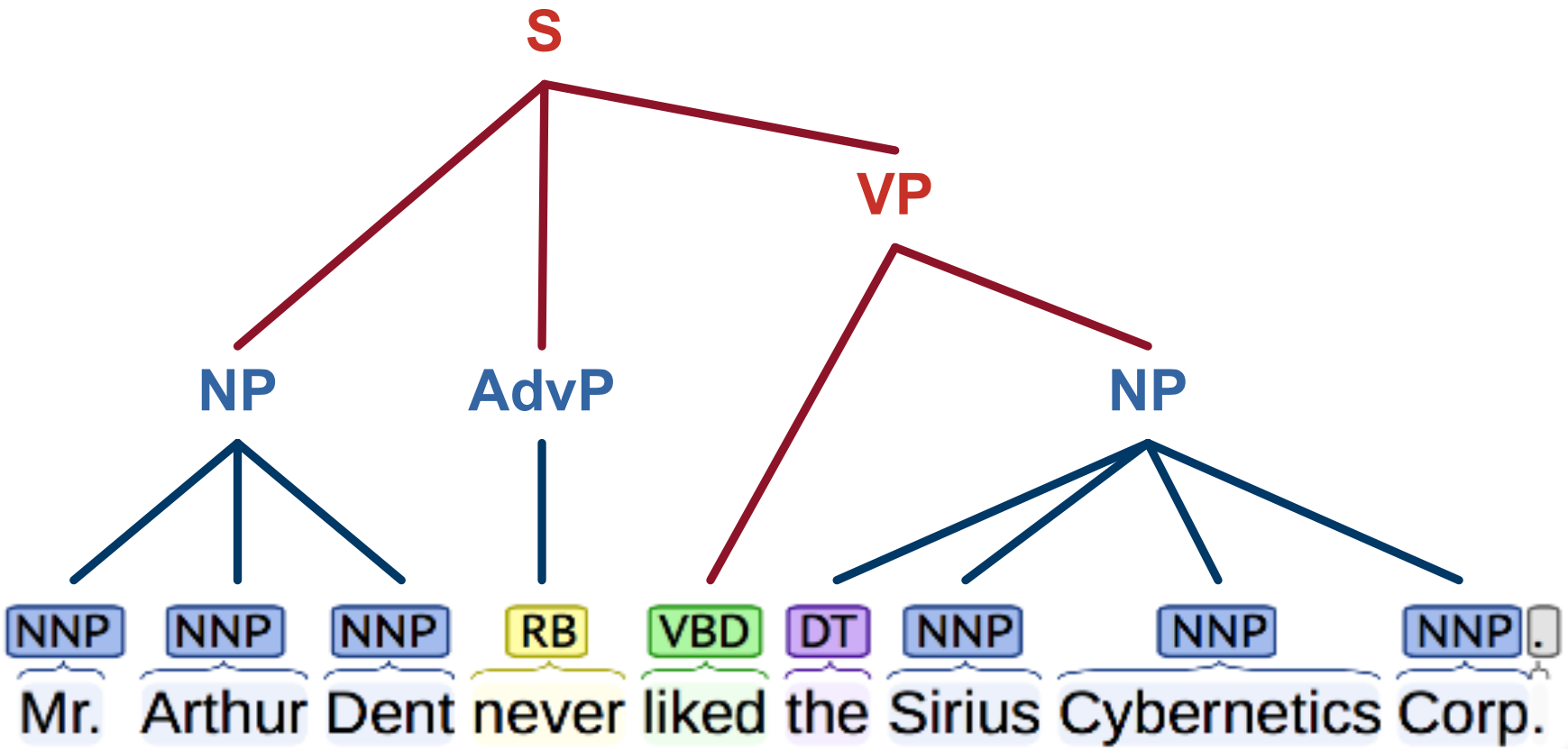
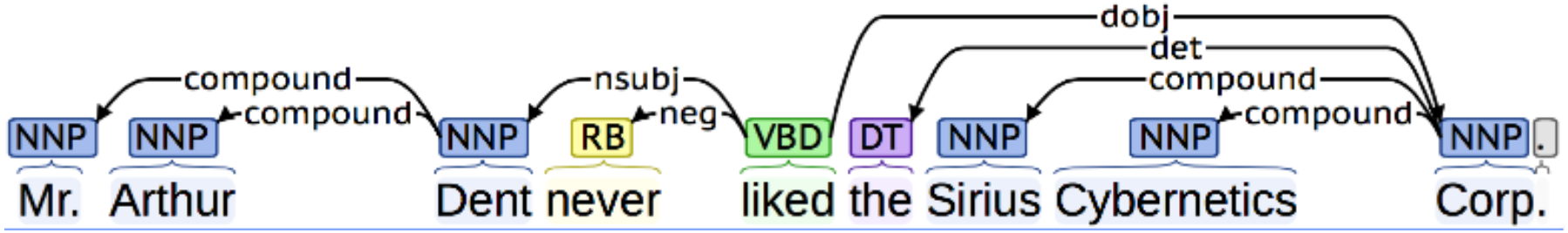
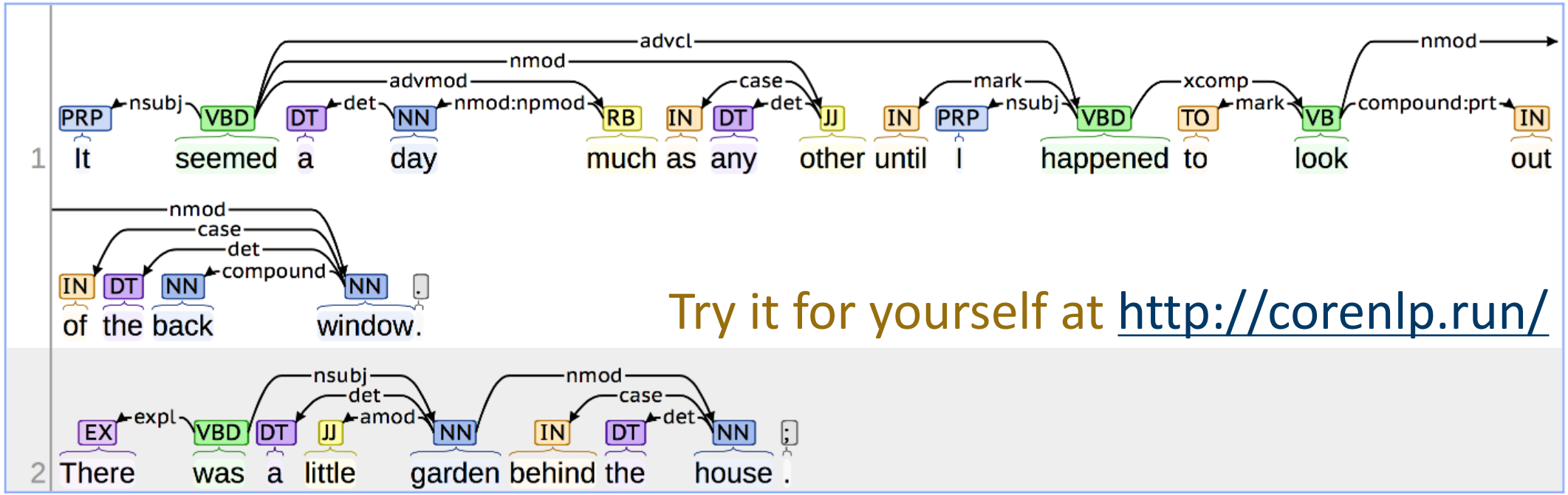
- Syntactic phrase structure analysis
  = parse tree of nested segments corresponding to syntactic units
- „minimal“ phrases as flat segments → chunk parsing



Corpus annotation: syntactic dependency analysis

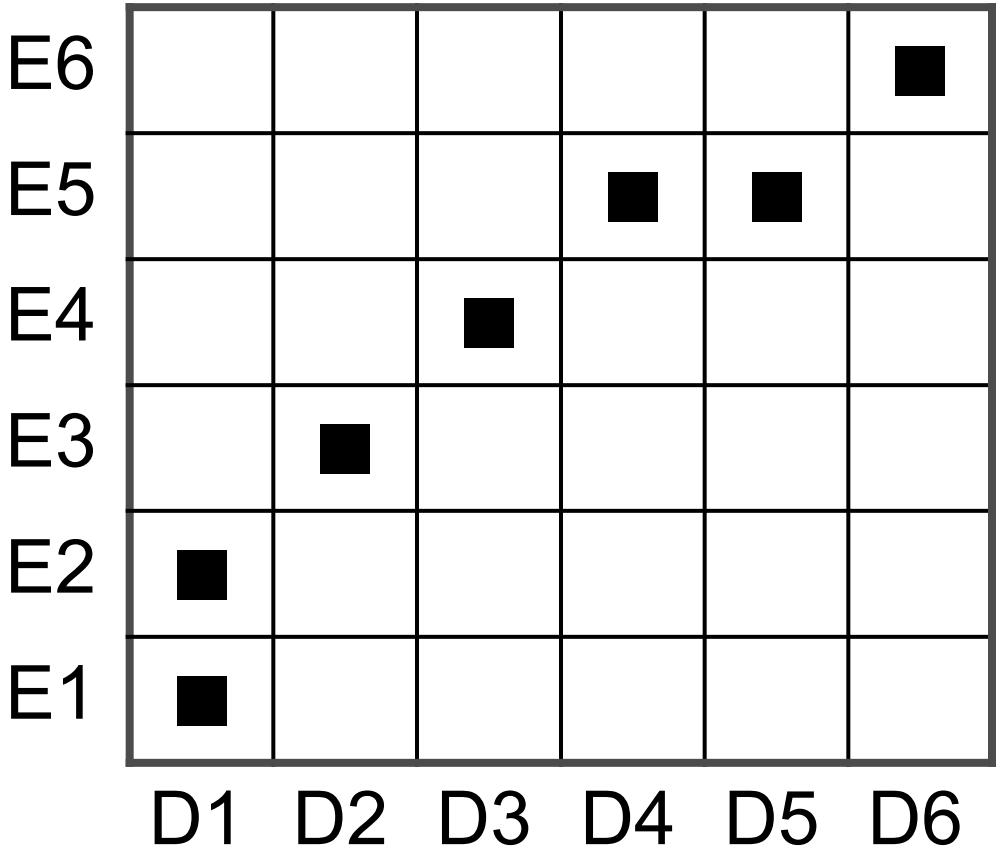




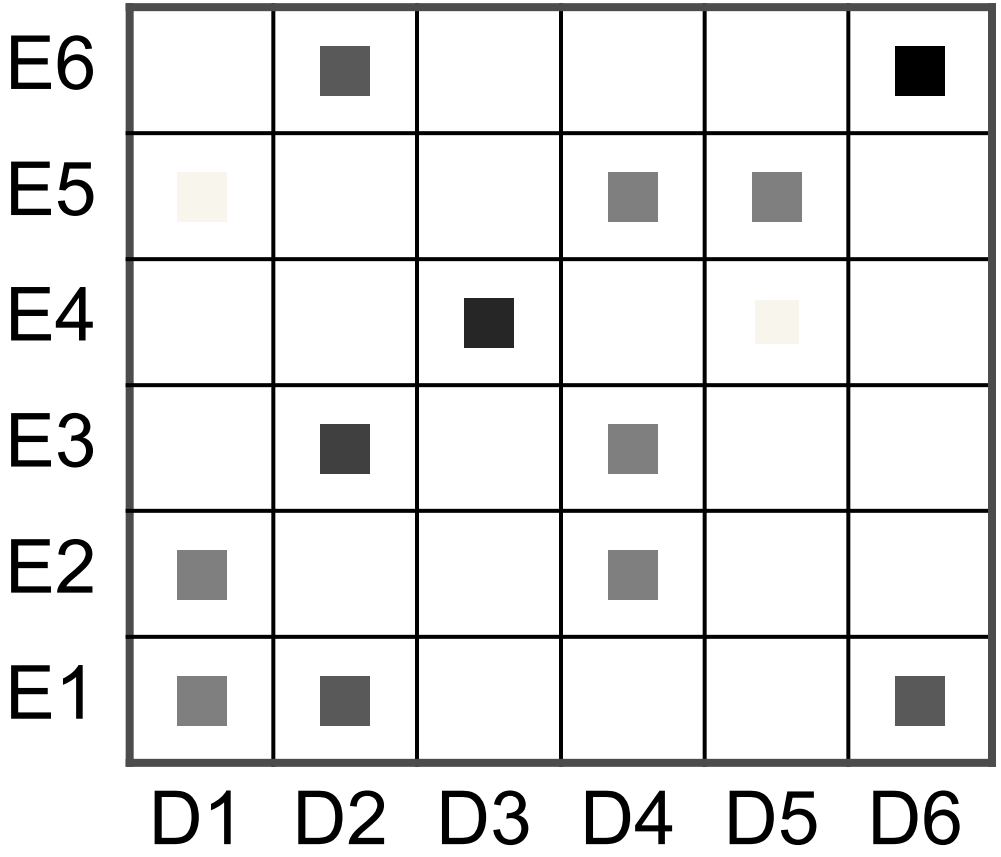
Sentence alignment for parallel corpora

Das stört mich keineswegs, ich halte das für eine gute Initiative, aber wiederum ist Europa nicht zur Stelle.	That is no problem for me.
	I think it is a good initiative, but again Europe is absent.
Es darf nicht wieder geschehen!	It should not happen again, Mr President.
Meine Fraktion verlangt, daß die italienische Präsidentschaft hier vor uns erklärt, welche Rolle sie spielt.	My Group wants the Italian presidency to come here and explain what its role is.
Herr Präsident, liebe Kolleginnen und Kollegen!	Mr President, ladies and gentlemen, I think it is important that we should discuss the situation in the Middle East this week.
Ich halte es für wichtig, daß wir diese Woche über die Situation im Nahen Osten reden.	
Darin sind wir uns alle einig.	We all agree on that.

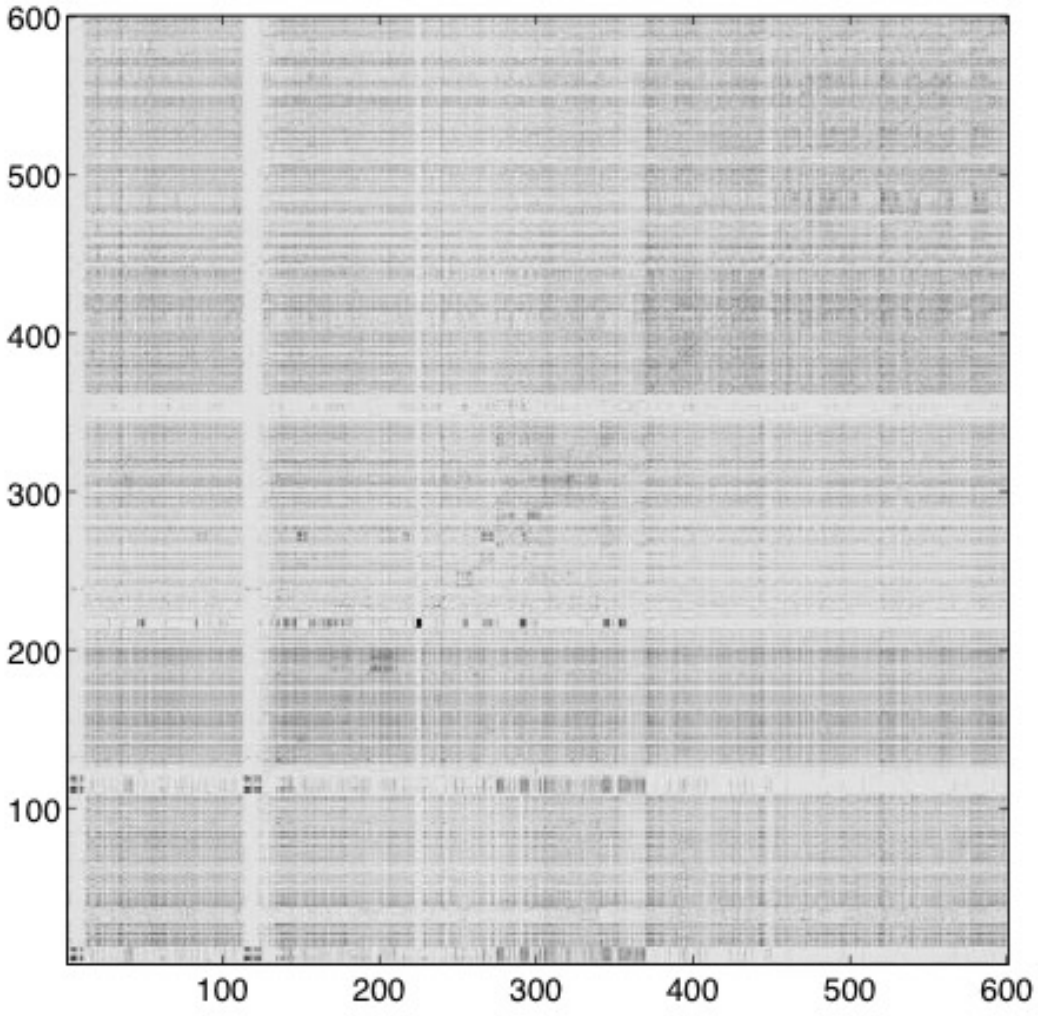
Sentence alignment: bitext map

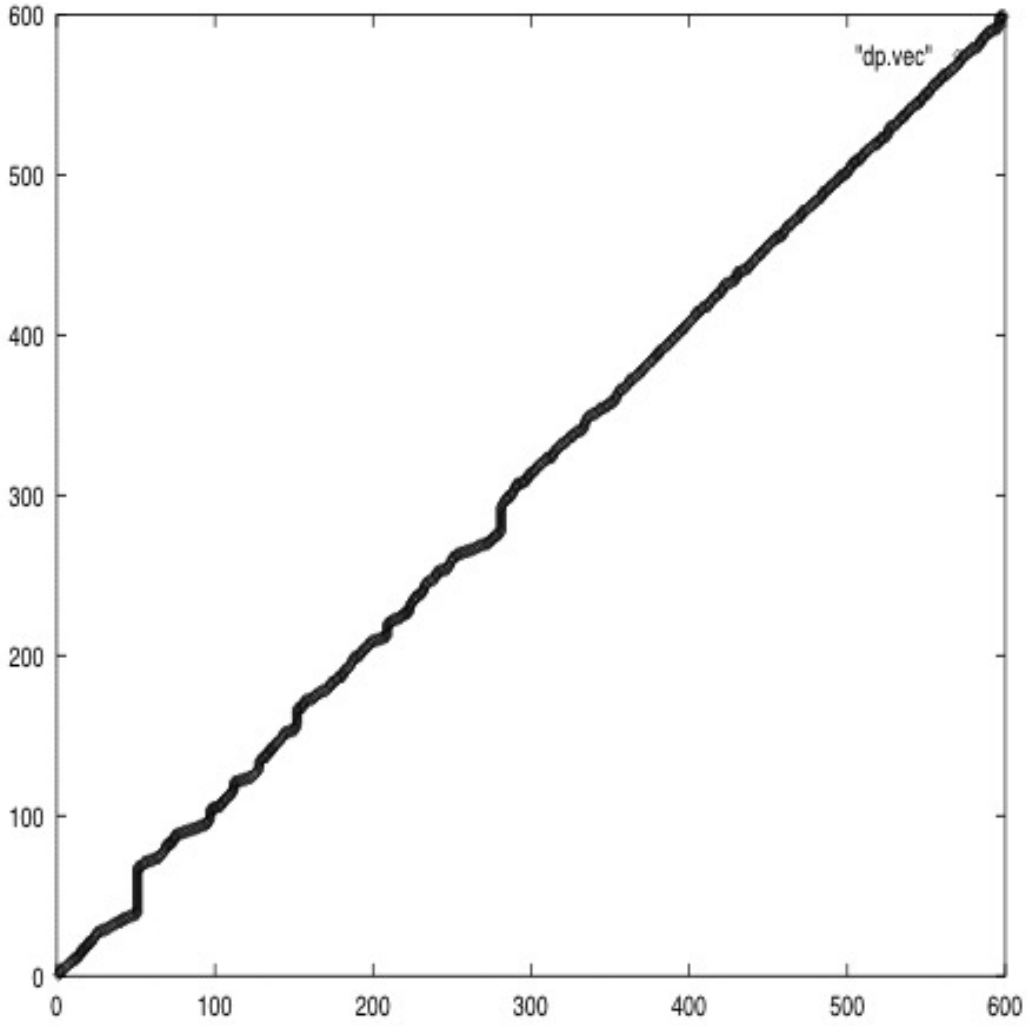


Sentence alignment as similarity search



Sentence alignment as similarity search





Thank you for listening!

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