Statistical Analysis of Corpus Data with R

The Limitations of Random Sampling Models for Corpus Data

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http://purl.org/stefan.evert/SIGIL

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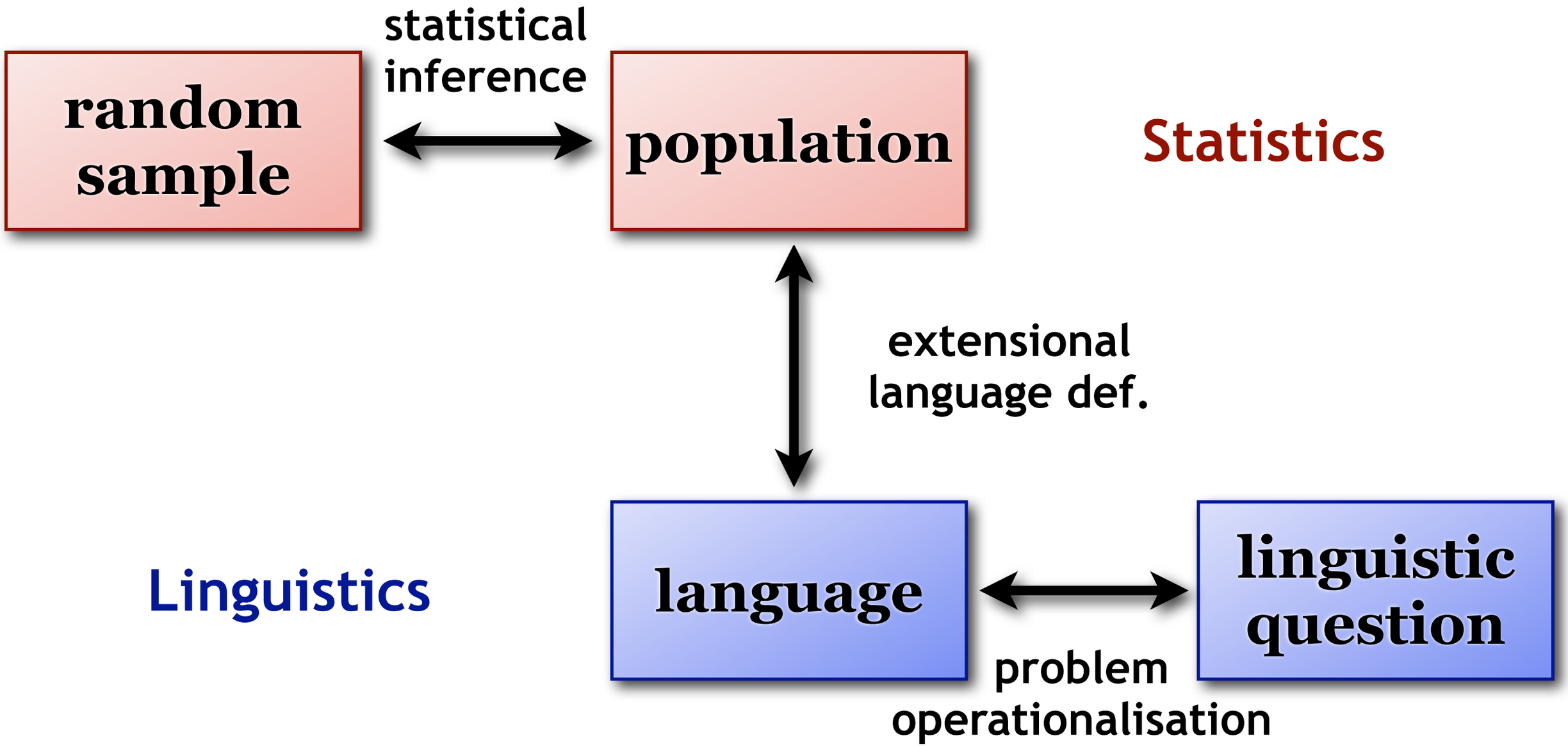
The role of statistics



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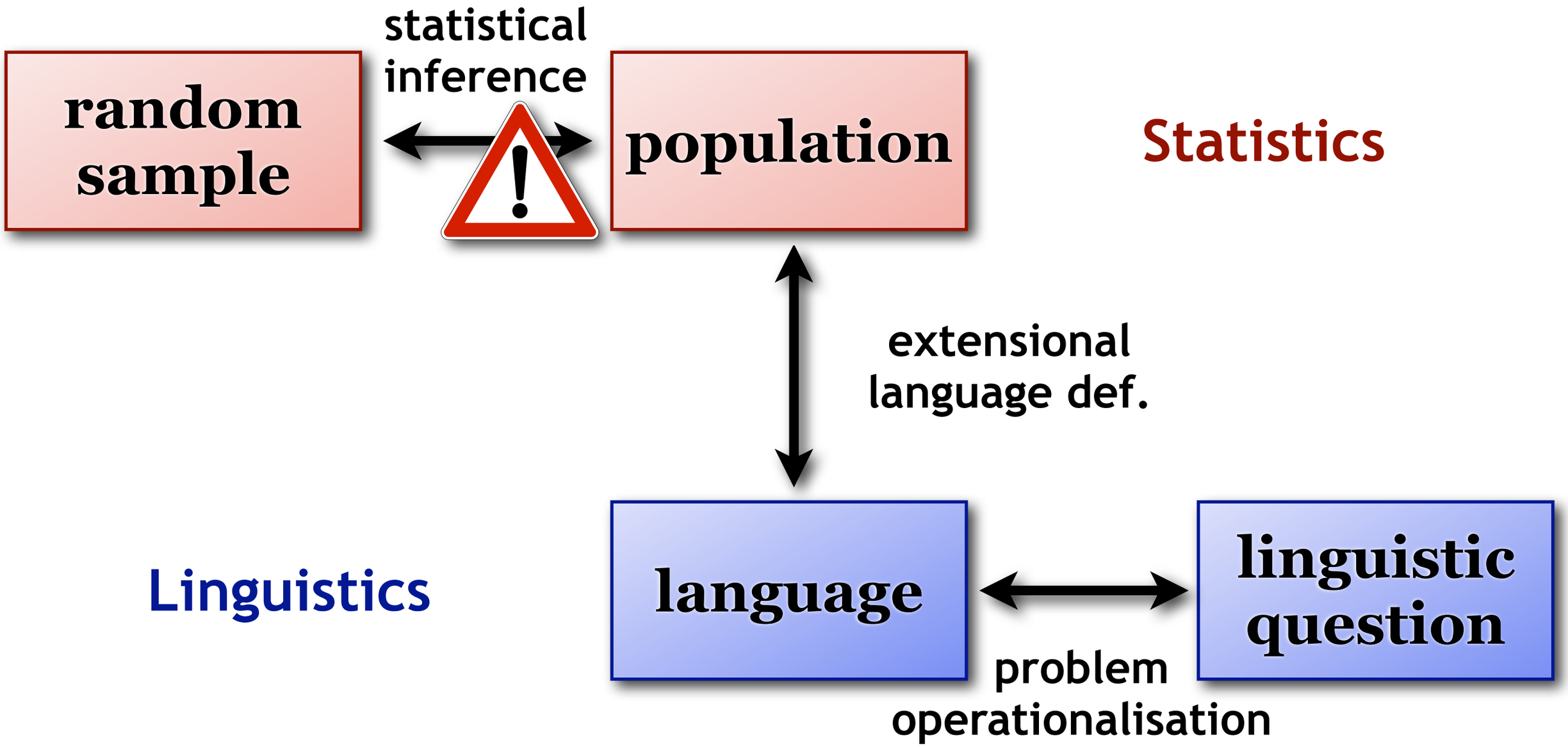

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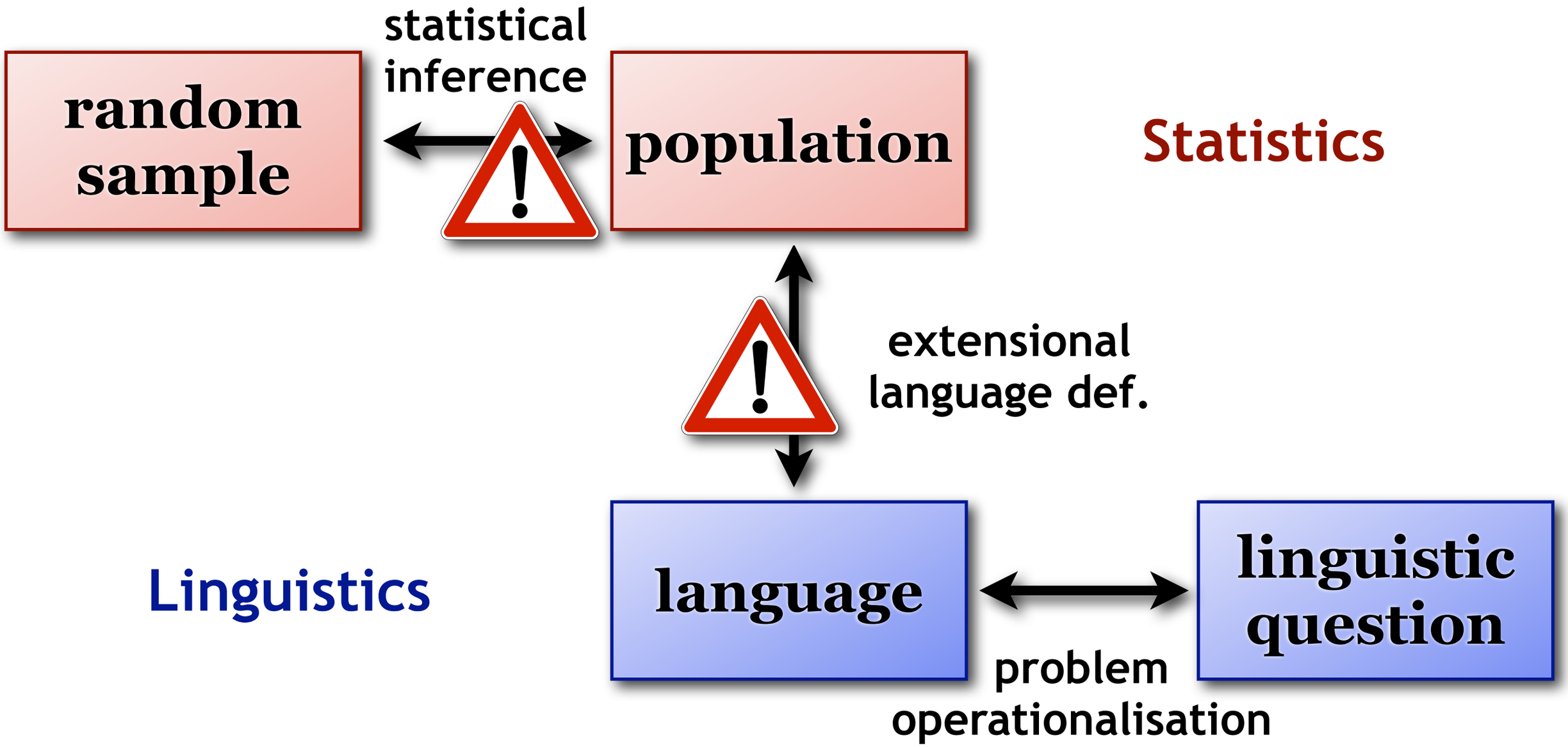

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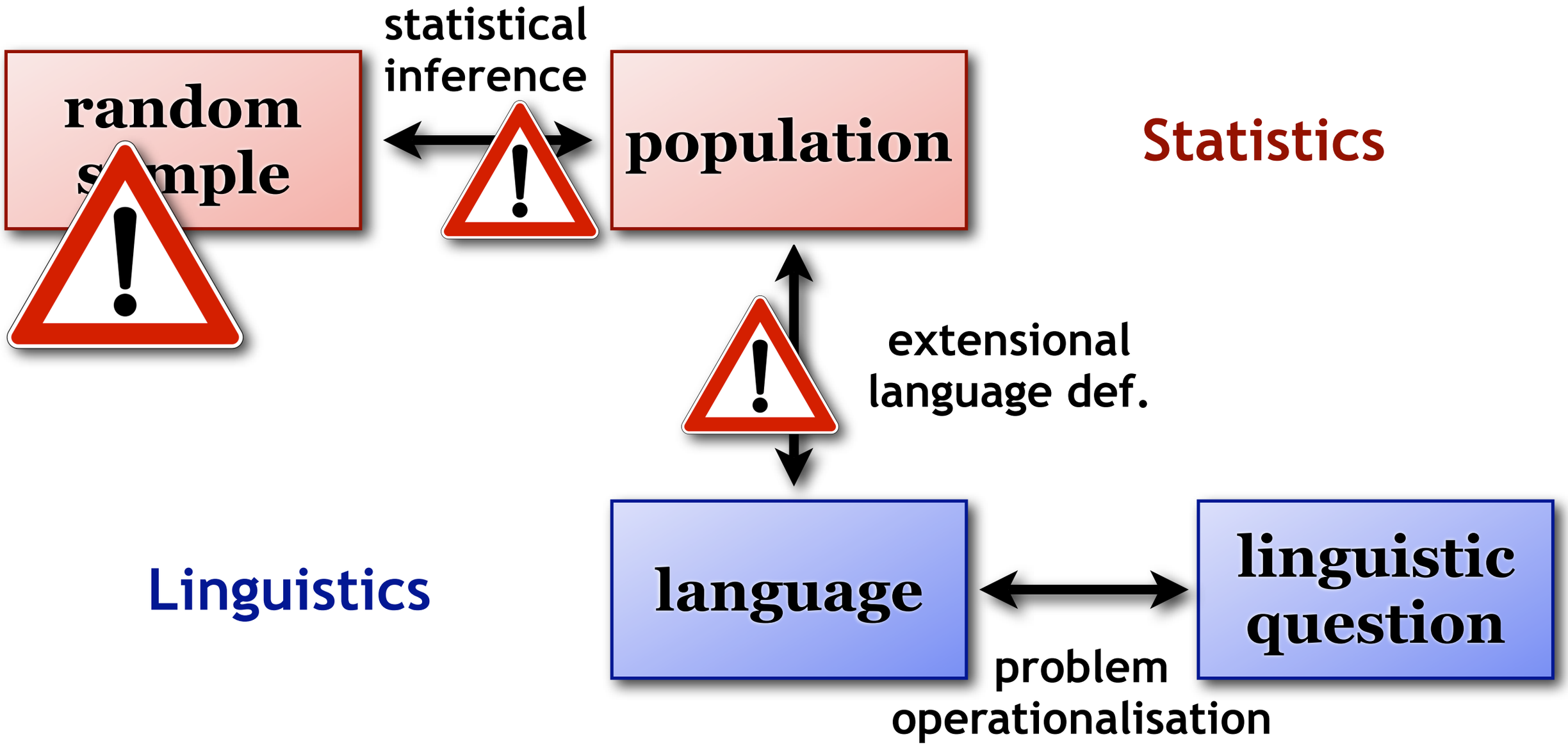

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  - if it's mostly spoken (80%), proportion is only 3.4%

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  - Fisher is conservative & computationally expensive
    - also numerical problems, e.g. in R version 1.x 

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  - not clear which measure of effect size is appropriate
  - e.g. **difference** of proportions, **relative risk** (ratio of proportions), **odds ratio**, logarithmic odds ratio, normalised X^2, …

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- Effect size for frequency comparison
  - not clear which measure of effect size is appropriate
  - e.g. **difference** of proportions, **relative risk** (ratio of proportions), **odds ratio**, logarithmic odds ratio, normalised X^2, ...
- Confidence interval estimation
  - accurate & efficient estimation of confidence intervals for effect size is often very difficult
  - exact confidence intervals only available for odds ratio

Problem 3:
Multiple hypothesis tests

- Each individual hypothesis test controls risk of type I error … but if you carry out thousands of tests, some of them *have* to be false rejections
  - recommended reading: *Why most published research findings are false* (Ioannidis 2005)
  - a monkeys-with-typewriters scenario

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  - but usually candidates selected *a posteriori* from data → many "unreported" tests for candidates with $f = 0$!
  - large number of such word pairs according to **Zipf's law** results in substantial number of type I errors
  - can be quantified with LNRE models (Evert 2004), cf. session on word frequency distributions with *zipfR*

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  - it would be very tedious if you had to take a random sample from a library, especially a hypothetical one, every time you want to test some hypothesis
- Use pre-compiled sample: a **corpus**
  - but this is not a random sample of tokens!
  - would be prohibitively expensive to collect 10 million VPs for a BNC-sized sample at random
  - other studies will need tokens of different granularity (words, word pairs, sentences, even full texts)

The Brown corpus

- First large-scale electronic corpus
  - compiled in 1964 at Brown University (RI)
- 500 samples of approx. 2,000 words each
  - sampled from edited AmE published in 1961
  - from 15 domains (imaginative & informative prose)
  - manually entered on punch cards

The British National Corpus

- 100 M words of modern British English
  - compiled mainly for lexicographic purposes: Brown-type corpora (such as LOB) are too small
  - both written (90%) and spoken (10%) English
  - XML edition (version 3) published in 2007
- 4048 samples from 25 to 428,300 words
  - 13 documents < 100 words, 51 > 100,000 words
  - some documents are collections (e.g. e-mail messages)
  - rich metadata available for each document

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- Representativeness: different genres, speakers, etc. included in appropriate proportion?
  - you may not agree with 10% of spoken English in BNC
  - can be corrected for if problem is known and sufficiently detailed meta-information is available

Problem 5:
Non-randomness

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Unit of sampling

- Key problem: **unit of sampling** (text or fragment) ≠ **unit of measurement** (e.g. VP)
  - recall sampling procedure in library metaphor …

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- Random sampling in the library metaphor
  - walk to a random shelf ...
    ... pick a random book ...
    ... open a random page ...
    ... and choose a random VP from the page
- A corpus is a random sample of books, not VPs!
  - we should only pick 1 VP from each document
  - sample size: $n = 500$ (Brown) or $n = 4048$ (BNC)

Pooling data

- In order to obtain larger samples, researchers usually **pool** all data from a corpus
  - i.e. they include all VPs from each book

- Do you see why this is wrong?

Pooling data

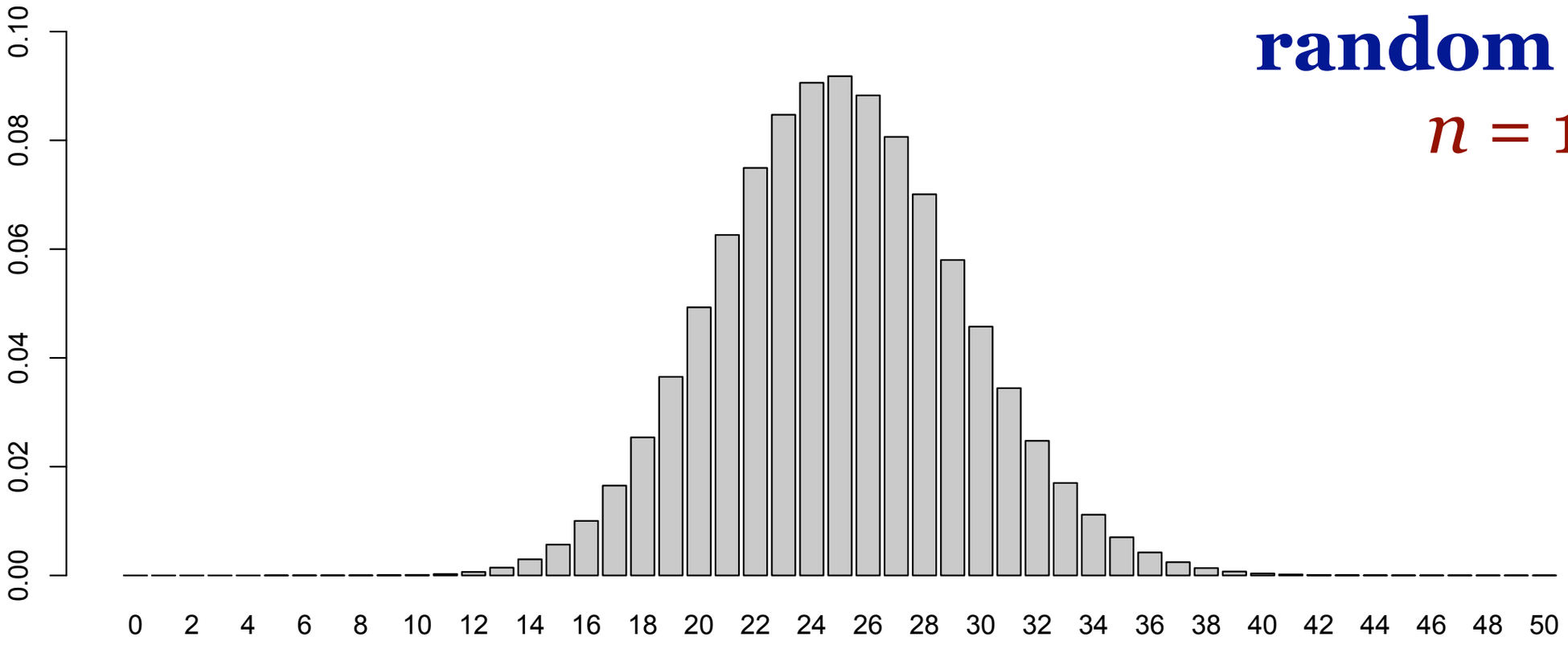
- Books aren't random samples themselves
  - each book contains relatively homogeneous material
  - much larger differences between books
- Therefore, pooled data isn't a random sample from the library
  - for each randomly selected VP, we co-select a substantial amount of very similar material
- Consequence: sampling variation increased

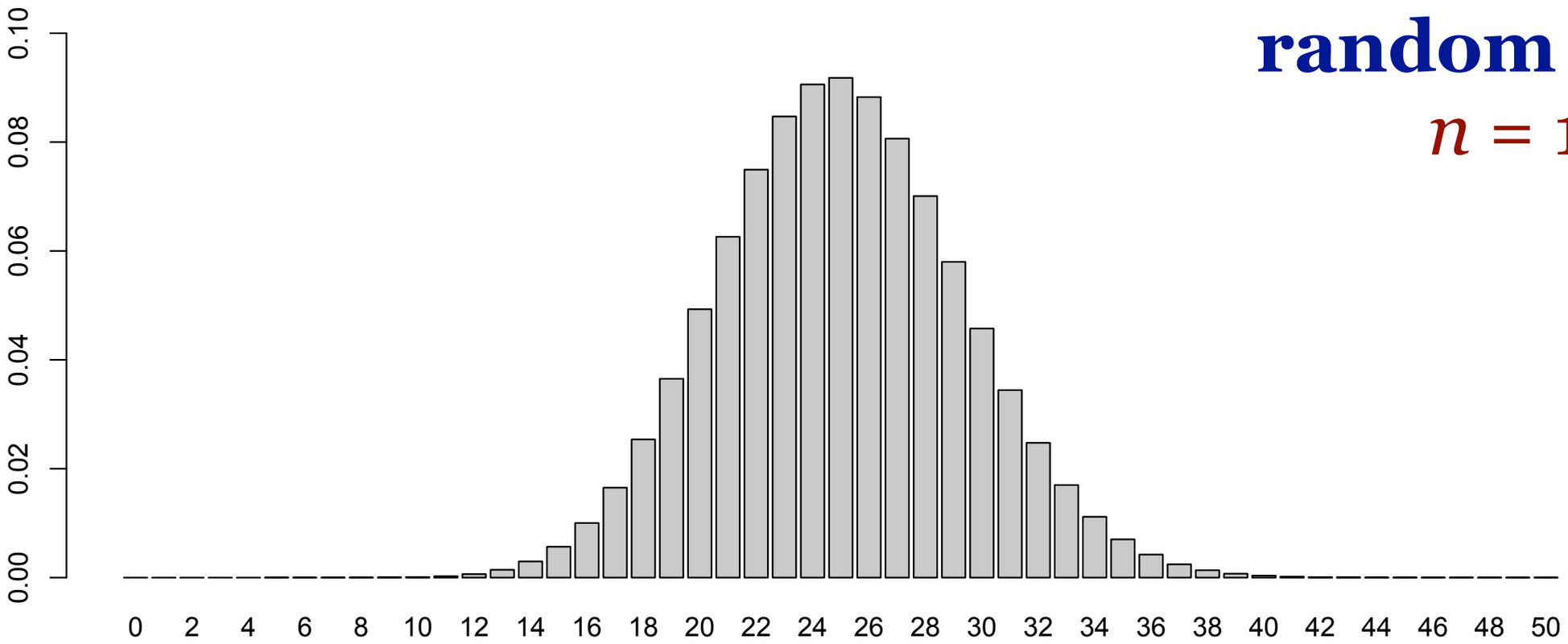
Pooling data

- Let us illustrate this with a simple example …
  - assume library with two sections of equal size
  - population proportions are 10% vs. 40%
    → overall proportion of 25% in the library
- Compare sampling variation for
  - random sample of 100 tokens from the library
  - two randomly selected books of 50 tokens each
    - book is assumed to be a random sample from its section

random sample

$n = 100$




random sample
$n = 100$
0.00
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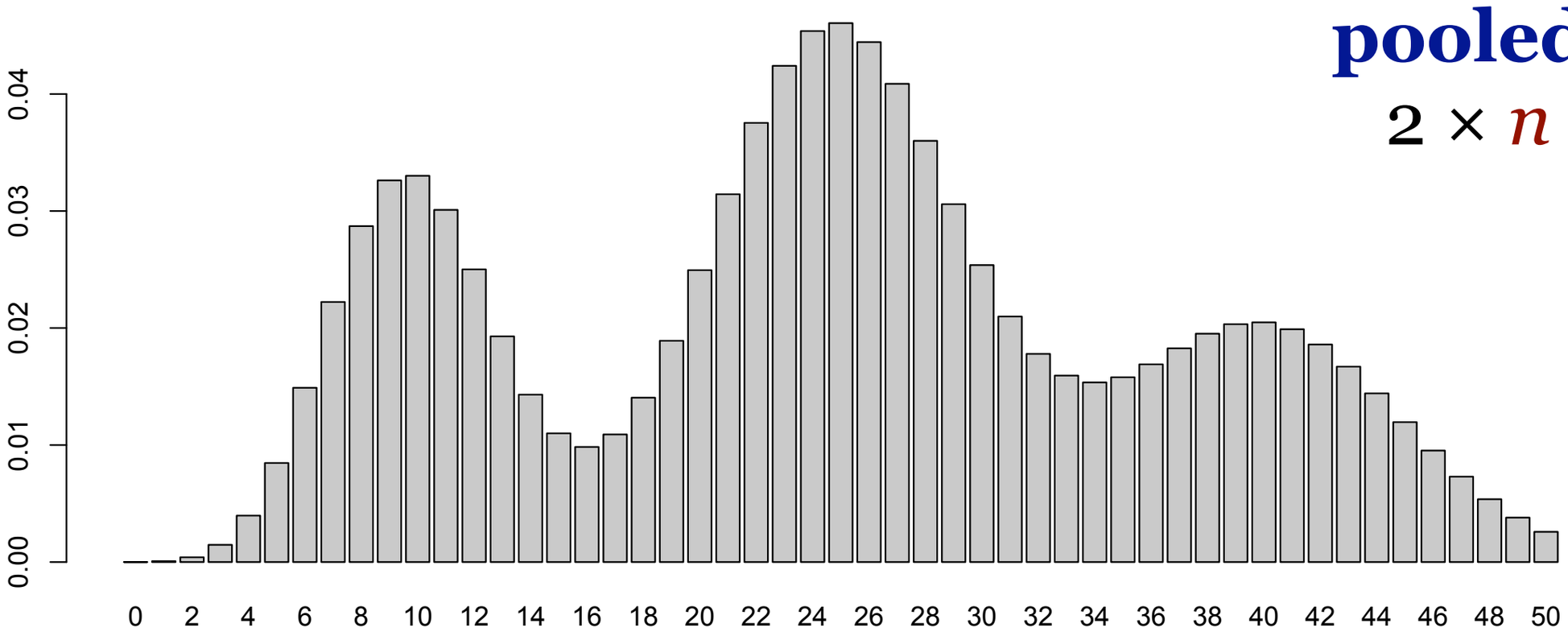
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50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  - 117 (!) occurrences in BNC, all in file HWX
  - very difficult to detect automatically
- Even worse for newspapers & Web corpora
  - see Evert (2004) for examples

Problem 5B: (Lexical) specialisation

- Illustrated by data pooling example
  - true population proportions usually different in distinct sections of the library (e.g. spoken vs. written English, different genres, registers, domains, ...)
  - if you pick just a few books, it is likely that some sections will be seriously over-represented
- Specialisation increases sampling variation
  - even if each book is a random sample from its section!

Problem 5B: Lexical specialisation

- Particularly serious (and well-known) problem for lexical phenomena (words, collocations, ...)
- Specialisation wrt. domain and topic
  - a book about a football team will use an entirely different vocabulary than a statistics textbook or a romantic novel
  - usually not enough meta-information about topics available to split corpus into homogeneous sections
- See e.g. Baayen (1996)

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- If a "content" word occurs once in a document, it is very likely to occur again
  - *The chance of two Noriegas is closer to p/2 than p²* (Church 2000; also Church & Gale 1995, Katz 1996)
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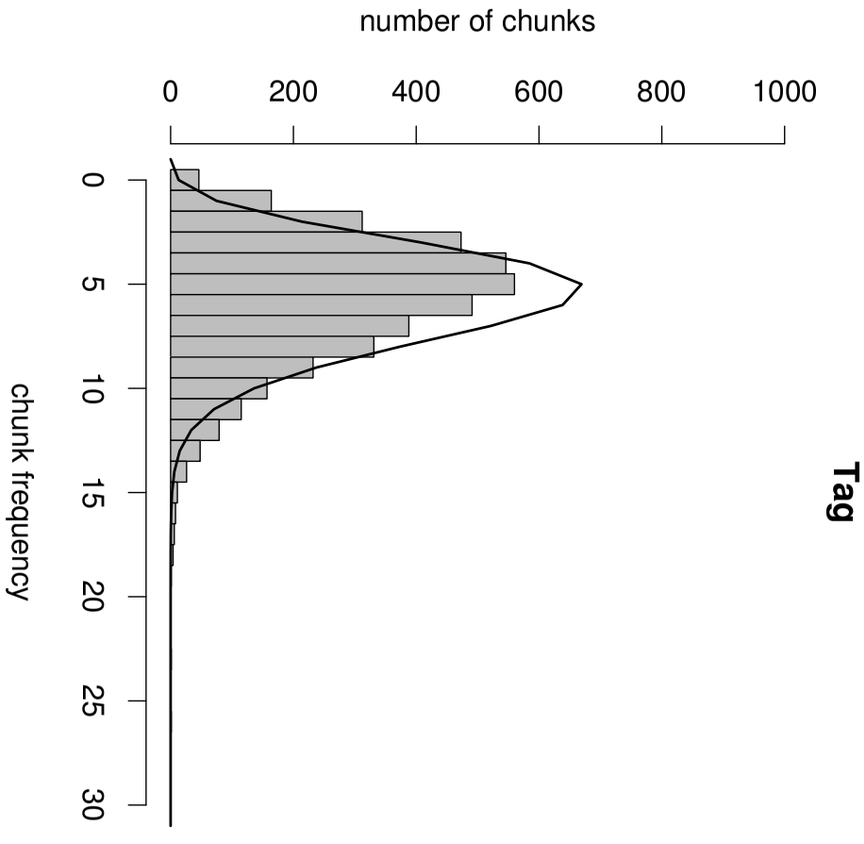
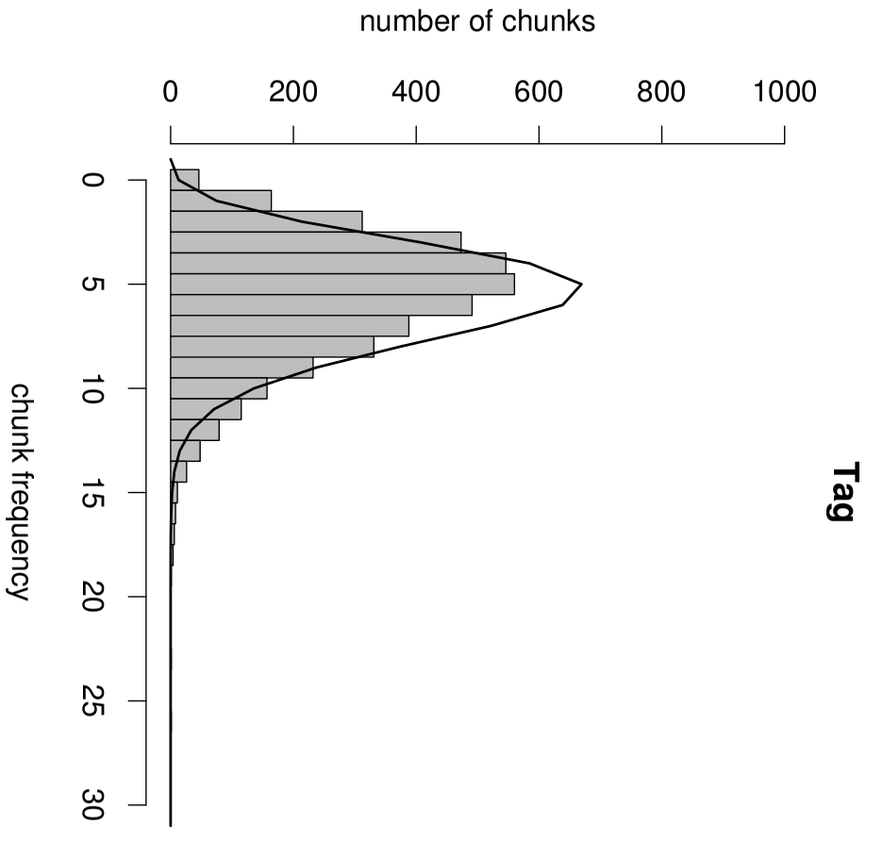
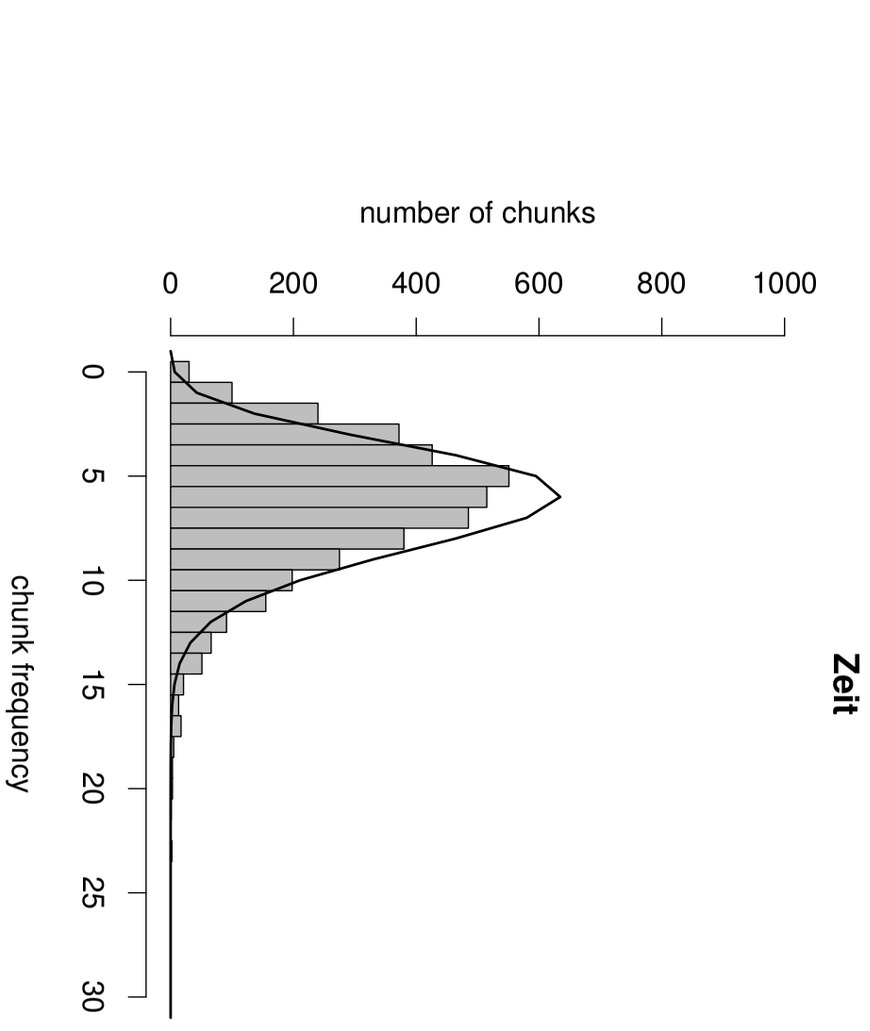
- Two complementary effects:
  - specialisation = non-randomness between documents
  - term clustering = non-randomness within documents



Data from *Frankfurter Rundschau* corpus,
divided into 10,000 equally-sized chunks





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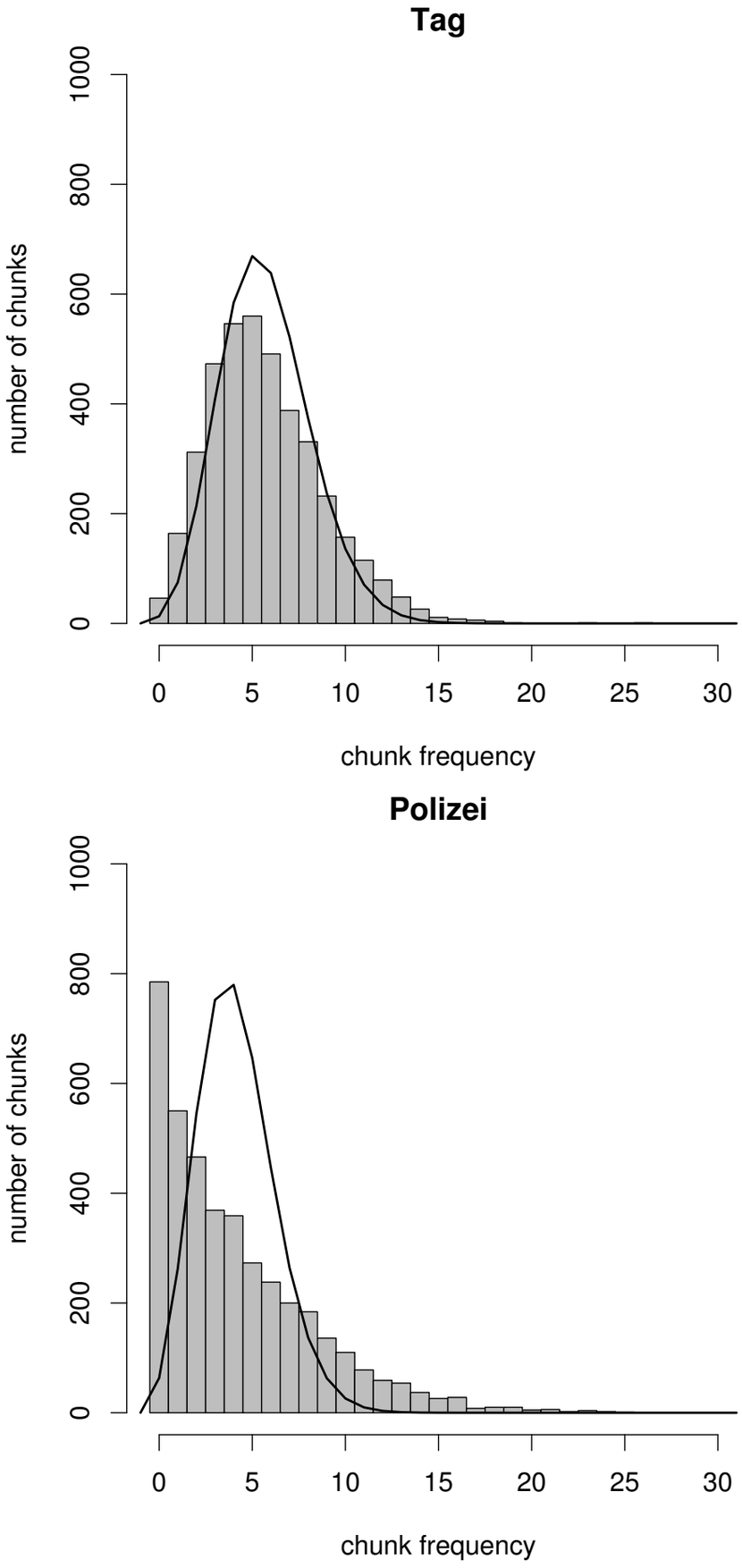

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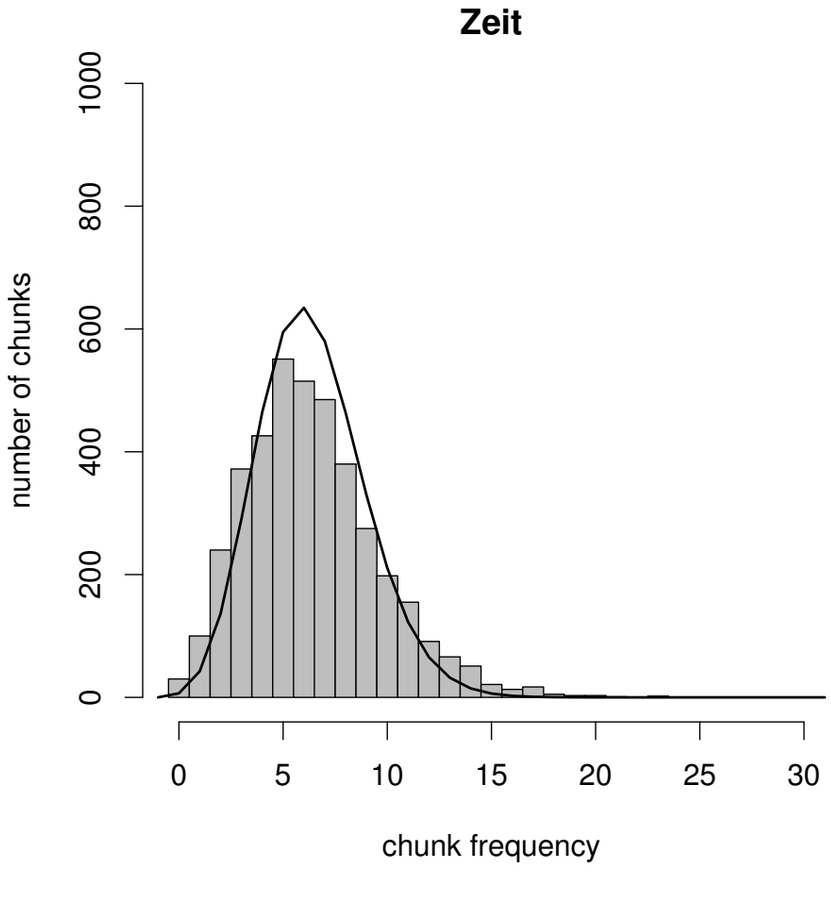

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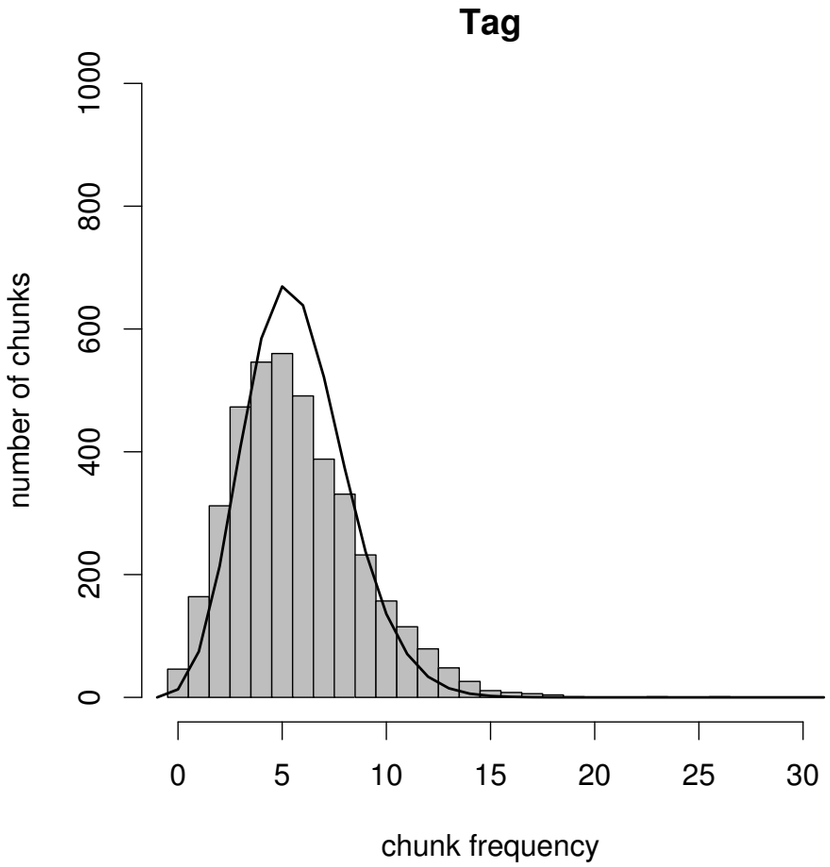

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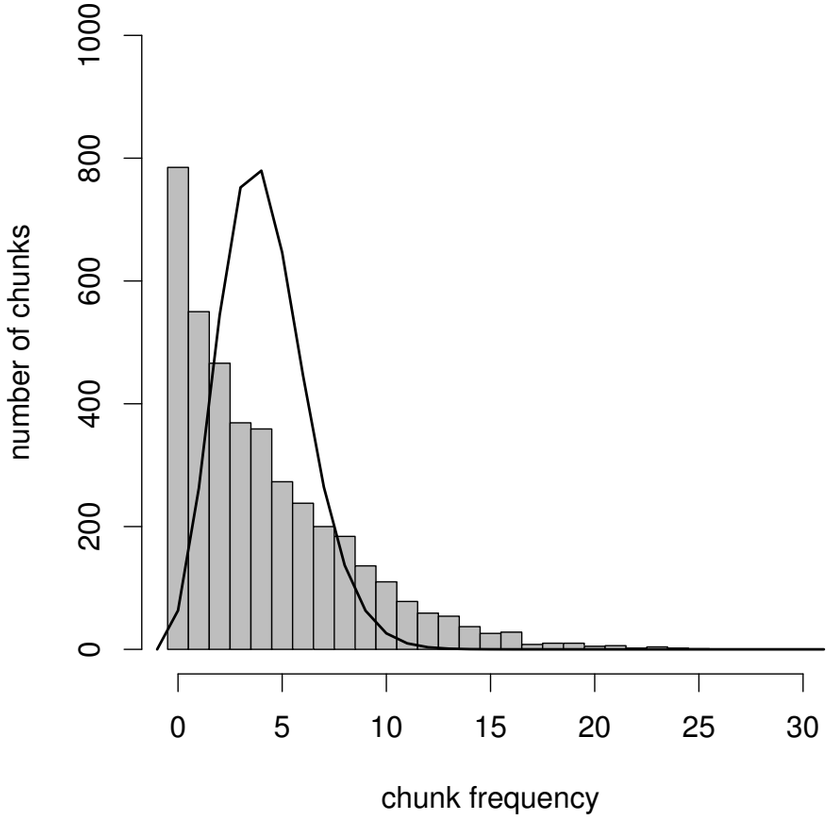
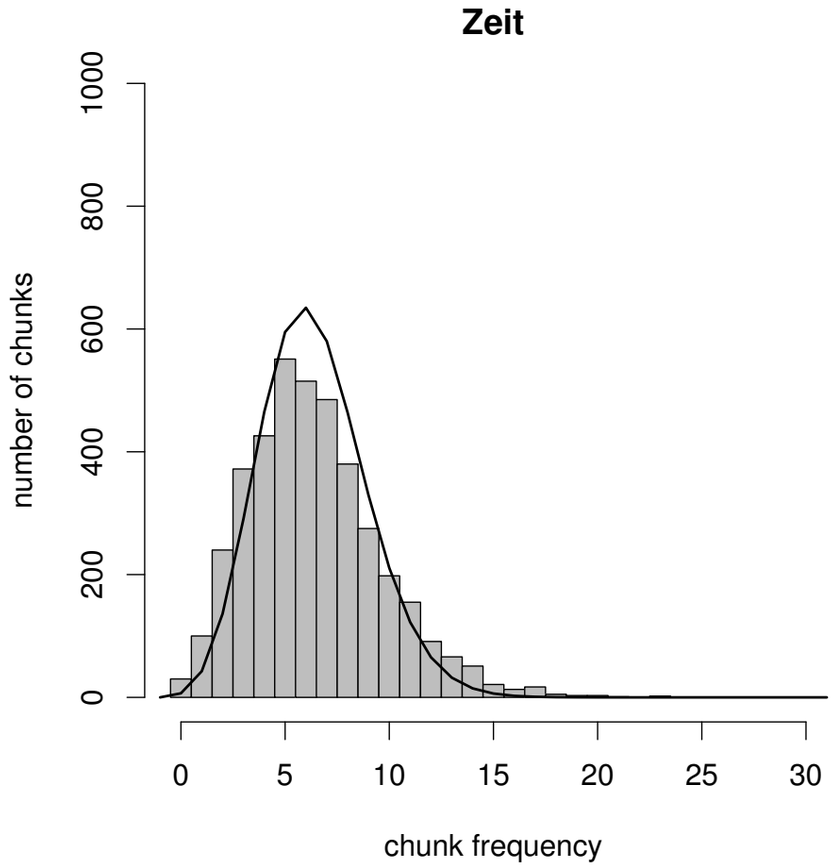
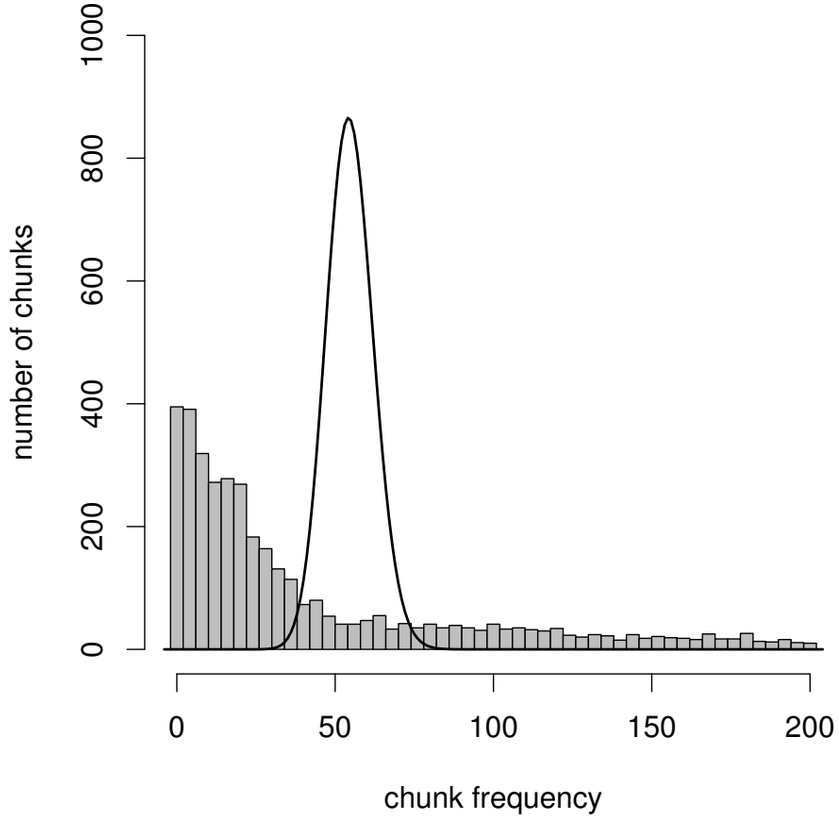




Uhr



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SIGIL: Corpus Frequency Test Wizard

back to main page

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One sample: frequency estimate (confidence interval)

back to top

Frequency count	Sample size
19	100

Clear fields

95% confidence interval

in automatic format

extrapolate to items Calculate with 4 significant digits

Two samples: frequency comparison

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Sample 2	25	200

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http://sigil.collocations.de/wizard.html

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Google

Google ▾ LG15 Apple ▾ Via Michelin RTL Wetter WLAN Router Actions ▾ LKW-Fahrschule Asperg SSAPEL

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  - doesn't mean statistical analysis should be discarded
  - random variation is a lower bound on true variability
- Can still be useful for the analysis of corpus data, but may also give very misleading answers
- **Always look at your data!**
  - R helps you to know & understand what you're doing (unlike online wizards and many commercial tools)

Alternative (better?) methods

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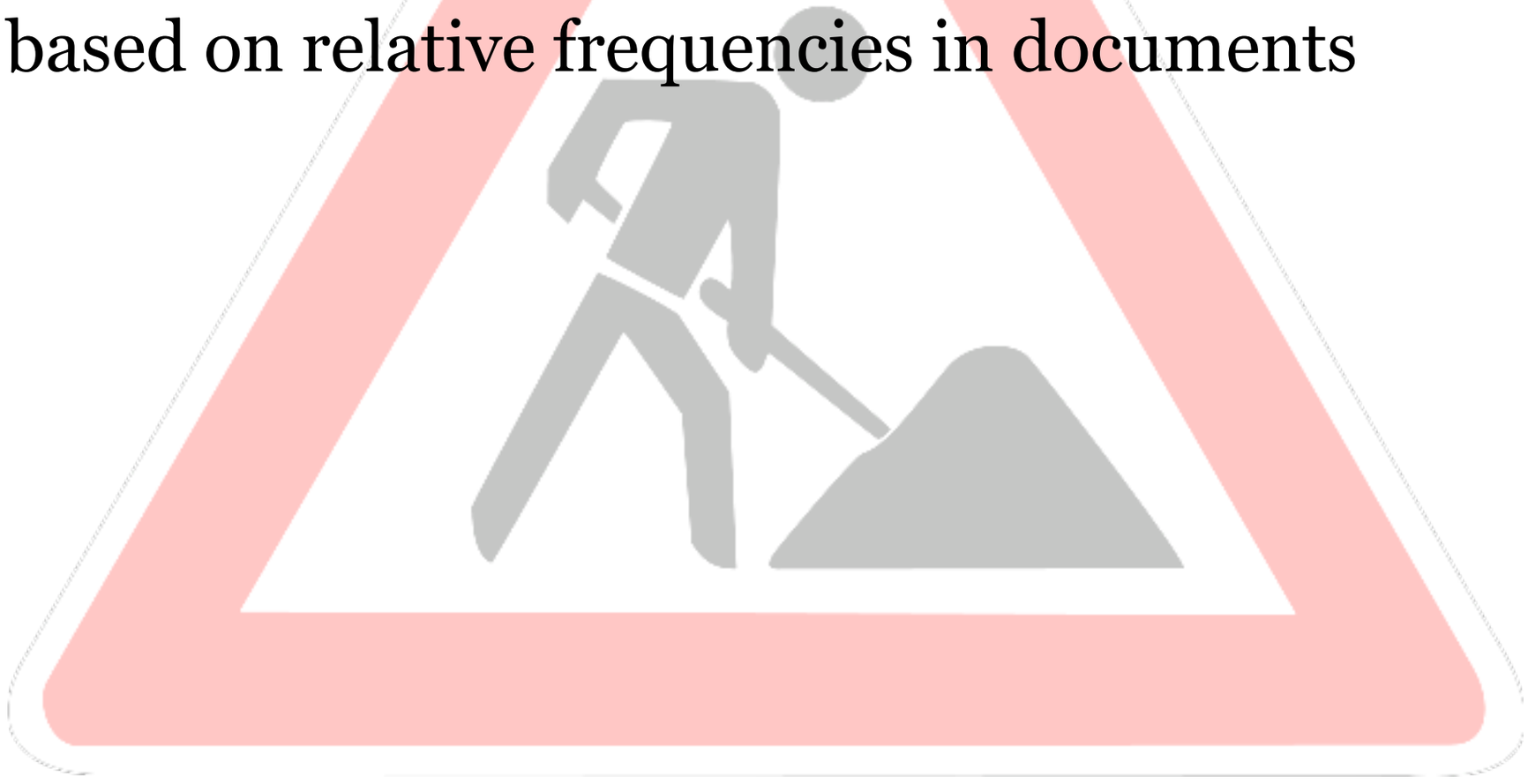
- Empirical approach → t-test & ANOVA
  - based on relative frequencies in documents



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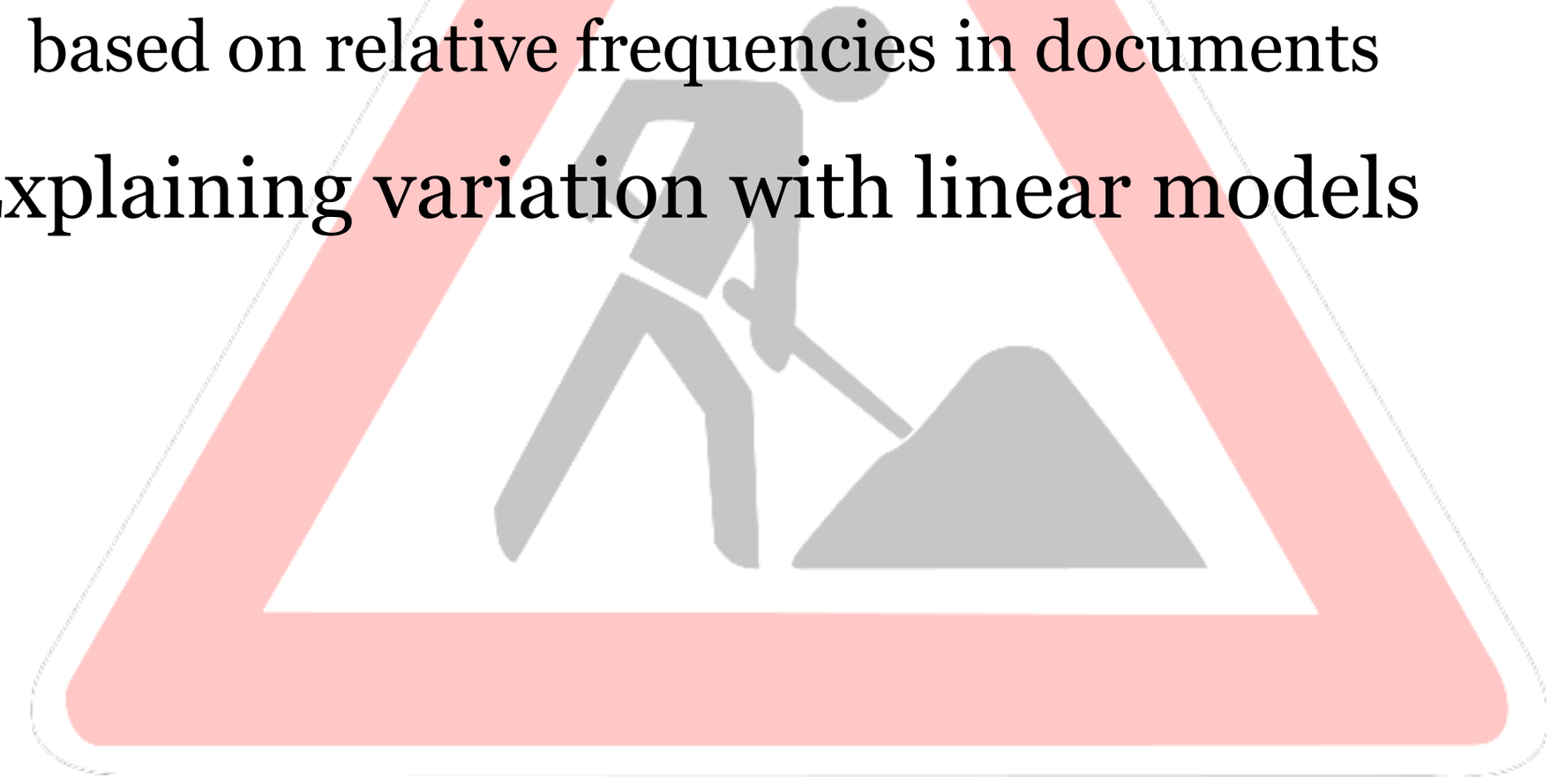

Alternative (better?) methods

- Empirical approach → t-test & ANOVA
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- Explaining variation with linear models
- Generalised linear models
  - binomial/Poisson family for low-frequency data
  - negative binomial family to account for term clustering (= Poisson mixtures, Church & Gale 1995)

Thank you for following this course!

Stefan & Marco

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