Analysing phonological systems: on Bayesian typological research

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In this talk I will cover the following:

- Goals of linguistic typology
- Different strategies of sampling
- The Bayesian way of thinking about linguistic typology
- Case study: vowels
Goals of linguistic typology

- Attest distributions (statistical and areal) of typological values
Goals of linguistic typology

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- Find a correlation between the distributions of different typological categories
  - Absolute universals
  - Distributional patterns and tendencies
  - Semantic maps
  - Diachronic change of typological values
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- Find a correlation between linguistic and non-linguistic patterns
  - Population movements
  - Population size
  - Language contact
  - Sociolinguistic parameters
  - Geopolitical environment (including the spread of diseases)
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- Deal with mixed typological values
Frequentist typological research

- Formulate a theoretical problem
  There is a category in some languages with values $\text{VAL}_1$ and $\text{VAL}_2$. 

- Get a grant, hire some students, or select a holiday you want to spend working on this topic...

- Pick a sample of languages, calculate the desired statistics, e.g. $\hat{\theta}$

- From now on $\hat{\theta}$ is the best estimation of $\theta$ that you know

- Add some confidence intervals if you need to convince an editor who is mad about statistics

- After you have published your paper, your project is finished
Frequentist typological research

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  There is a category in some languages with values VAL 1 and VAL 2. What is the probability $\theta$ of finding VAL 1 in a randomly picked language?
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There are different types of sampling

Random sampling
each member of the population has an equal probability of selection
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but each language is grouped in a language family and an area, so observations are not independent...
Language families (languages > 10)
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Stratified random sampling divide the population into groups that differ in important ways, and then perform random sampling for each group.
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!!! The Glottolog version in the lingtypology package suggests that there are **214 unique combinations** (142 sign languages and 82 isolates counted as one family)
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‼️ The Glottolog version in the lingtypology package suggests that there are 214 unique combinations (142 sign languages and 82 isolates counted as one family)

⇒ So to create a statistically reasonable sample one needs to get around 300 languages
I am not the first to discuss this problem

- [Bell 1978] "Language Samples"
- [Dryer 1989] "Large Linguistic Areas and Language Sampling"
- [Nichols 1992] "Linguistic Diversity in Space and Time"
- [Rietveld and Van Hout 1993] "Statistical Techniques for the Study of Language and Language Behaviour"
- [Rijkhoff and Bakker 1998] "Language sampling"
- [Maslova 2000] "A dynamic approach to the verification of distributional universals"
- [Widmann 2001] "Language Sampling for Typological Studies"
- [Janssen et al. 2006] "Randomization Tests in Language Typology"
- [Baker 2010] "Language Sampling"
Sampling bias

- Geneological
- Caused by contact
- Cultural
- Typological
- Populational
Sampling bias

- Geneological
- Caused by contact
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- Typological
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Sampling bias

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**Typologistical** — only typologists think that one typological value corresponds to one so called language
Theoretical linguists
- Complain about how hard it is to solve a problem
- Don’t publish any results until it will be ideal

Computational linguists
- Solve the wrong problem
- Publish messy data and messy results

My suggestion:
- Don’t do any sampling
- Use a linguistic family (or analogous units) as a minimal unit of typological research
- Analyse all languages in a family
- Publish your data
- Make a call for contributions
- Update your results
Theoretical linguists

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frequentist view

- There is a population with one fixed value $\theta$
- Sample from the population and estimate the value $\hat{\theta}$
- If you want to replicate the previous study, resample the data and reestimate the value $\hat{\theta}$

Bayesian view

- There is a value $\theta$ that could be described as a distribution of probabilities
- Take into account previous works and formulate prior knowledge about $\theta$
- Sample from the population and estimate the value $\theta$
- Use Bayes’ formula to get posterior distribution of $\theta$
- Use an obtained result as a future prior and update your previous data
Case study: how frequent are \( a, i \) and \( u \)? (10 families)
Case study: how frequent are \(a\), \(i\) and \(u\)? (10 families)

![Graphs showing the frequency of vowels a, i, and u](image)

Sample of 128 languages
Case study: how frequent are $a$, $i$ and $u$? (29 families)
What about phonology?

It is possible to use phonological units or relations from any phonological theory you like:

- Features, feet, syllables, etc.
- Feature constituents, OT constraints, exemplars, phonological are diachronic alternations
- Phonological distinctions (e.g. /i/ vs. /ɨ/)
- ...
Send me a letter!
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Presentation is available here:
tinyurl.com/y3wtkcbq
References


