Measuring and Modelling Lexical Diversity across Languages

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Outline

Background

- Definition, measures
- **Qualitative results**: lexical diversity space, lexical diversity scales

Statistical Modelling

- Sociolinguistic factors, language families and regions
- **Quantitative results**: simple linear model, mixed-effects model

Future Directions

- Potential repercussions on word order flexibility

Definition

Lexical diversity

The **distribution of word forms** used to encode a **constant information content**

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Quantitative measures

Frequency distributions

Order types (word forms delimited by white spaces) according to their token frequencies (Zipf,1932,1949)

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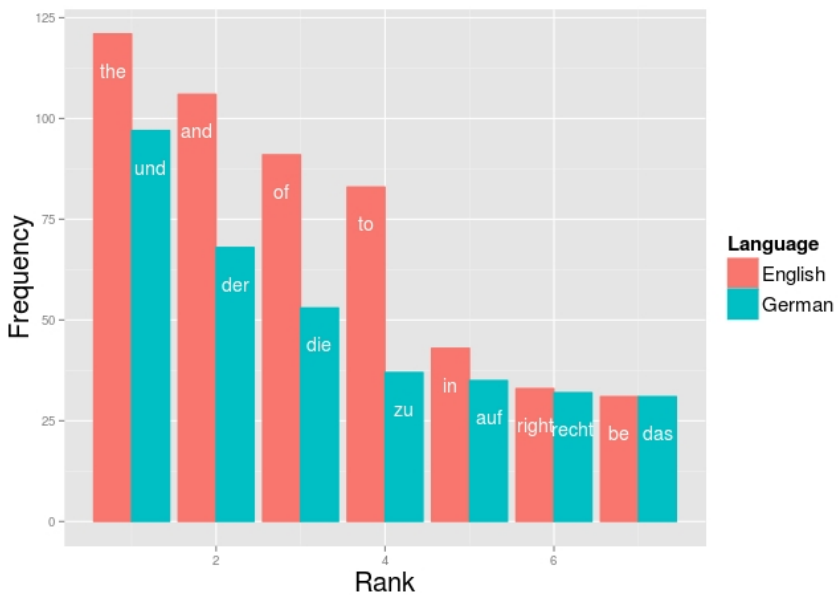

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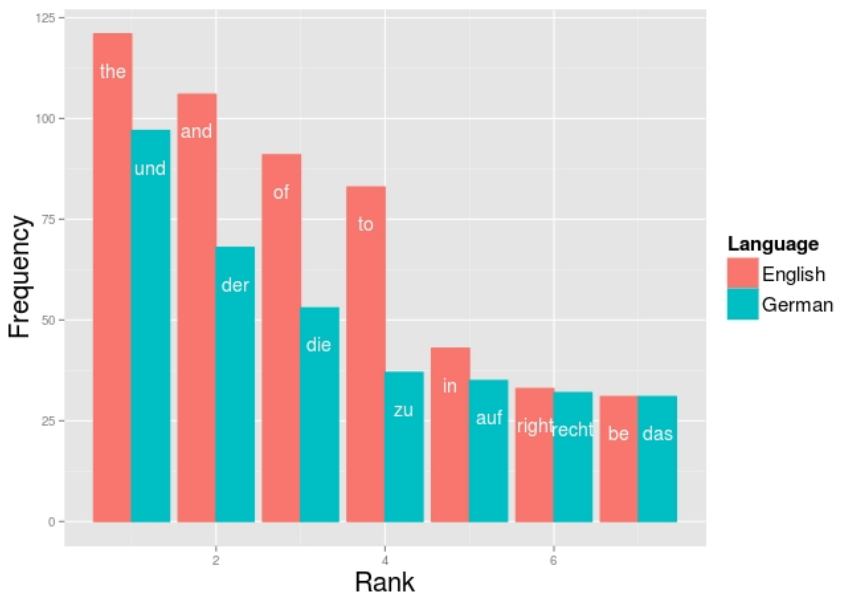

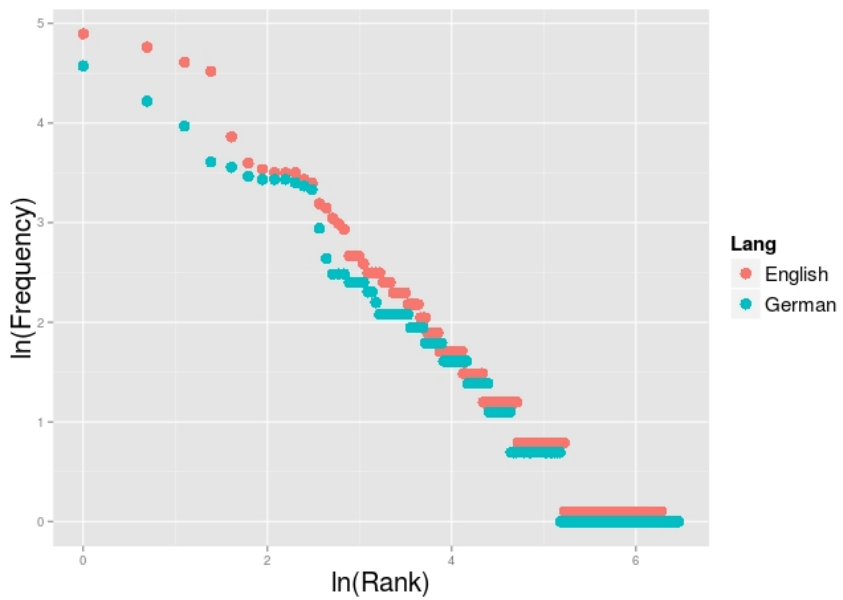

Quantitative measures

Zipf-Mandelbrot's law (Zipf,1949; Mandelbrot, 1953)

$$f(r_i) = \frac{C}{\beta + r_i^{\alpha}},$$

$C > 0,$
$\alpha > 0,$
$\beta > -1,$
$i = 1, 2, \ldots, n$

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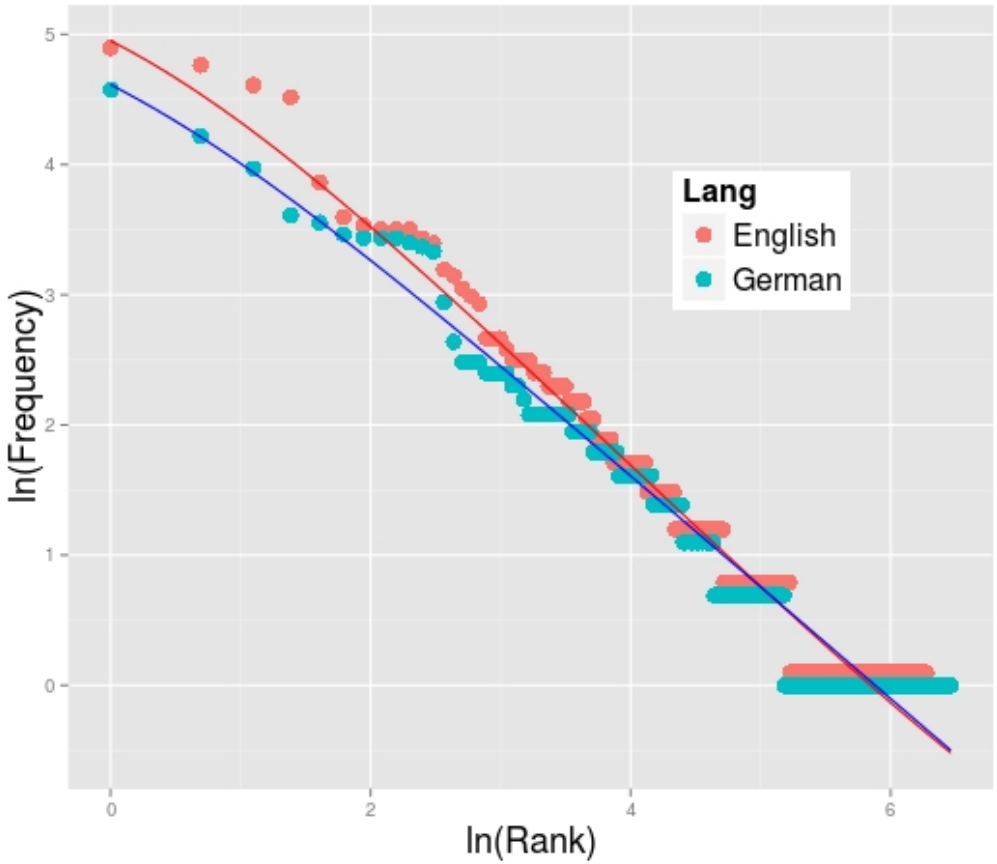

Quantitative measures

Shannon entropy (Shannon & Weaver, 1949)

$$H = -K \sum_{i=1}^{k} p_i \times log_2(p_i)$$

$$p_i : \frac{frequency\ of\ w_i}{total\ number\ of\ tokens}$$

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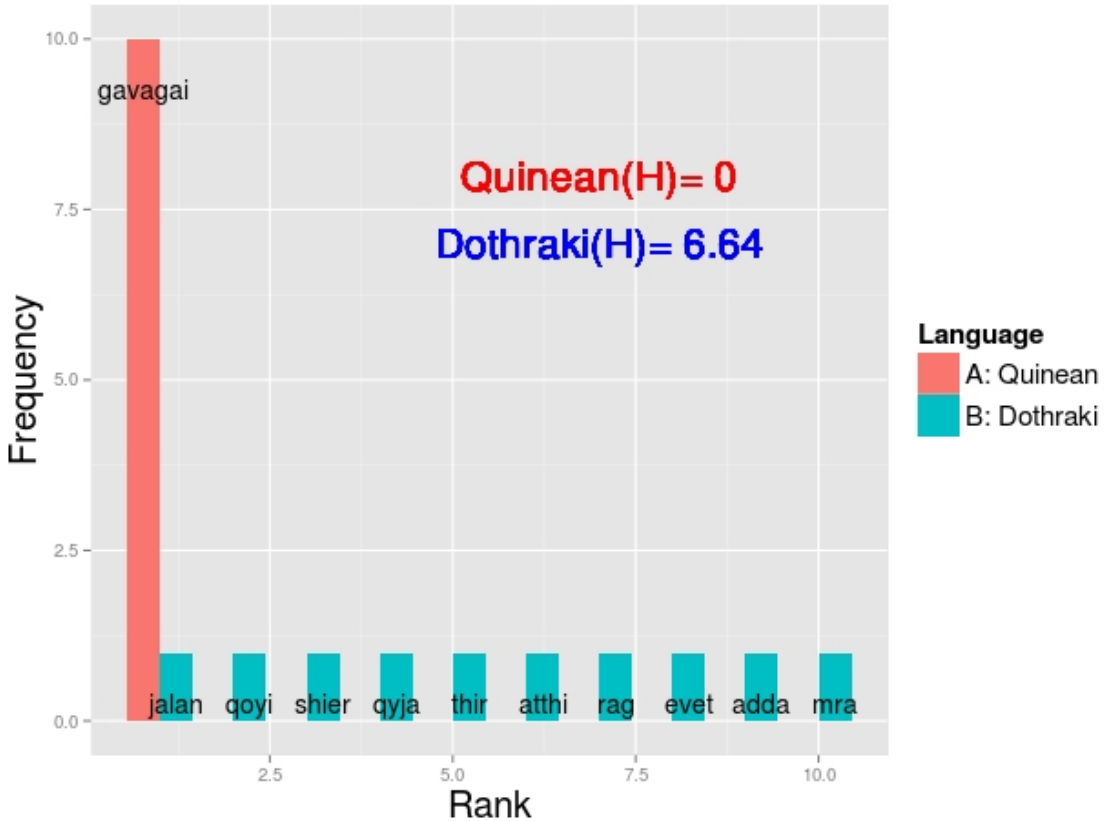

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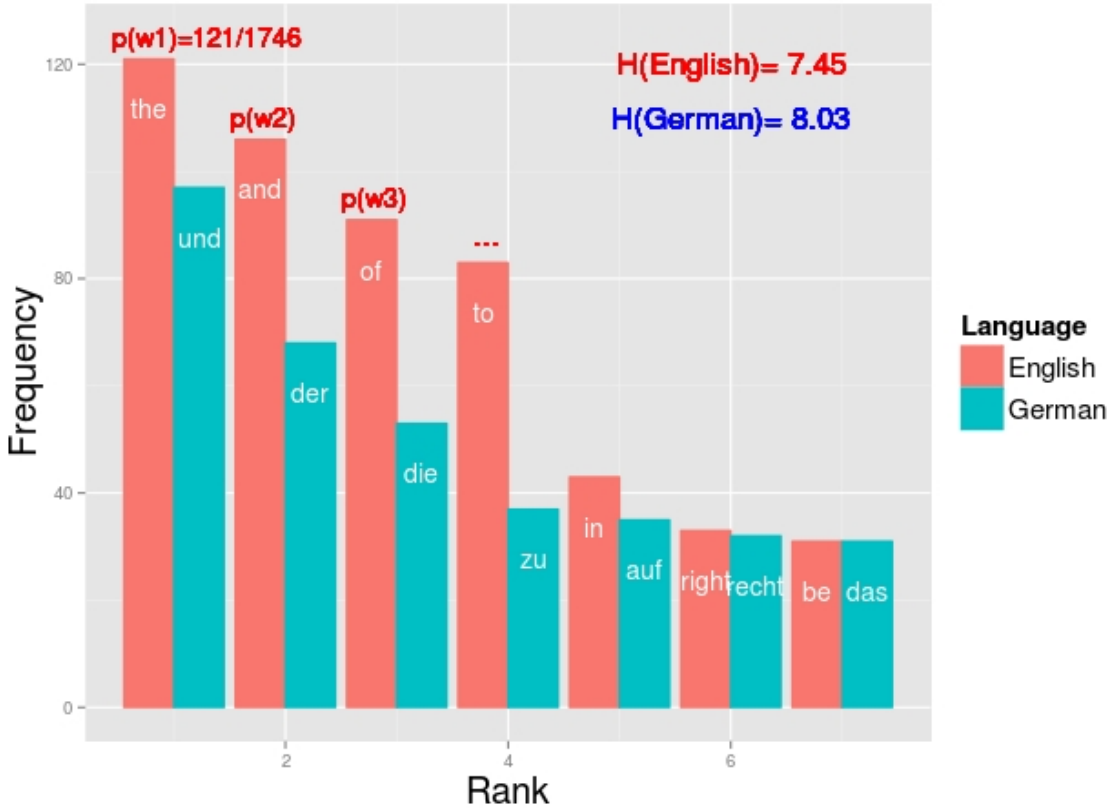
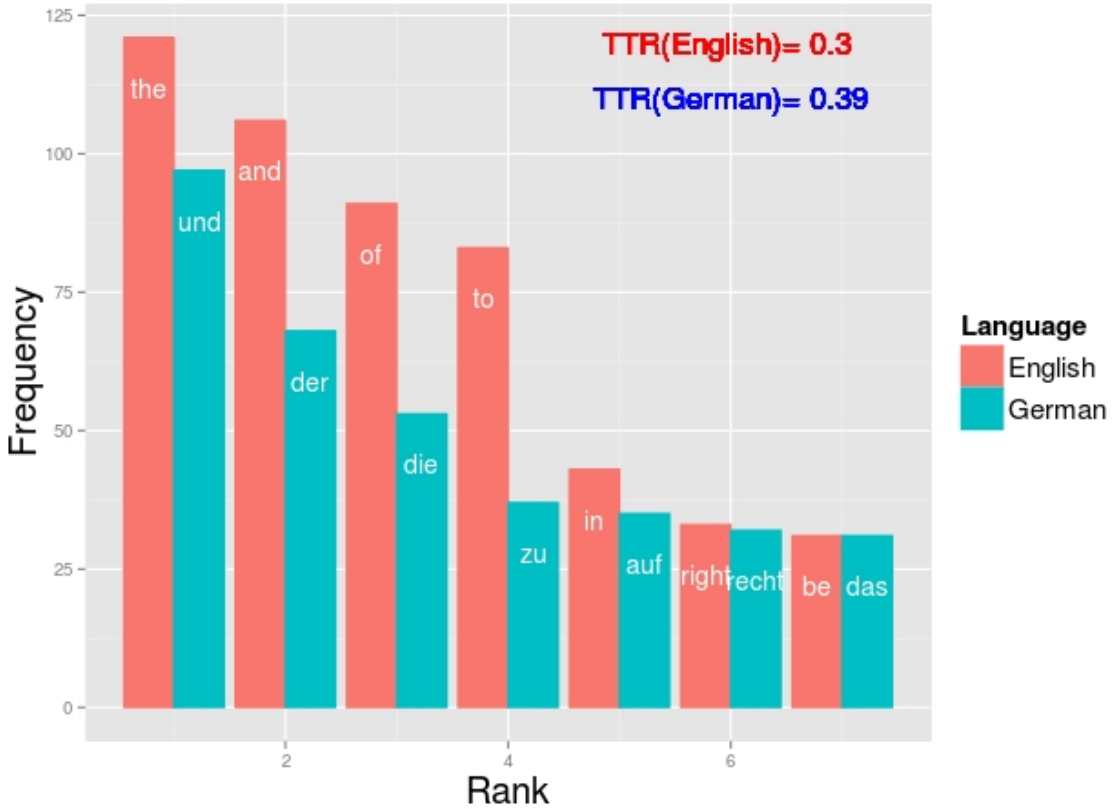


Quantitative measures

Type-Token Ratio (TTR)

$$TTR = \frac{number\ of\ types}{number\ of\ tokens}$$



Measures: Summary

Linguistic Studies

- **ZM-law**
  Zipf (1932, 1935, 1949), Ha et al. (2006), Baroni (2009), Popescu et al. (2008,2009, 2010), Baixeries et al. (2013), Bentz et al. (2014)

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Qualitative results

LDT in Diachrony: Old English and Modern English

Bentz, Kiela, Hill & Buttery (2014) Zipf's law and the grammar of languages. A quantitative study of Old and Modern English parallel texts. *Corpus Linguistics and Linguistic Theory.* aop.

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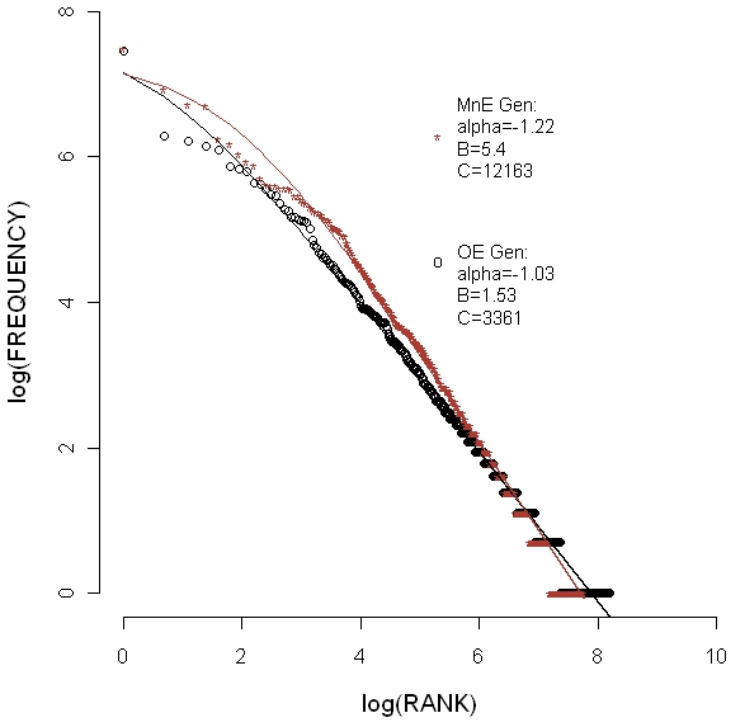
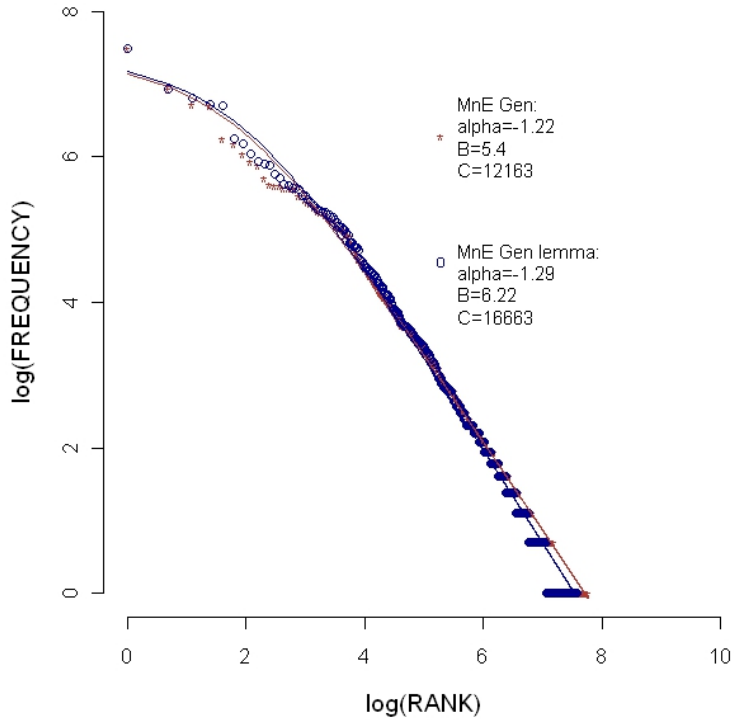


10b) MnE Genesis + lemmatized version



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What drove this change in frequencies?

Inflections: OE *land, lande, landes* → ModE *land, in the land, of the land*

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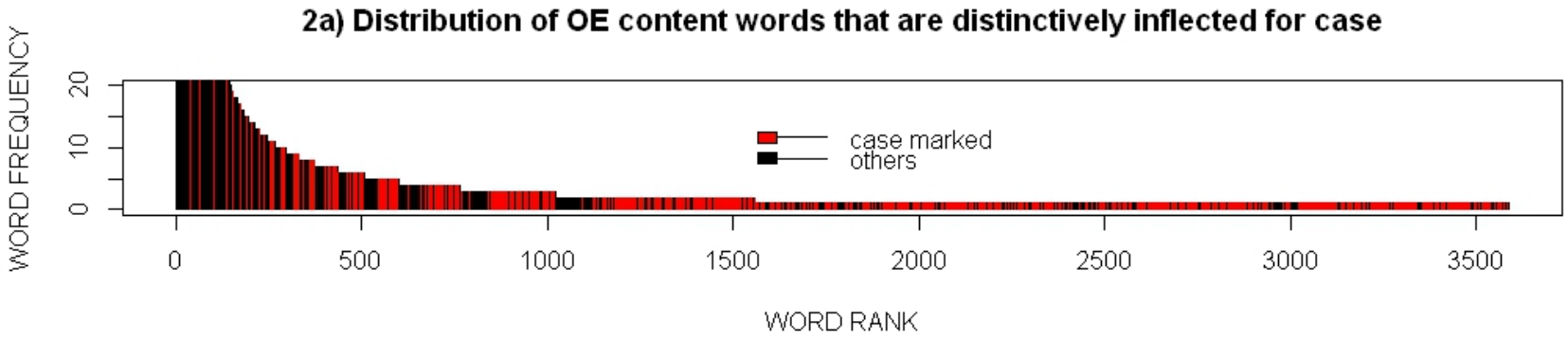

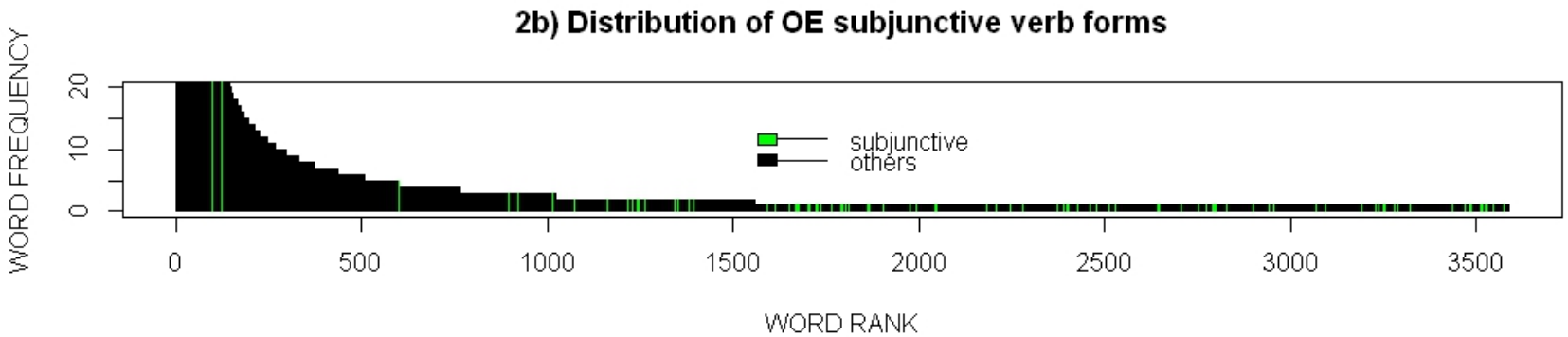

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Inflections in German and English

Lemmatization: yields frequency distributions without inflected types for English and German

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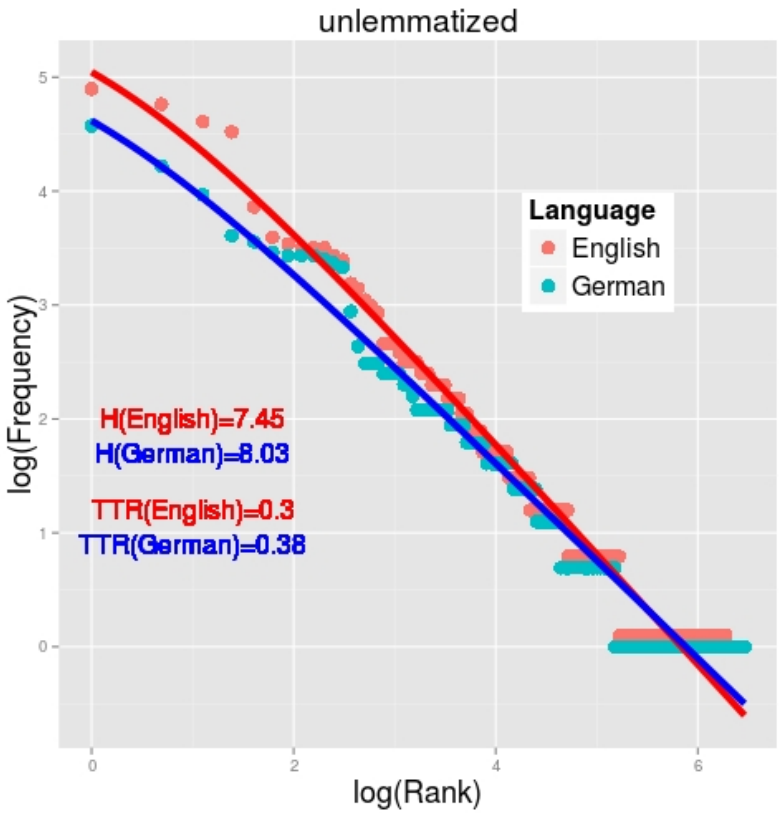

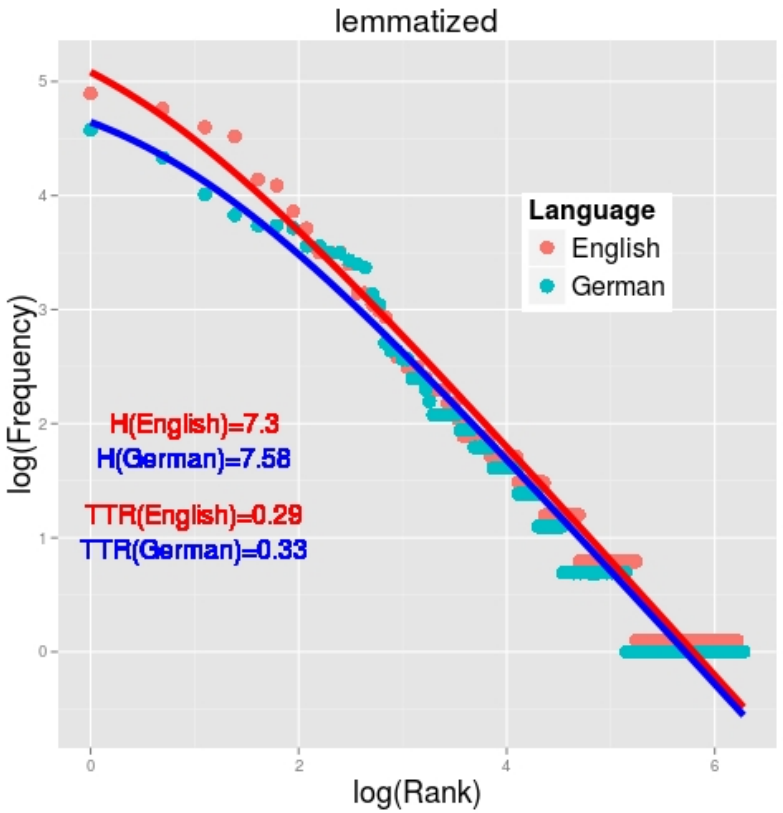

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Qualitative results

Inflections and frequencies

Having inflections in a language automatically creates lower frequency items

$\rightarrow$ higher entropy (higher uncertainty)

$\rightarrow$ higher type-token ratios

$\rightarrow$ lower ZM-parameters

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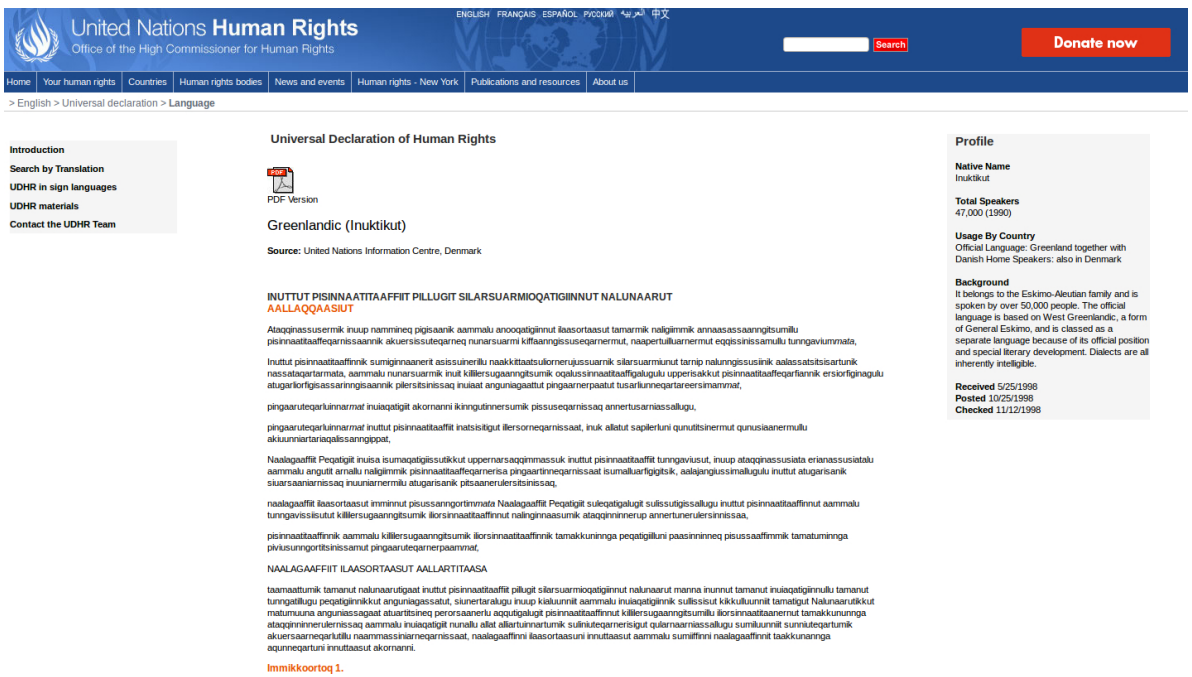
Qualitative results

Synchronic analyses: LDT across languages of today

Parallel texts
- Universal Declaration of Human Rights (UDHR) in ∼400 languages
- Parallel Bible Corpus (∼800 languages)
- Europarl Corpus (21 languages)



United Nations **Human Rights**
Office of the High Commissioner for Human Rights

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Introduction
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Universal Declaration of Human Rights

PDF Version

Greenlandic (Inuktikut)

Source: United Nations Information Centre, Denmark

INUTTUT PISINNAATITAAFFIT PILLUGIT SILARSUARMIOQATIGIINNUT NALUNAARUT
AALLAQQAASIUT

Ataqqinassusermik inuup nammineq pigisaanik aammalu anooqatigiinnut ilaasortaasut tamarmik naligiimmik annaasassaanngitsumillu pisinnaatitaaffeqarnissaannik akuerisissuteqarneq nunarsuarmi kiffaanngissuseqarnermut, naapertuilluarnermut eqqissinissamullu tunngaviu*mmata*,

Inuttut pisinnaatitaaffinnik sumiginnaanerit asissuinerillu naakkittaatsuliornerujussuarnik silarsuarmiunut tarnip nalunngissusiinik aalassatsitsisartunik nassataqartarmata, aammalu nunarsuarmik inuit killilersugaanngitsumik oqalussinnaatitaaffigalugulu upperisakkut pisinnaatitaaffeqarfiannik ersiorfiginagulu atugarliorfigisassaringisaannik pilersitsinissaq inuiaat anguniagaattut pingaarnerpaatut tusarliunneqartareersimam*mat*,

pingaaruteqarluinnar*mat* inuiaqatigiit akornanni ikinngutinnersumik pissuseqarnissaq annertusarniassallugu,

pingaaruteqarluinnar*mat* inuttut pisinnaatitaaffiit inatsisitigut illersorneqarnissaat, inuk allatut sapilerluni qunutitsinermut qunusiaanermullu akiuunniartariaqalissanngippat,

Naalagaaffiit Peqatigiit inuisa isumaqatigiissutikkut uppernarsaqqinnassuk inuttut pisinnaatitaaffit tunngaviusut, inuup ataqqinassusiata erianassusiatalu aammalu angutit arnallu naligiimmik pisinnaatitaaffeqarnerisa pingaartinneqarnissaat isumalluarfigigitsik, aalajangiussimallugulu inuttut atugarisanik siuarsaaniarnissaq inuuniarnermilu atugarisanik pitsaanerulersitsinissaq,

naalagaaffiit ilaasortaasut imminnut pisussanngortin*mmata* Naalagaaffiit Peqatigiit suleqatigalugit sulissutigissallugu inuttut pisinnaatitaaffinnut aammalu tunngavissiisutut killilersugaanngitsumik ilorsinnaatitaaffinnut nalinginnaasumik ataqqinninnerup annertunerulersinnissaa,

pisinnaatitaaffinnik aammalu killilersugaanngitsumik ilorsinnaatitaaffinnik tamakkuninnga peqatigilluni paasinninneq pisussaaffimmik tamatuminnga piviusunngortitsinissamut pingaaruteqarnerpaa*mmat*,

NAALAGAAFFIIT ILAASORTAASUT AALLARTITAASA

taamaattumik tamanut nalunaarutigaat inuttut pisinnaatitaaffiit pillugit silarsuarmioqatigiinnut nalunaarut manna inunnut tamanut inuiaqatigiinnullu tamanut tunngatillugu peqatigiinnikkut anguniagassatut, siunertaralugu inuup kialuunnit aammalu inuiaqatigiinnik sullissisut kikkulluunniit tamatigut Nalunaarutikkut maturnuuna anguniassagaat atuartitsineq perorsaanerlu aqqutigalugit pisinnaatitaaffinnut killilersugaanngitsumillu ilorsinnaatitaanernut tamakkununnga ataqqinninnerulernissaq aammalu inuiaqatigiit nunallu allat allartuinnartumik suliniuteqarnerisigut qularnaarniassallugu sumiluunniit sunniuteqartumik akuersaarneqarlutillu naammassiniarneqarnissaat, naalagaaffinni ilaasortaasuni innuttaasut aammalu sumiiffinni naalagaaffinnit taakkunannga aqunneqartuni innuttaasut akornanni.

Immikkoortoq 1.

Profile

Native Name
Inuktikut

Total Speakers
47,000 (1990)

Usage By Country
Official Language: Greenland together with Danish Home Speakers: also in Denmark

Background
It belongs to the Eskimo-Aleutian family and is spoken by over 50,000 people. The official language is based on West Greenlandic, a form of General Eskimo, and is classed as a separate language because of its official position and special literary development. Dialects are all inherently intelligible.

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Lexical Diversity Space

Calculating **Zipf-Mandelbrot parameters** for 359 languages (words delimited by white spaces)

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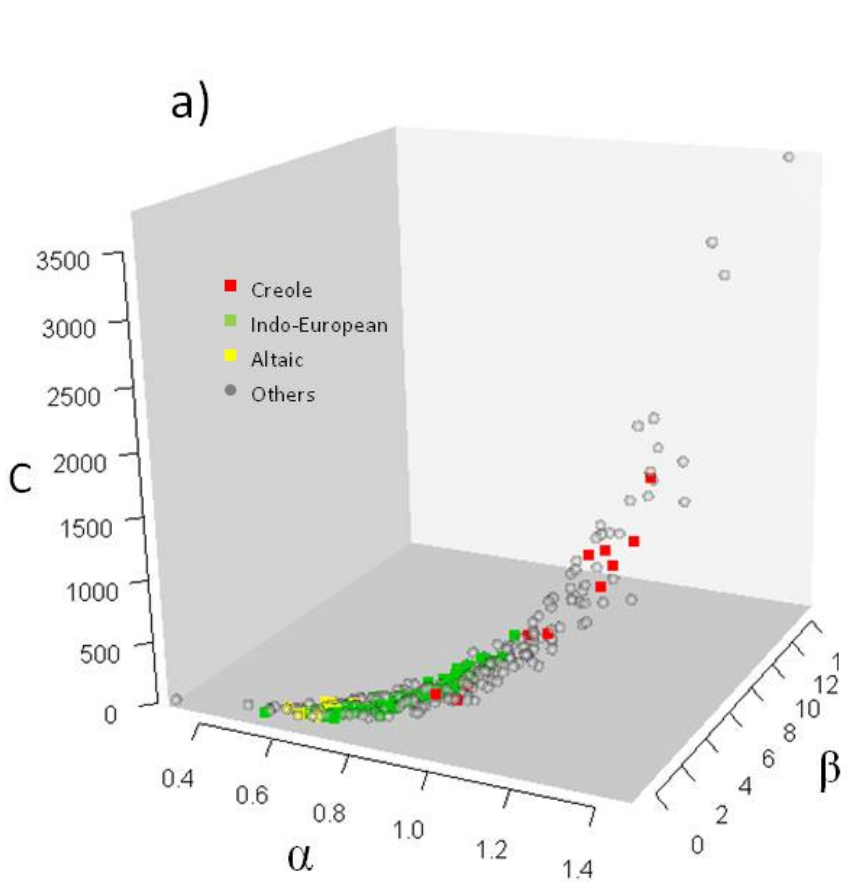

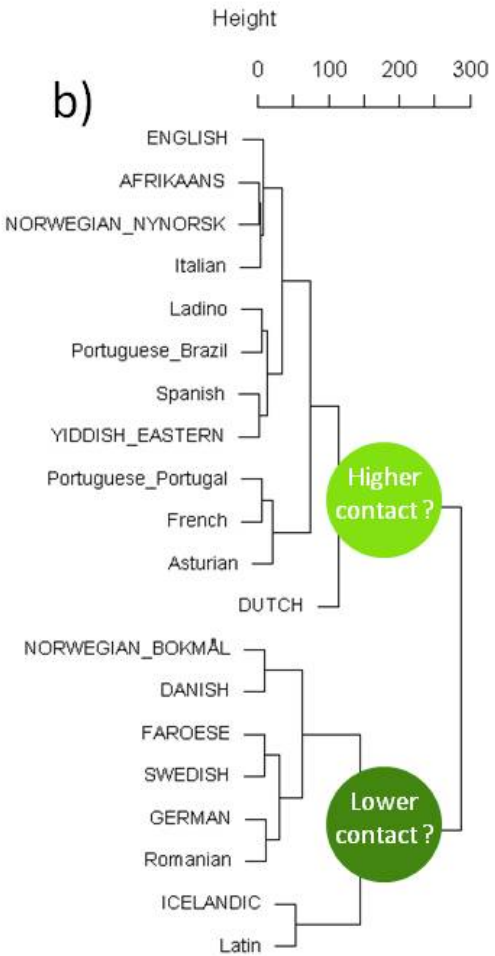

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Lexical Diversity Scales

Calculating **Shannon entropy H** and **Type-Token Ratios** for 359 languages

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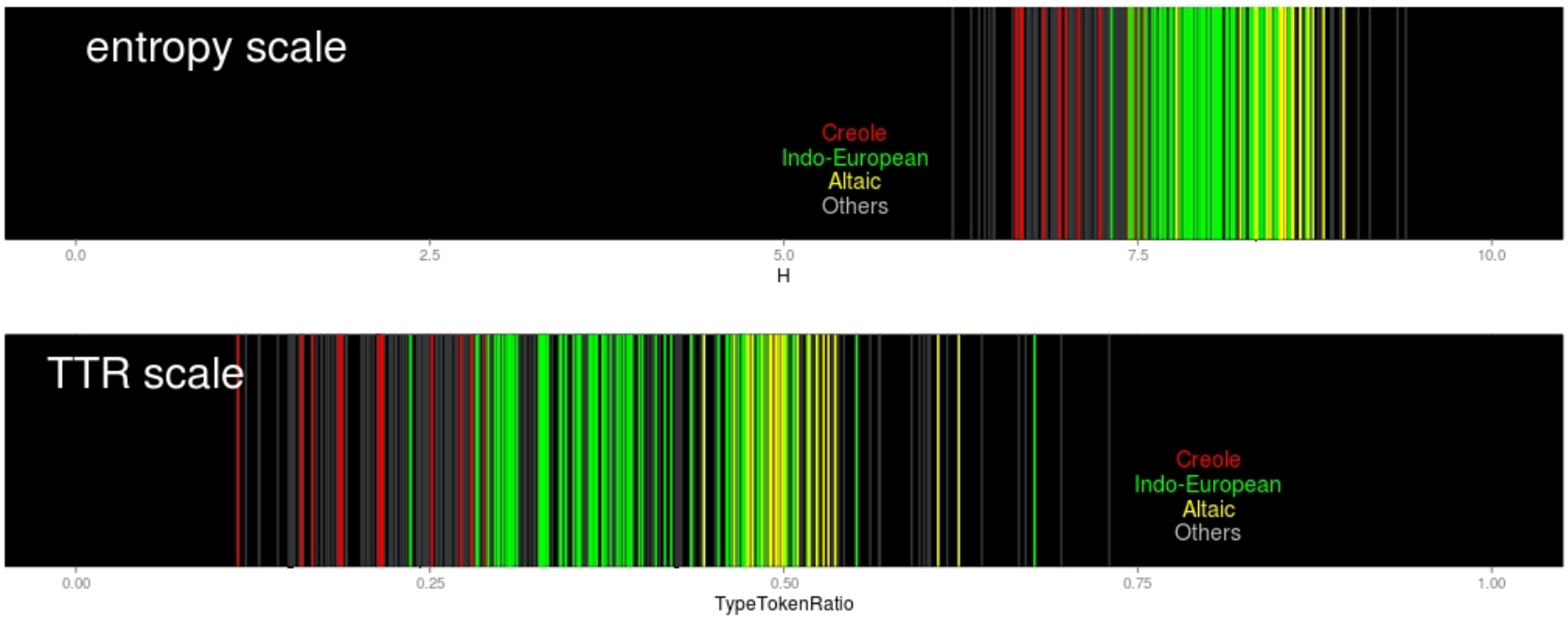

Quantitative Analyses

Statistical Modelling of Lexical Diversity

Is it possible to predict LDTs of languages?

Bentz, Verkerk, Kiela, Hill & Buttery (submitted) Adpative languages: Modelling the co-evolution of population structure and lexical diversity

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- language regions
- writing systems
- **non-native influence** (McWhorter, 2002, 2007, 2011; Wray & Grace, 2007; Lupyan & Dale 2010, 2012; Trudgill, 2011; Bentz & Winter, 2013)

Simple Linear Regression

- LDT measures (ZM-parameters, entropy H, TTR) for 359 language

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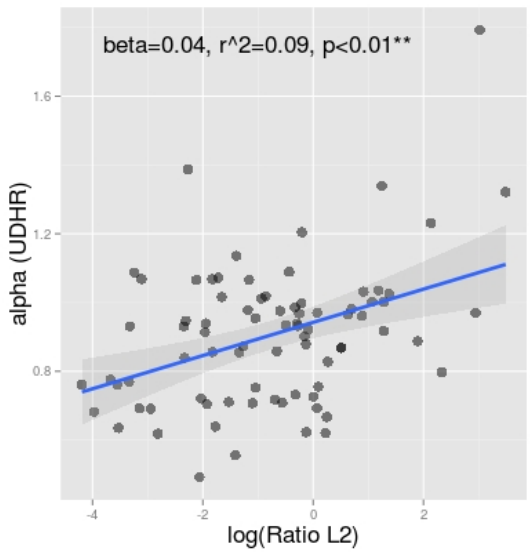

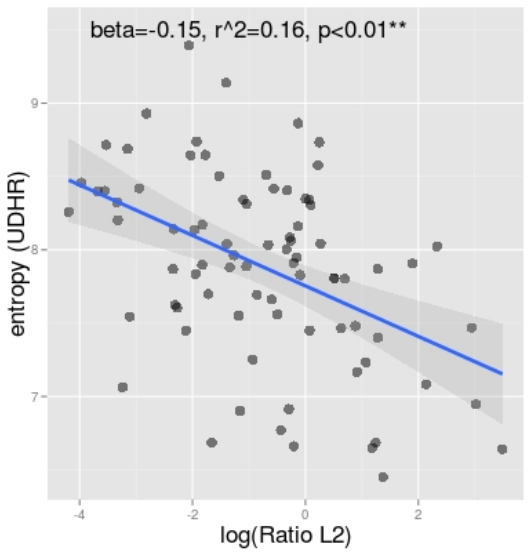

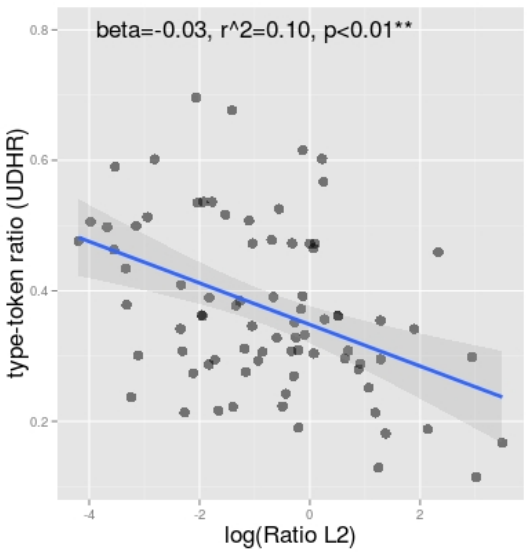

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Mixed-effects regression

Regressing LDT on L2 ratios but controlling for non-independence of datapoints (language families, regions, writing systems)
Results: α ($\chi^2(1) = 1.38, p > 0.5$), H ($\chi^2(1) = 9.28, p < 0.001$), TTR ($\chi^2(1) = 7.11, p < 0.01$)

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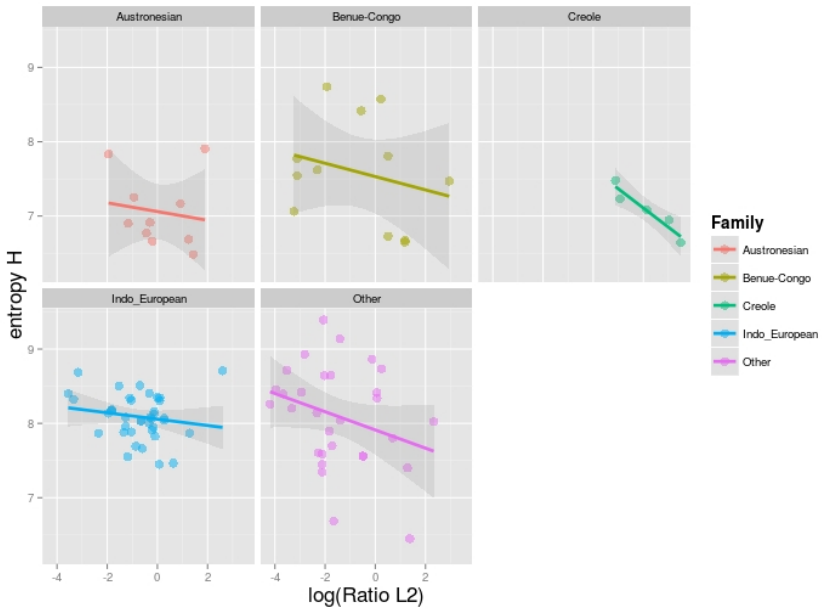

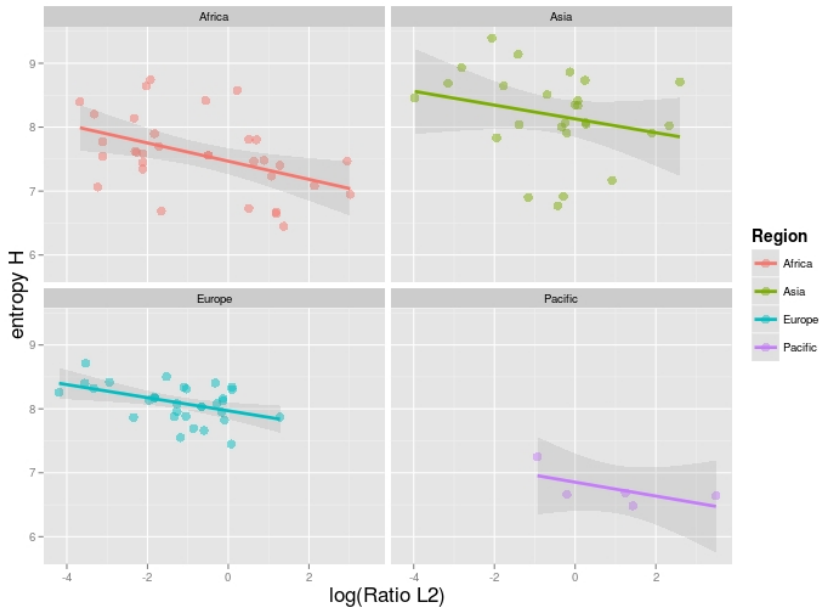

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Interpretation/ Future directions

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Suggestions

- Languages are **complex adaptive systems** shaped by the cognitive and conceptual needs of their speakers (Croft, 2000; Ritt, 2004; Christiansen & Chater, 2008; Beckner et al., 2009)
- A lack of lexical diversity might be made up for by encoding of information at a different level (constructions, fixed word order, multi word expressions)

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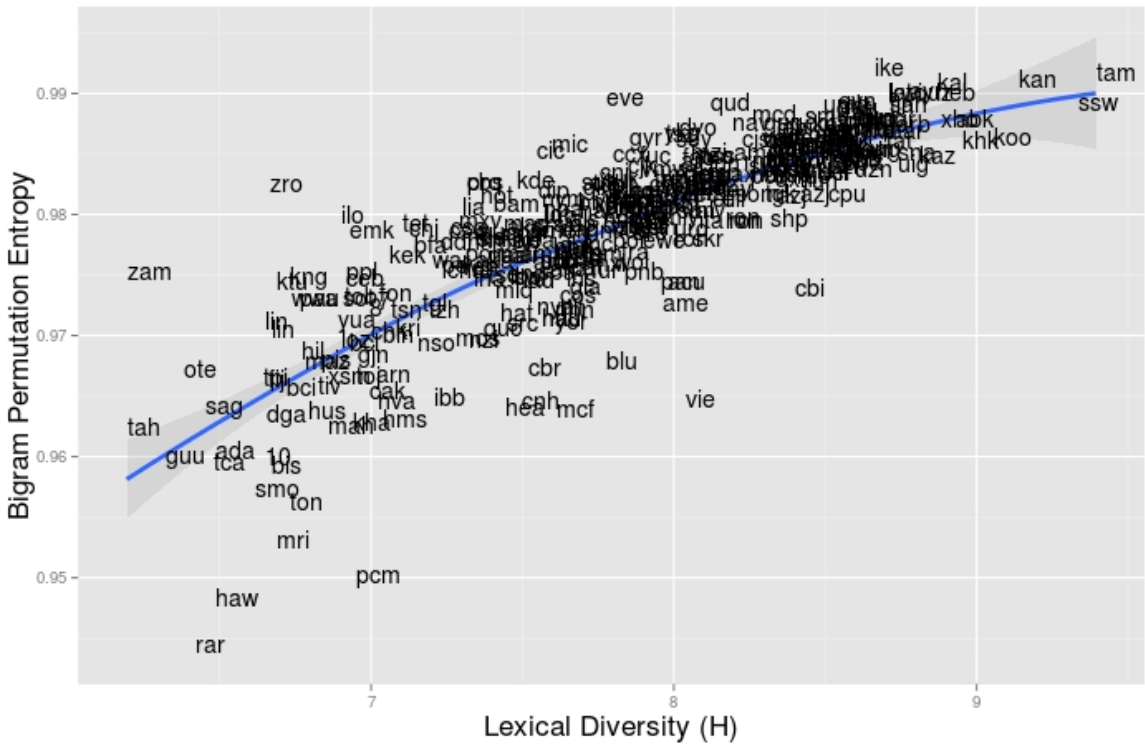

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- It can be measured **quantitatively** (ZM-law, Shannon entropy, type-token ratios)

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- It can be measured **quantitatively** (ZM-law, Shannon entropy, type-token ratios)
- It is linked to language learning via **frequency effects**

Conclusion

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- It can be measured **quantitatively** (ZM-law, Shannon entropy, type-token ratios)
- It is linked to language learning via **frequency effects**
- It can be **statistically predicted** across languages (language families, language regions, writing systems, potential non-native influence)

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Thank You!

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