# The evolution of word-order universals: Some word-order correlation are lineage specific - others might be universal

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WORDS BONES GENES TOOLS
Tracking Linguistic, Cultural, and Biological Trajectories of the Human Past

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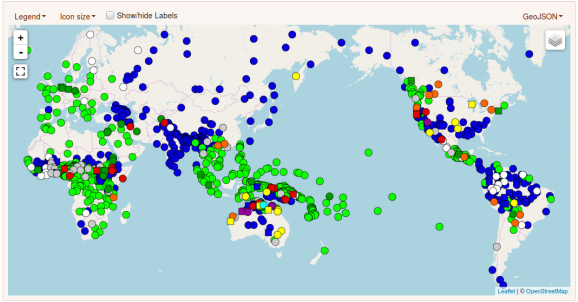
# Introduction

# Word order correlations

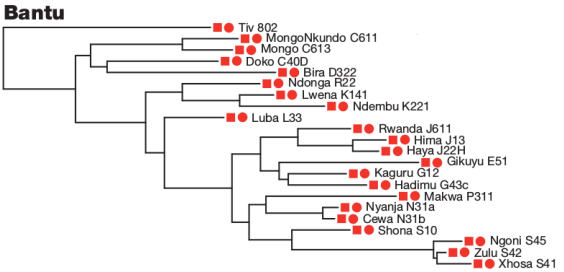
- Greenberg, Keenan, Lehmann etc.: general tendency for languages to be either consistently head-initial or consistently head-final
- alternative account (Dryer, Hawkins): phrases are consistently left- or consistently right-branching
- can be formalized as collection of implicative universals, such as
  *With overwhelmingly greater than chance frequency, languages with normal SOV order are postpositional. (Greenberg's Universal 4)*
- both generativist and functional/historical explanations in the literature



# Phylogenetic non-independence

- languages are phylogenetically structured
- if two closely related languages display the same pattern, these are not two independent data points

$\Rightarrow$ we need to control for phylogenetic dependencies




(from Dunn et al., 2011)

# Phylogenetic non-independence

## Maslova (2000):

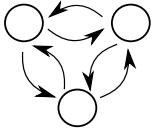
*"If the A-distribution for a given typology cannot be assumed to be stationary, a distributional universal cannot be discovered on the basis of purely synchronic statistical data."*

*"In this case, the only way to discover a distributional universal is to* ***estimate transition probabilities*** *and as it were to 'predict' the stationary distribution on the basis of the equations in (1)."*

# The phylogenetic comparative method

# Modeling language change

**Markov process**



# Modeling language change

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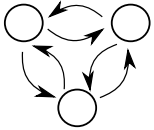
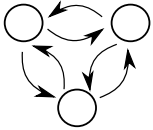


**Phylogeny**

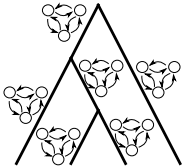
# Modeling language change

**Markov process**



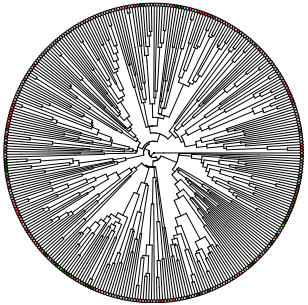
**Phylogeny**

**Branching process**



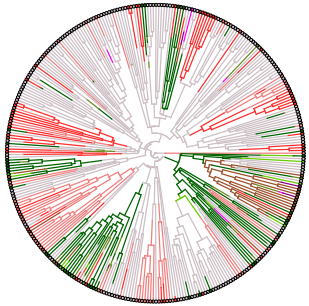
# Estimating rates of change

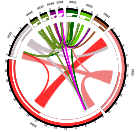
- if phylogeny and states of extant languages are known...



# Estimating rates of change

- if phylogeny and states of extant languages are known...
- ... transition rates, stationary probabilities and ancestral states can be estimated based on Markov model



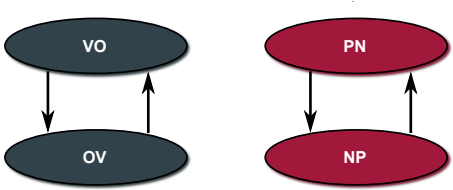


# Correlation between features

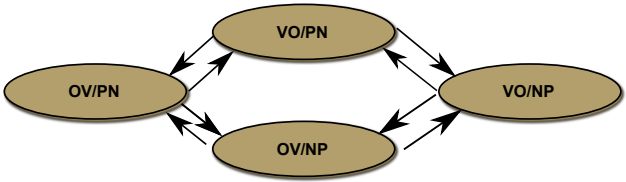
## Pagel and Meade (2006)

- construct two types of Markov processes:
  - **independent:** the two features evolve according to independend Markov processes
  - **dependent:** rates of change in one feature depends on state of the other feature
- fit both models to the data
- apply statistical model comparison

***Independent model***




***Dependent model***



# Dunn et al. (2011)

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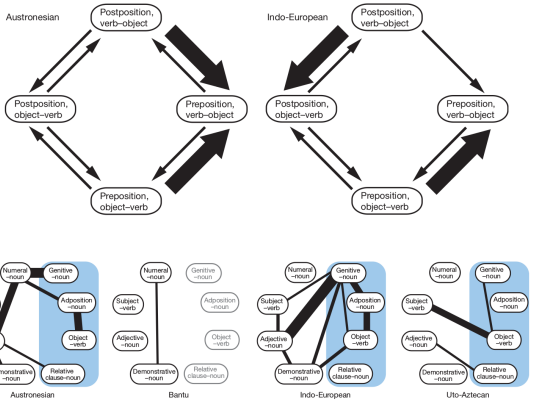
- all 28 pairs of 8 word-order features considered
- 4 language families: Austronesian, Bantu, Indo-European, and Uto-Aztecan
- main finding: wildly different results between families
- conclusion:
  **word-order correlations are lineage-specific**



# Universal and lineage-specific models

# This study

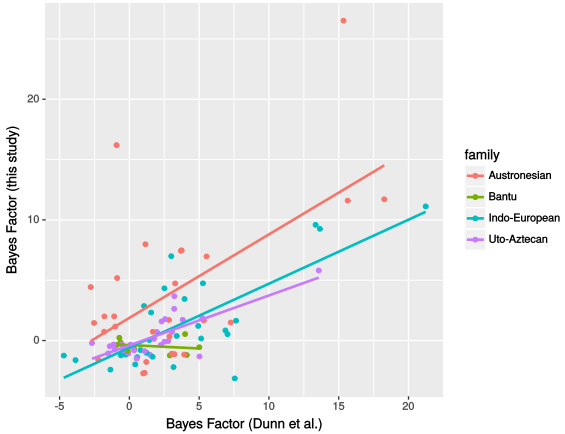
## Experiments

1. replication of Dunn et al. (2011) with different data
2. model comparison: universal vs. lineage-specific correlations
3. word-order correlations across a world-tree of languages
4. automatically identifying lineage-specificity

# Data

- **word-order data:** WALS
- **phylogeny:**
  - ASJP word lists (Wichmann et al., 2016)
  - feature extraction (automatic cognate detection, *inter alia*) $\rightsquigarrow$ character matrix
  - Maximum-Likelihood phylogenetic inference with Glottolog (Hammarström et al., 2016) tree as backbone
  - advantages over hand-coded Swadesh lists
    - applicable across language familes
    - covers more languages than those for which expert cognate judgments are available
  - 1004 languages in total
  - Austronesian: 123; Bantu: 41; Indo-European: 53; Uto-Aztecan: 13

# Replication of Dunn et al.

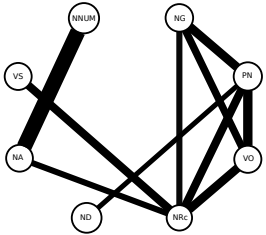


# Comparing universal and lineage-specific models

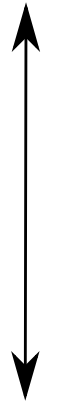
- so far: fitting a separate model for each language family
  - **advantage:** good fit of the lineage-specific data
  - **disadvantage:** many parameters (8 per family for a dependent model)
- statistical model comparison: quantifying to what degree the data support the excess parameters of lineage-specific models
- models to be compared:
  - **universal:** one set of rates (8 parameters), applying to all 4 families
  - **lineage specific:** a separate set of rates for each family
- comparison via **Bayes Factor**
  (implementation with RevBayes; Höhna et al. 2016)

# Results

- very strong evidence for universality:
  - noun-adjective ↔ noun-numeral
  - adposition-noun ↔ verb-object
- strong evidence for universality:
  - adposition-noun ↔ verb-object ↔ noun-genitive ↔ noun-relative clause
- strong or very strong evidence for lineage specificity:
  - behavior of noun-adjective and noun-numeral

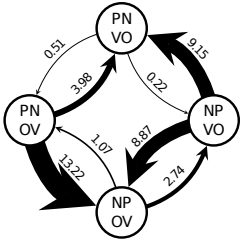


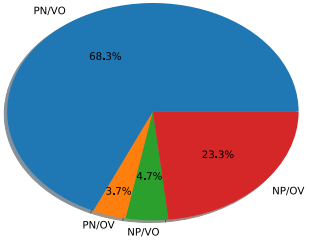

| feature pair | Bayes Factor |
|---|---|
| NA-NNum | 16.24 |
| PN-VO | 15.22 |
| PN-NG | 9.45 |
| VO-NRc | 9.21 |
| PN-NRc | 8.69 |
| NRc-VS | 8.18 |
| NG-VO | 7.92 |
| NG-NRc | 6.55 |
| NA-NRc | 6.49 |
| PN-ND | 5.42 |
| ND-NRc | 4.32 |
| VO-VS | 3.15 |
| PN-VS | 1.71 |
| NA-ND | 0.54 |
| ND-VO | 0.37 |
| NA-VO | -2.07 |
| ND-NG | -3.17 |
| NA-PN | -3.40 |
| NNum-VS | -8.13 |
| NNum-NRc | -8.40 |
| NA-VS | -9.66 |
| NG-VS | -9.84 |
| NA-NG | -10.94 |
| ND-NNum | -12.12 |
| ND-VS | -15.01 |
| PN-NNum | -16.37 |
| NNum-VO | -17.57 |
| NG-NNum | -28.63 |



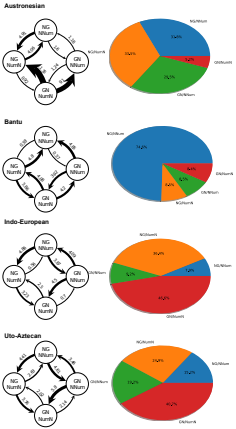
# Results

## universal (PN/VO)

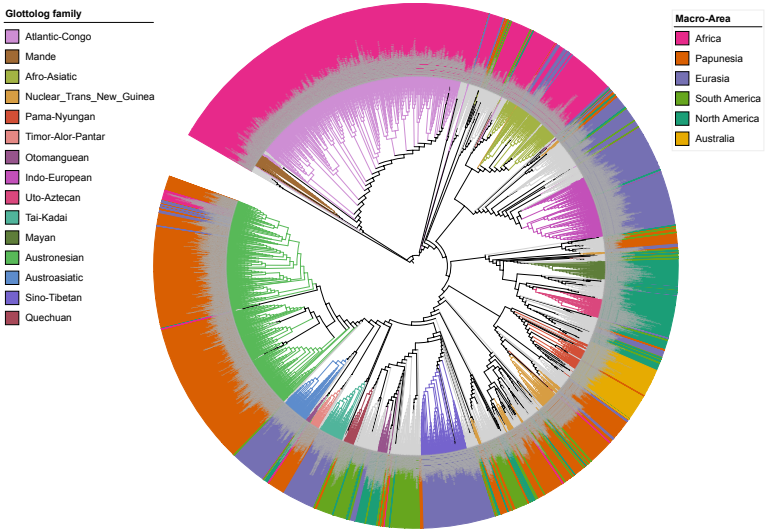



## lineage-specific (NG/NNum)

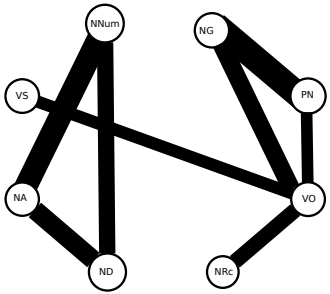


# Using the world tree

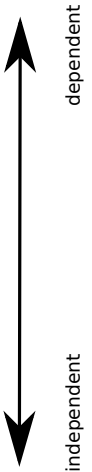


# Results

- strong evidence for dependent model for 21 out of 28 feature pairs
- no evidence for independent model
- strongest evidence (BF>100) supports Dryer (1992)

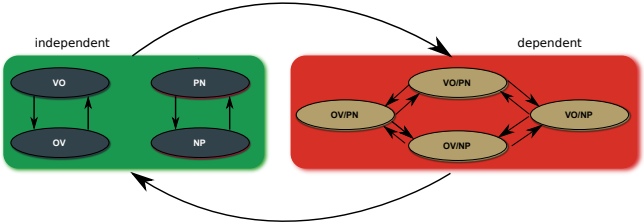



| feature pair | Bayes Factor |
|---|---|
| PN-VO | 267.83 |
| PN-NG | 220.74 |
| NA-NNum | 192.78 |
| NA-ND | 163.62 |
| NG-VO | 152.64 |
| ND-NNum | 140.17 |
| VO-NRc | 129.74 |
| VO-VS | 105.73 |
| NG-NRc | 99.82 |
| PN-NRc | 99.28 |
| NA-NRc | 84.36 |
| NG-VS | 83.68 |
| ND-NRc | 71.32 |
| PN-VS | 57.51 |
| NNum-VS | 37.25 |
| NNum-NRc | 36.54 |
| NRc-VS | 17.28 |
| ND-NG | 16.75 |
| NA-NG | 16.55 |
| ND-VO | 14.00 |
| NNum-VO | 12.43 |
| PN-ND | 6.99 |
| NA-VS | 5.91 |
| NA-PN | 3.84 |
| NA-VO | 3.24 |
| ND-VS | 1.25 |
| PN-NNum | -0.75 |
| NG-NNum | -2.38 |

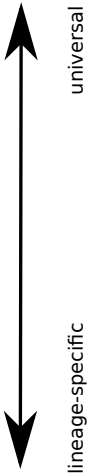


# Automatically identifying lineage-specificity

- lineages with different dynamics can be inferred automatically on the world tree
- latest version of *BayesTraits* (v. 3) implements a model ("discrete covarion model") where languages can be either in a dependent or an independent state
- statistical model comparison between universal and lineage-dependent model (in this sense)

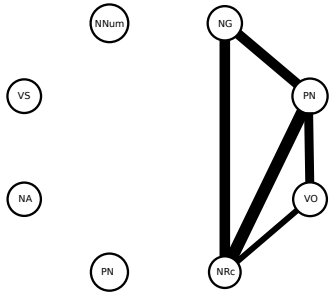



| feature pair | Bayes Factor |
|---|---|
| PN-NRc | 0.42 |
| NG-NRc | -0.90 |
| PN-NG | -1.37 |
| PN-VO | -2.29 |
| VO-NRc | -4.86 |
| NA-ND | -11.66 |
| NA-NRc | -21.42 |
| ND-NNum | -22.86 |
| ND-NRc | -23.16 |
| NG-VO | -25.20 |
| PN-VS | -25.70 |
| ND-VS | -28.63 |
| NG-VS | -29.05 |
| VO-VS | -29.74 |
| PN-ND | -30.35 |
| ND-VO | -30.90 |
| NA-NNum | -31.42 |
| ND-NG | -37.75 |
| NA-VS | -40.18 |
| NRc-VS | -44.06 |
| NA-PN | -44.25 |
| NNum-VS | -45.30 |
| NA-VO | -49.34 |
| NNum-NRc | -53.38 |
| PN-NNum | -55.88 |
| NA-NG | -58.86 |
| NNum-VO | -64.76 |
| NG-NNum | -66.61 |



# Automatically identifying lineage-specificity

- no evidence for truely universal dependent model
- equivocal evidence for 5 feature pairs
- define a cluster for which there was strong evidence for universality in experiment 2

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| NG-VO | -25.20 |
| PN-VS | -25.70 |
| ND-VS | -28.63 |
| NG-VS | -29.05 |
| VO-VS | -29.74 |
| PN-ND | -30.35 |
| ND-VO | -30.90 |
| NA-NNum | -31.42 |
| ND-NG | -37.75 |
| NA-VS | -40.18 |
| NRc-VS | -44.06 |
| NA-PN | -44.25 |
| NNum-VS | -45.30 |
| NA-VO | -49.34 |
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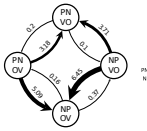
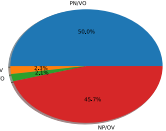
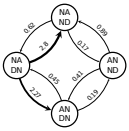
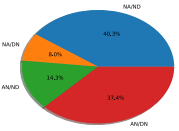
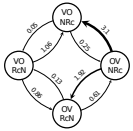
# What the dependencies look like

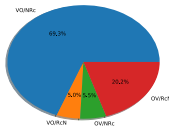


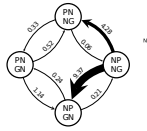



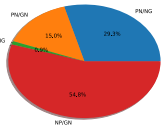



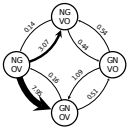



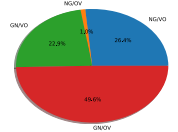



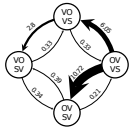



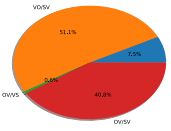



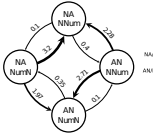



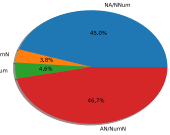



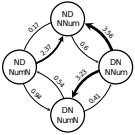



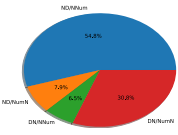



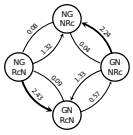



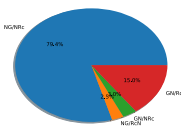



# Conclusion

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- empirical
  - *universal* vs. *lineage-specific* is not an absolute distinction, but a matter of degree
  - some "classical" word-order correlation fall very close to the universal end
- methodological
  - important to fit statistical model across language-families

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