NAACL - SIGTYP 2022

# Typological Word Order Correlations with Logistic Brownian Motion

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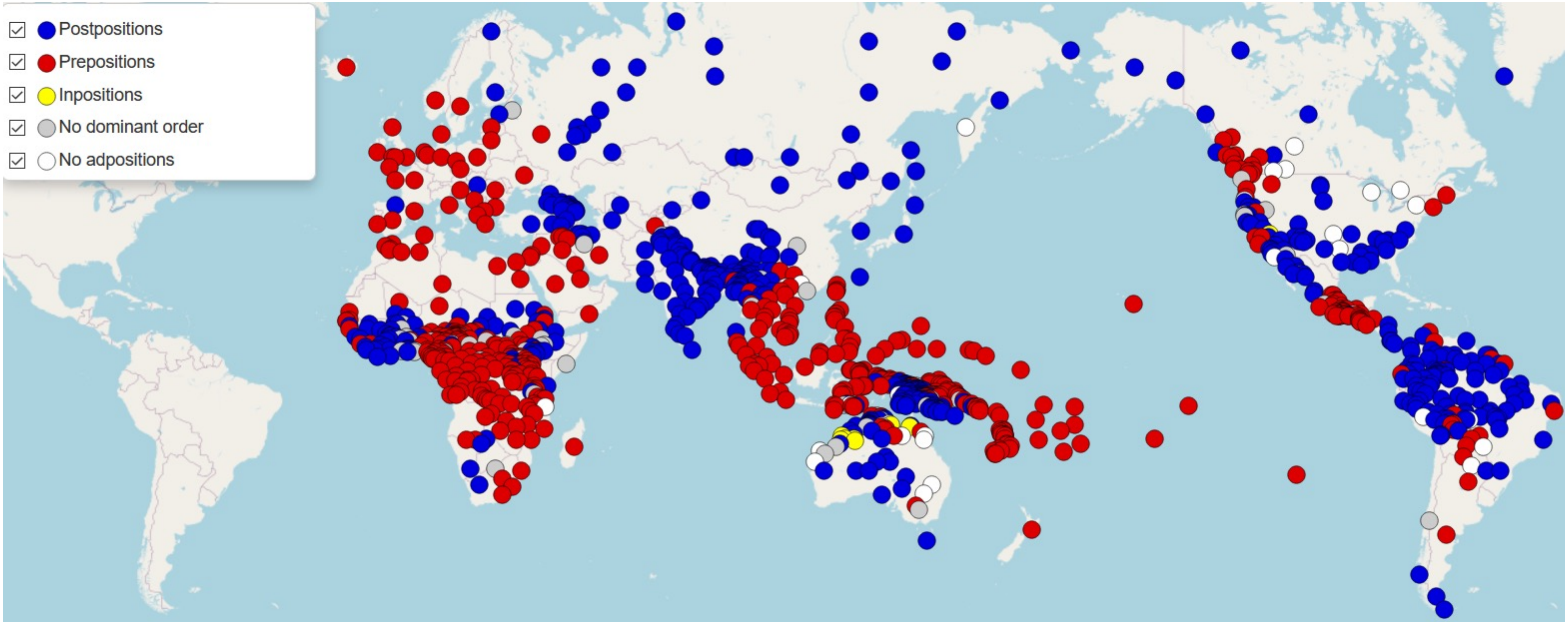
# Word-Order Traits in Languages




World Atlas of Languages (Dryer and Haspelmath, 2013)

# Aim

- Probing for universal correlation patterns in the evolution of word-order traits
- Testing if cross-family models can capture correlation patterns not found in single-family models.

using a Logistic Brownian Motion Model

# Word-Order Traits in Languages

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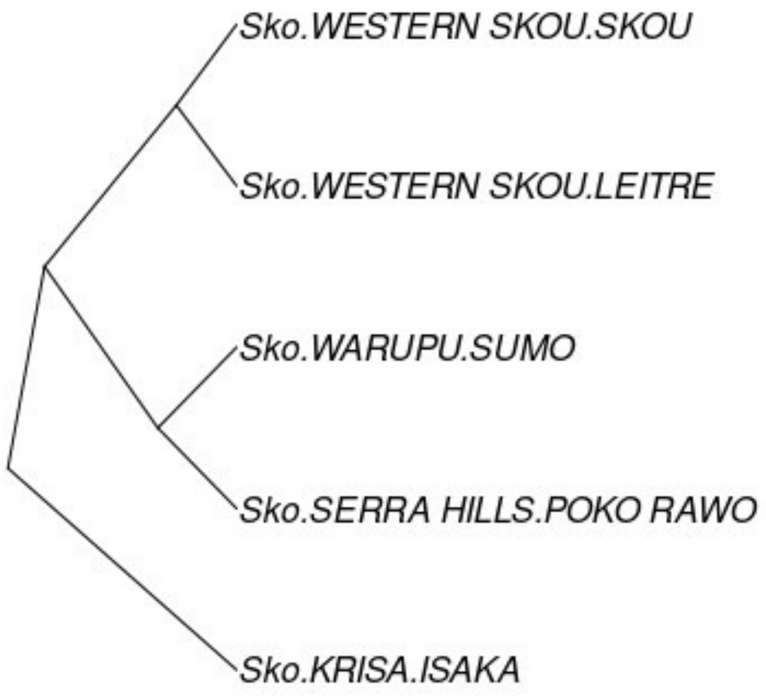
- Adjective-Noun
- Adposition-Noun
- Demonstrative-Noun
- Genitive-Noun
- Numeral-Noun
- Object-Verb
- Relative Clause-Noun
- Subject-Verb

28 binary trait pair combinations derived from WALS (Dryer and Haspelmath, 2013)

# Language Families

- Evolutionary history in the form of phylogenetic trees
- 33 language families
- 768 languages in total
- Provided by Jäger (2018)



# Logistic Brownian Motion

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$$x \sim MultiNormal(a, V),$$

trait values $x$,

means $a$,

Variance-Covariance matrix $V = R \otimes C$

# Logistic Brownian Motion

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$$\boldsymbol{x \sim Binomial(p)}$$

$$\boldsymbol{inv\_logit(p)} \sim MultiNormal(a, V),$$

trait values $x$,

**value probabilities $p$,**

means $a$,

Variance-Covariance matrix $V = R \otimes C$

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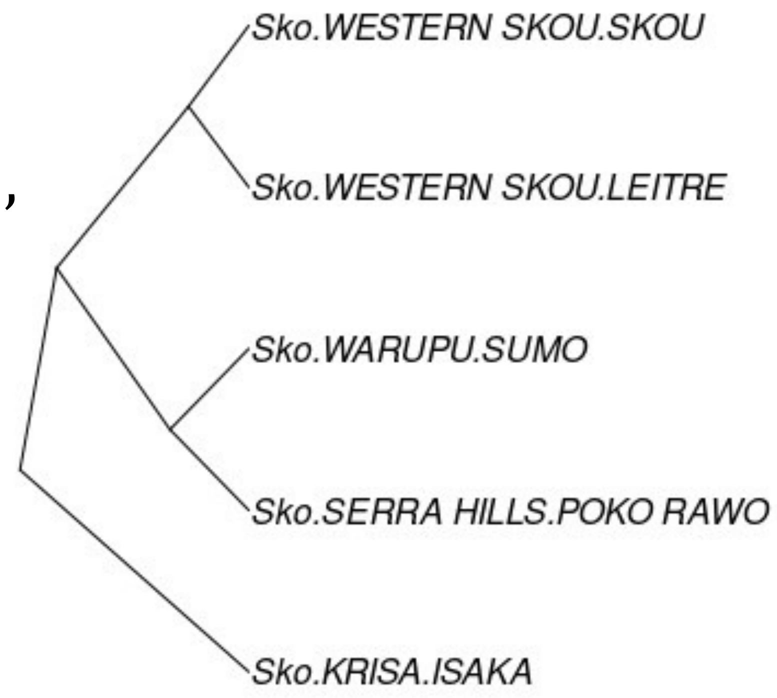

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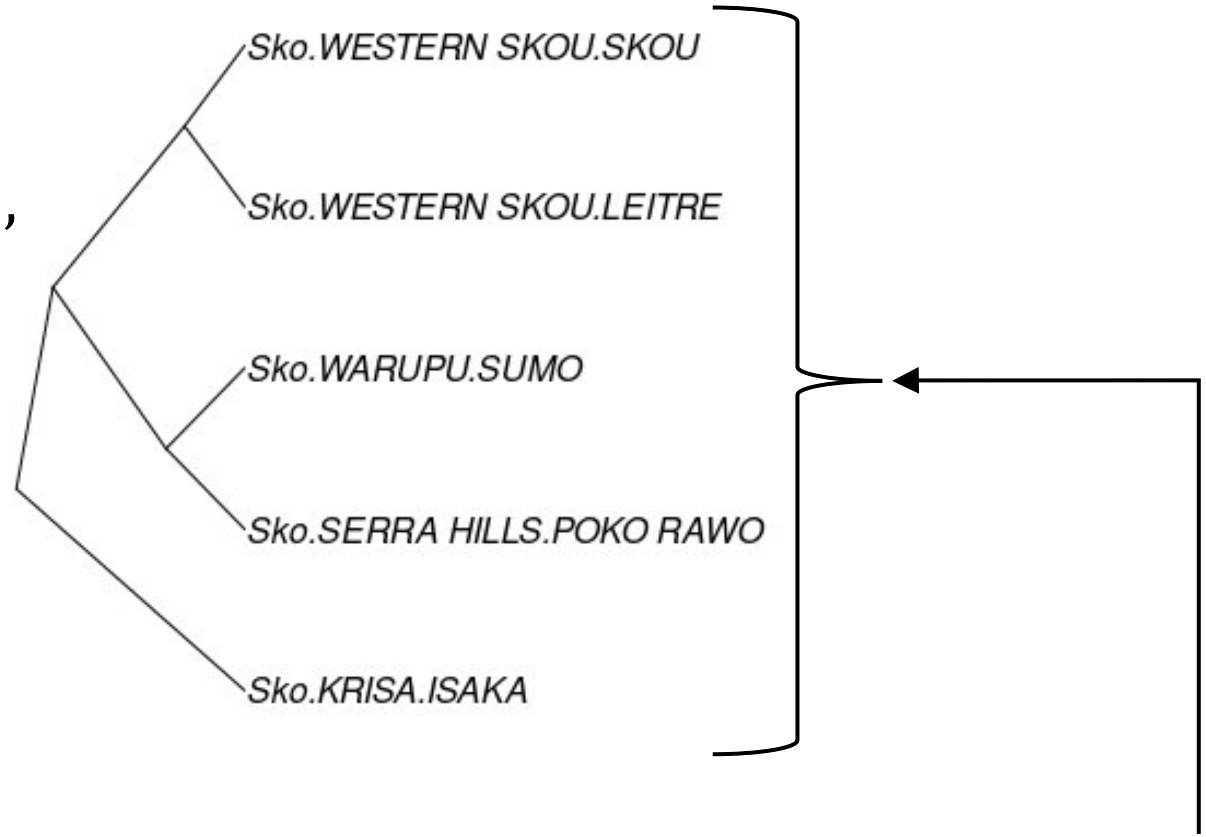


probabilities $\boldsymbol{p}$
/trait values $\boldsymbol{x}$

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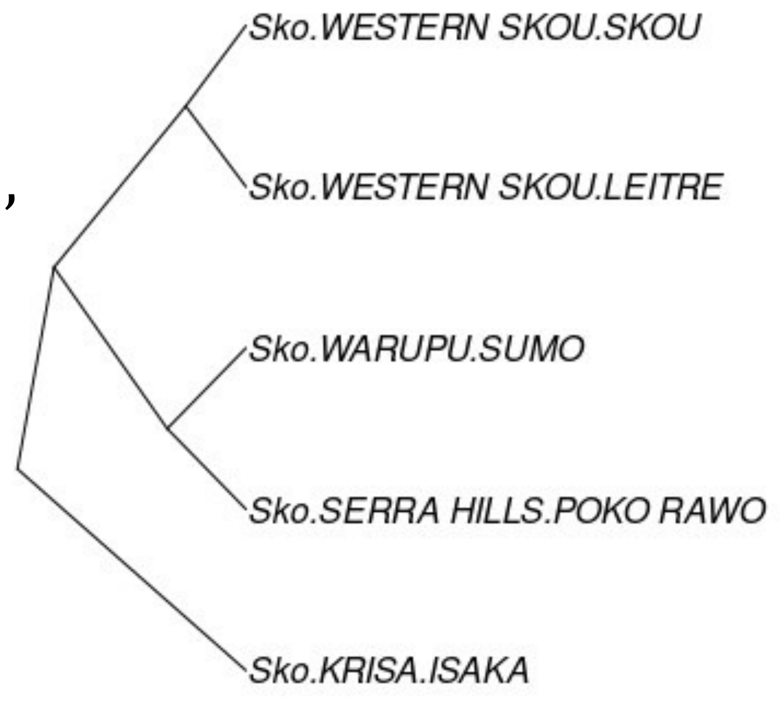


means $\boldsymbol{a}$
/root values

probabilities $p$
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# Logistic Brownian Motion

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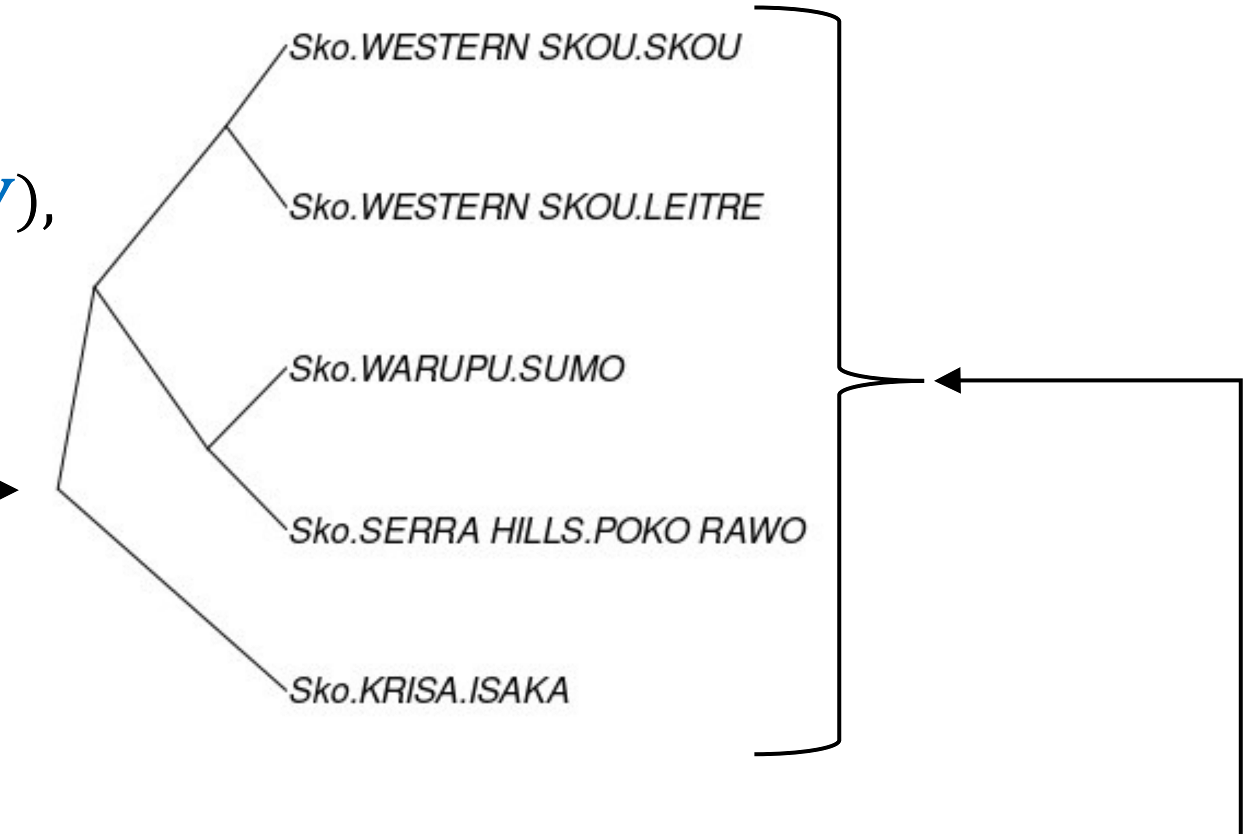
$$\boldsymbol{V} = R \otimes C,$$

$\otimes$: Kronecker product




means $a$
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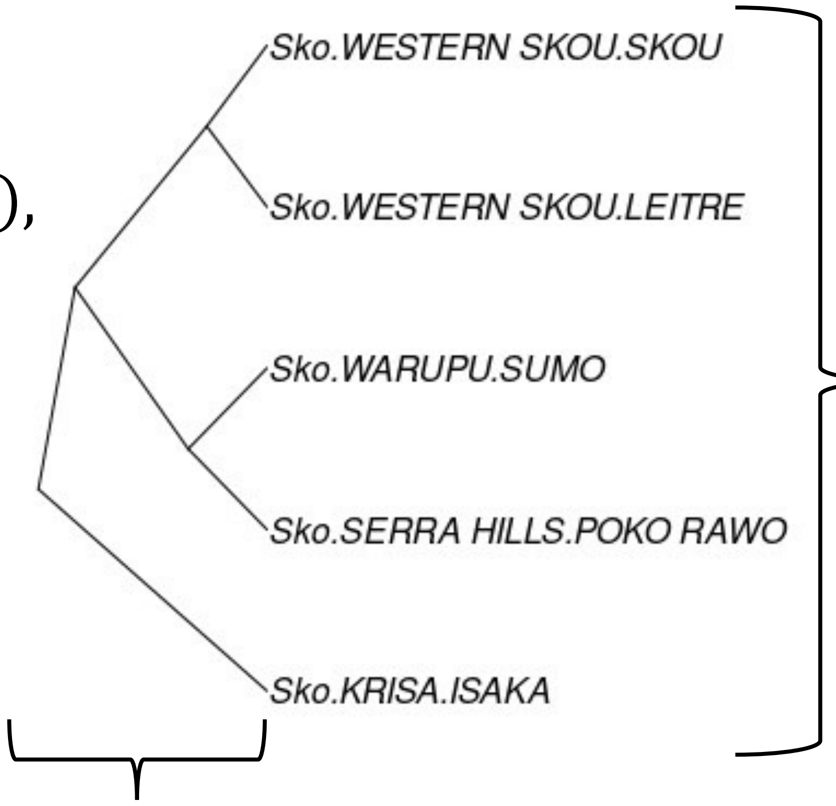


means $a$
/root values

Variance-Covariance matrix $\boldsymbol{C}$
/shared history

probabilities $p$
/trait values $x$

# Logistic Brownian Motion

$$x \sim Binomial(p)$$

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$$\boldsymbol{V} = \boldsymbol{R} \otimes C$$

$$\boldsymbol{R} = \begin{bmatrix} \boldsymbol{\sigma^2}_{\boldsymbol{11}} & \sigma_{21} \\ \sigma_{12} & \boldsymbol{\sigma^2}_{\boldsymbol{22}} \end{bmatrix}$$

Evolutionary rate

# Logistic Brownian Motion

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Trait correlation

# Setup

1. Models for each single family:

*Correlated:*

$$R = \begin{bmatrix} {\sigma^2}_{11} & \sigma_{21} \\ \sigma_{12} & {\sigma^2}_{22} \end{bmatrix}$$

*Independent:*

$$R = \begin{bmatrix} {\sigma^2}_{11} & 0 \\ 0 & {\sigma^2}_{22} \end{bmatrix}$$

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## 2. Models across all families:

*Lineage-specific correlation:*

$$R_f = \begin{bmatrix} {\sigma^2}_{11f} & \sigma_{21f} \\ \sigma_{12f} & {\sigma^2}_{22f} \end{bmatrix},$$

for each family $f \in F$

*Universal correlation:*

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# Results

- Single Family Models:
  - No trait pairs correlated consistently across language families
  - Observation consistent for Bayes Factors and Information Criteria (WAIC, LOOIC)

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- Cross-Family Models:
  - Bayes Factors:

    Lineage-specific correlations valued much higher than universal models
  - Information Criteria:

    Contrarily, universal models valued much higher than lineage-specific

# Conclusions

- Single-Family models and Bayes Factors for Universal models are in favour of only lineage-specific correlations
- However, Information Criteria for Universal models are in favour of universal correlations

⇒ **No clear evidence in favour of any universal trait correlations**

⇒ **No clear evidence to support that cross-family models can capture universal correlations better**

# References


- Matthew S. Dryer and Martin Haspelmath, editors. 2013. WALS Online. Max Planck Institute for Evolutionary Anthropology, Leipzig.
- Gerhard Jäger. 2018. A bayesian test of the lineage-specificity of word order correlations. In 12th International Conference on Language Evolution (Evolang XII), Torun