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Algorithmic generation of random languages argues for syntax as a source of phylogenetic information

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Language comparison and phylogenetic reconstruction:

1) Correspondence problem
2) Metric problem
3) Probability problem

but in particular...

Language comparison and phylogenetic reconstruction:

4) **Globality problem**

The classical comparative method and modern lexical/morpho-phonological methods have addressed problems 1-3 (with some difficulties):

1) Correspondence problem: Swadesh-list “meaning” comparison (e.g. Dyen et al. 1992), “root” comparison (e.g. Gray and Atkinson 2003)
2) Metric problem: “distances” (e.g. Dyen et al. 1992), “characters” (e.g. Ringe et. al 2002)
3) Probability problem (e.g. Ringe 1992, Nichols 1996)

No solution has been found for the **Globality problem**.

Reason: Lexical and morphological characters are not comparable across families (e.g. all etymological unrelated characters, all maximum distances).

Solution: Exploring different domains, e.g. Syntax (Guardiano and Longobardi 2005, Longobardi and Guardiano 2009)

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Evidence for syntax as a signal of historical relatedness

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Problems 1,2 and 4 are solved through the notion of “syntactic parameter” (Chomsky 1981, Baker 2001).

Parameters are species-invariant, ultimately biological, options: the same open choices are presupposed by every language (i.e. by every infant) and environmentally set during the acquisition

1) Correspondence problem: parameters are **unambiguous**

2) Metric problem: parameters are **discrete** (binary values)

4) Globality problem: parameters are **universal**

3) **Probability problem**

Parametric Comparison Method (PCM) (Guardiano and Longobardi 2005, Longobardi and Guardiano 2009)

Languages are encoded as lists of binary parameters (+,-).

Parametric Comparison Method (PCM) (Guardiano and Longobardi 2005, Longobardi and Guardiano 2009)

Problem: parameters are not **independent**, but there are **implications** which make some parameter values predictable.

Grammaticalized definiteness and enclitic articles

	English	Norwegian	Russian
p10: gramm. Def. (articles)	+	+	-
p14: def-checking N (+p10)	-	+	?

Grammaticalized definiteness and enclitic articles

	English	Norwegian	Russian
p10: gramm. Def. (articles)	+	+	-
p14: def-checking N (+p10)	-	+	0

Sample parameters:

65 syntactic parameters from the Nominal Domain (Dps)

Sample languages:

21 IE languages (5 Romance, 5 Germanic, 5 Slavic, 3 Indo-Iranian, 2 Celtic, 1 Greek)

3 Finno-Ugric languages (Finnish, Estonian, Hungarian)

2 Altaic languages (Turkish, Buryat)

2 Semitic languages (Semitic, Arabic)

2 Basque varieties

2 Chinese (Mandarin, Cantonese)

1 Wolof

It -+---00+-+++++---0--+-+0--0000+++0+0+----+000-+--0--0+-+---00-+--
Sp ++---00+-+++++---0--+-+0+++-+++++0+0+----+000-+--0--0+-+---00+++-
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Rm ++---00+-++++++--+0--+-+00++-+++++0+0+----+000-+--0--0--+0--00--0-
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How to choose a distance measure?

Since we have a lot of '0' values, we cannot rely on a simple Hamming distance.

We can use a **Jaccard-Tanimoto distance** between "comparable" values:

$\delta(A,B) = d(A,B) / d(A,B) + i(A,B)$

$= \text{differences} / \text{identities} + \text{differences}$

E.g.: Italian-English: (35 id., 6 diff.) $\delta = 6 / 41 = \mathbf{0.146}$

Are these distances **significant** from a statistical viewpoint?

Comparison of “real” distances versus “randomly generated” distances (Bortolussi et al. 2011).

Bortolussi et al. (2011): Sampling over a uniform distribution of **languages**

Bortolussi et al. (2011)	L1	L2	L3	L4	Probability of P_= +
P1	+	+	+	-	0.75
P2 (only if +P1)	+	+	-	0	0.67
P3 (only if +P2)	+	-	0	0	0.5
Probability of L_=+	**0.25**	**0.25**	**0.25**	**0.25**	

Problem: since the sample is made of mostly IE languages, this kind of sampling generates IE-like languages.

A new sampling algorithm: assumption of a uniform distribution of **parameters**

Our algorithm	L1	L2	L3	L4	Probability of P_= +
P1	+	+	+	-	**0.5**
P2 (only if +P1)	+	+	-	0	**0.5**
P3 (only if +P2)	+	-	0	0	**0.5**
Probability of L_=+	0.125	0.25	0.25	0.5	

Independent parameters are first assigned a value by chance.

Following parameters are checked for implications.

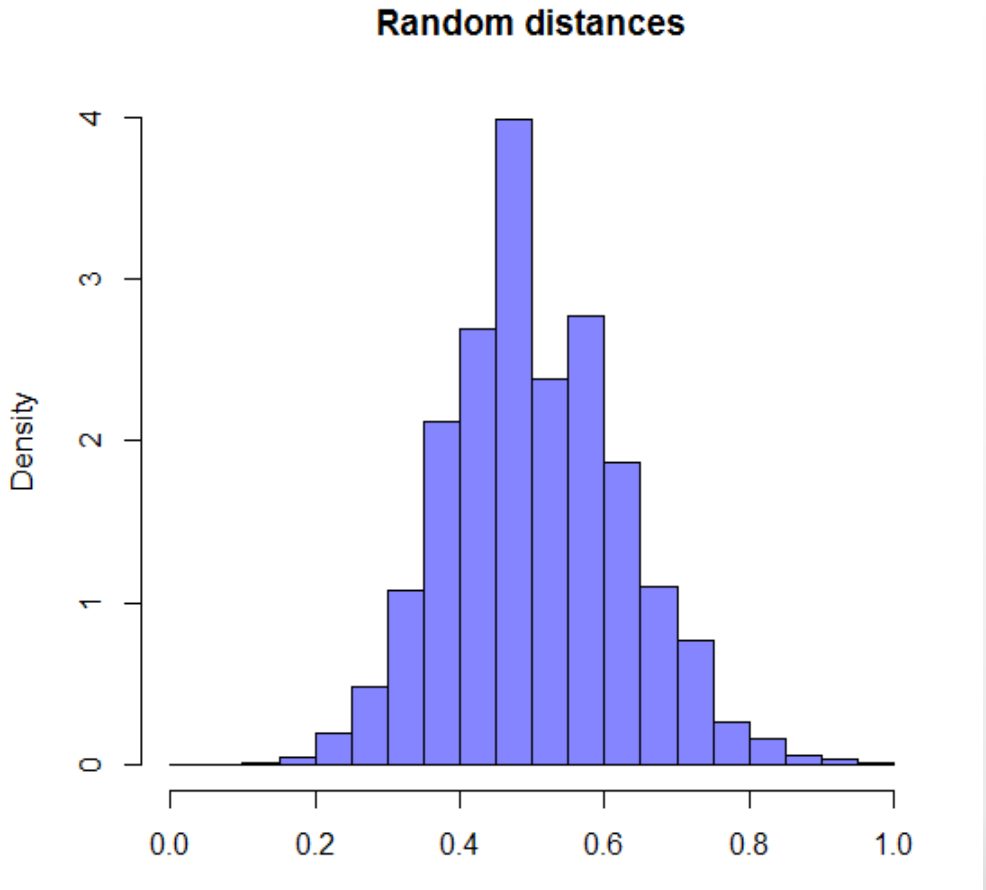
Random sample

1000 random languages

~500.000 random pairs

Mean: 0.510

Median: 0.5



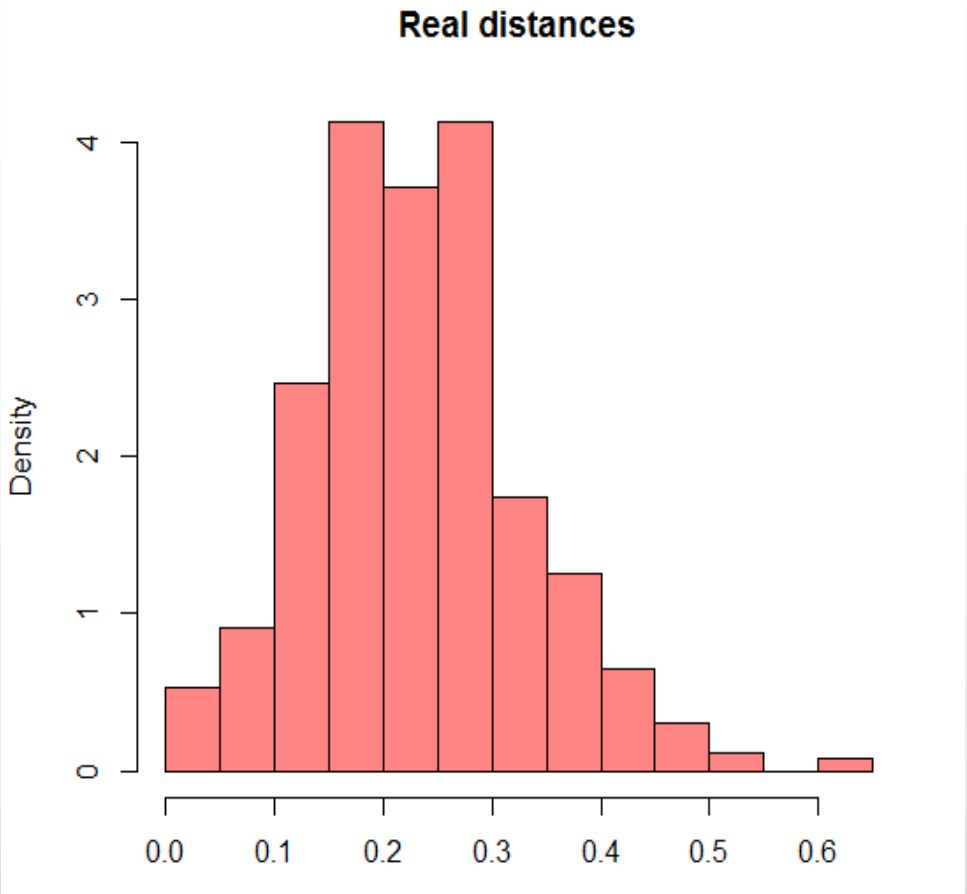
Real sample

33 real languages

528 real pairs

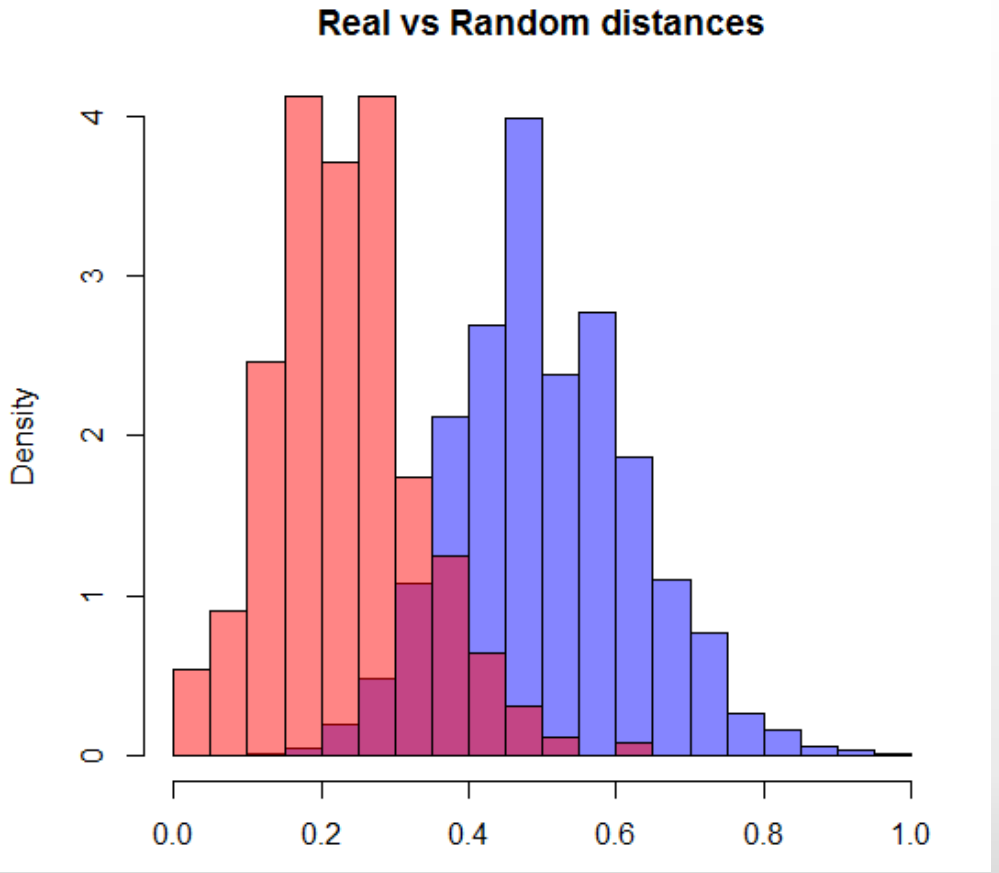
Mean: 0.234

Median: 0.226



Mann-Whitney *U* test = $p<2.2*e^{-16}$

The two datasets cannot be drawn from the same distribution

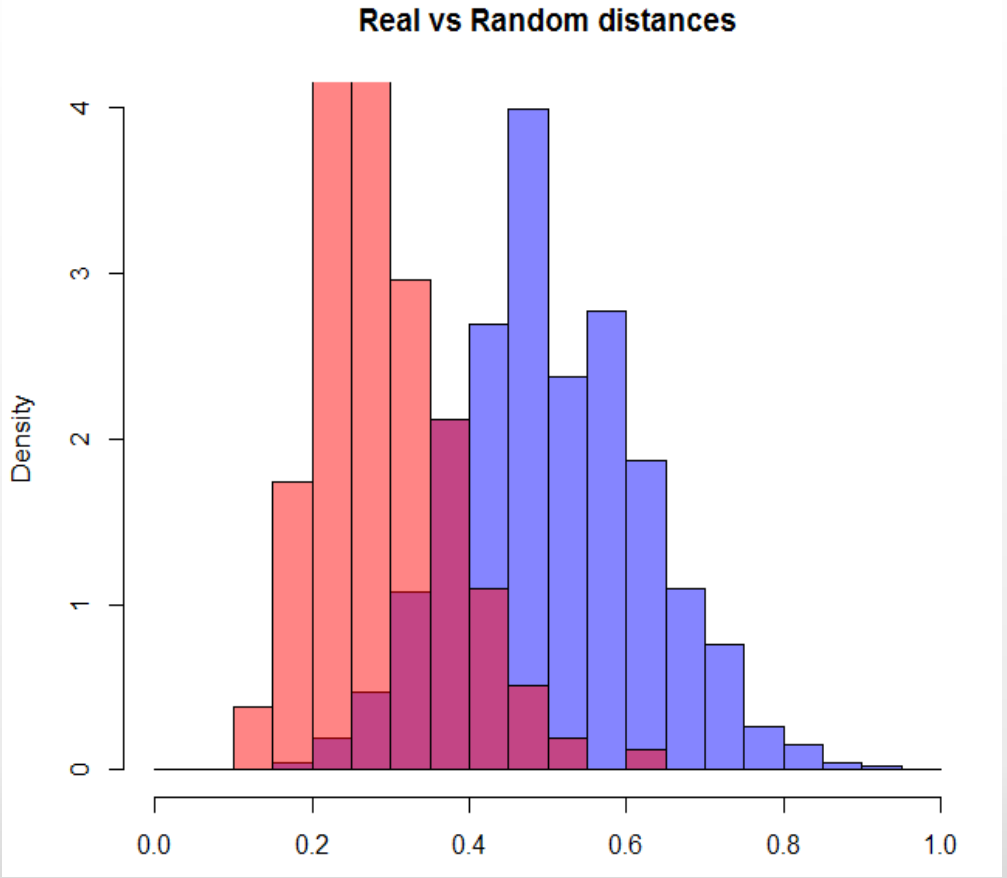


Family-external pairs only

Mann-Whitney *U* test = $p<2.2*e^{-16}$

The two datasets cannot be drawn from the same distribution

(**Anti-Babelic principle**, Guardiano and Longobardi 2005)



Possible explanation?

Chance threshold	Distance value	Pairs expected by chance	Pairs under the threshold
$P=10^{-4}$	0.111	0.05	42
$P=10^{-3}$	0.174	0.528	146
$P=10^{-2}$	0.250	5.28	310

Possible explanation?

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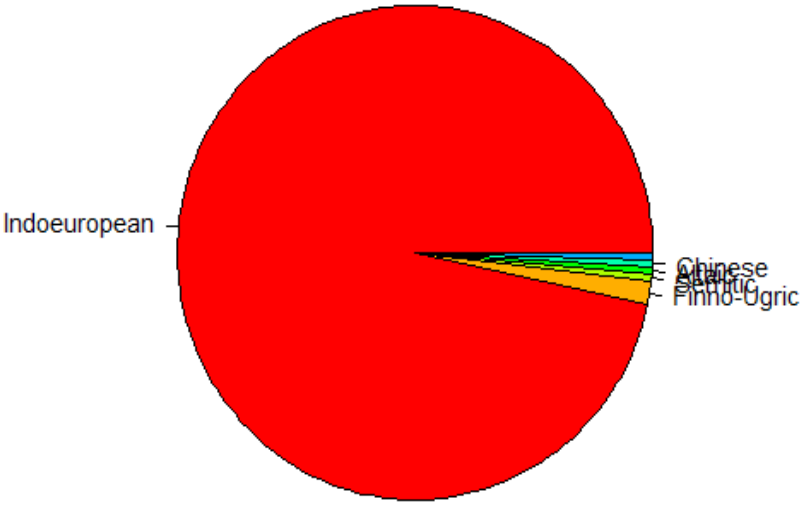
History as the driving force?

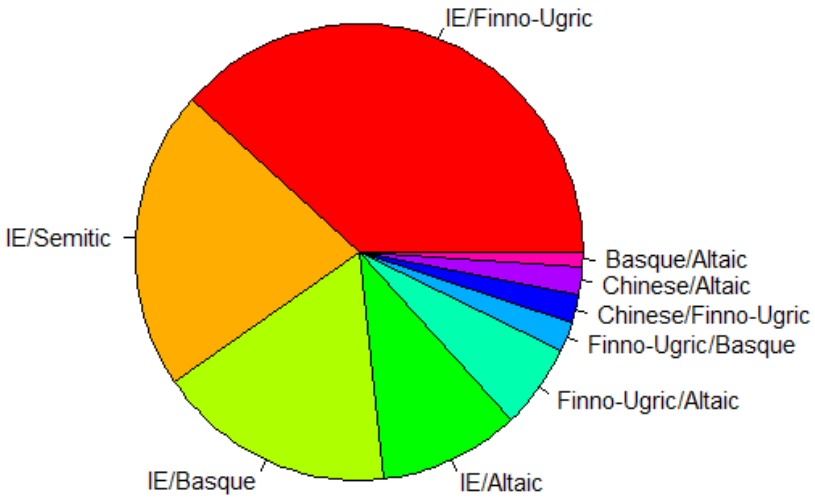
Family-internal pairs (211)



	Under threshold	Total	Percentage
Indoeuropean	204	210	97.14%
Finno-Ugric	3	3	100.00%
Semitic	1	1	100.00%
Basque	1	1	100.00%
Altaic	1	1	100.00%
Chinese	1	1	100.00%

History as the driving force?

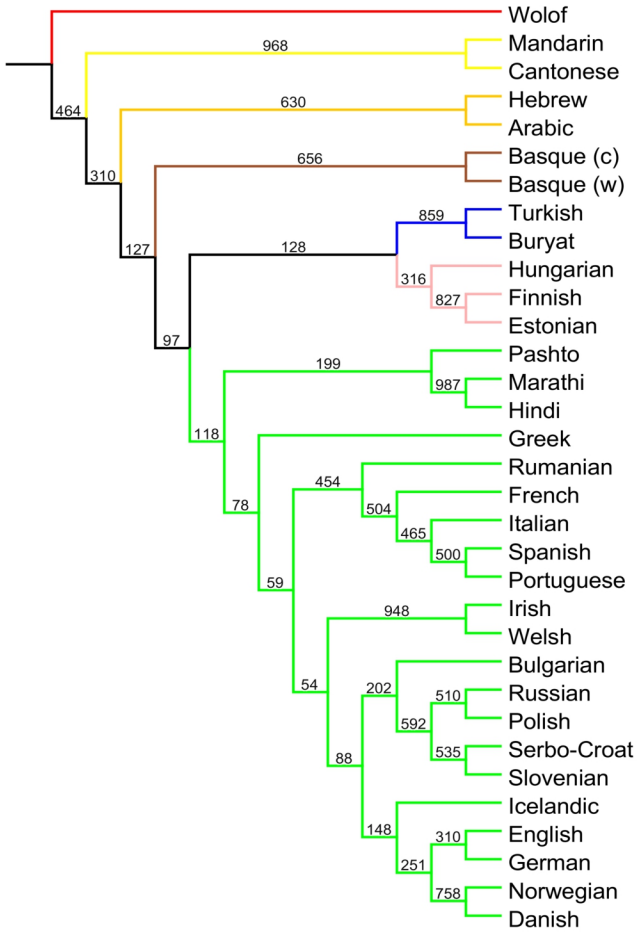
Family-external pairs (99)



	Under threshold	Total	Percentage
Finno-Ugric/Altaic	6	6	100.00%
IE/Finno-Ugric	38	63	60.32%
IE/Semitic	21	42	50.00%
Chinese/Altaic	2	4	50.00%
IE/Basque	17	42	40.48%
IE/Altaic	10	42	23.81%
Finno-Ugric/Basque	2	6	33.33%
Finno-Ugric/Chinese	2	6	33.33%
Altaic/Basque	1	4	25.00%

Phylogenetic tree

(KITSCH, bootstrapped, 1000 resamples)



Conclusions:

- We provided an algorithm for generating random languages and studying the space of variation modeled taking into account implications between parameters
- Investigating syntax within a generative framework focusing on the intricate system of implications between parameters proved that the parametric approach is able to retrieve a high level of correct historical information
- This is an indirect argument for the ultimate “reality” of syntactic parameters
- Data from more languages could allow us to strenghten our claims

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