Statistical Issues in Areal Typology

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Background

Based on joint work with

- Johanna Nichols (UC Berkeley) on macro-areas and typological enclaves
- Dirk Janssen (U Kent) and Fernando Zúñiga (CEP Santiago, Chile) on Monte-Carlo methods

For links to publications and presentations, see www.uni-leipzig.de/~bickel/projects/research/stats.html

Areal Typology and Statistics

- Predominance of categorial (yes/no) models throughout the 20th century, but..
- as many have noted, areas are gradual phenomena with quantitative parameters (*N* isoglosses, *N* exceptions, *N* languages, area extent, chance vs. nonchance etc.)
- obviously, such phenomena demand quantitative analysis, i.e. statistics, but…
- …what kind of statistics? What parameters play which role? What's the IV, what's the DV? What's a good sample?

What is areality?

- The classic approach defines areas by typological isoglosses and detects areas by fishing for isoglosses among typological variables.
- Under this approach, areality is an empirical typological observation (a ‘typological fact’, statistically a DV)
- But there are well-known problems with this:
  - How many isoglosses are enough? (The classical examples involve between 5 and 20 variables.)
  - How to avoid accidental isogloss groups? Wouldn’t one expect *some* isoglosses in ~1000 variables by chance alone?
  - Areality turns out as a single datapoint (mostly binary, or ranking, as when van der Auwera’s isopleth method is used), i.e. as a single DV holding for a language. Can’t test this!

What is areality?

Alternative: **Predictive Areality Theory** (Bickel & Nichols 2005/ALT6, 2006/BLS32):

- Each variable has its own history of and potential for change and spread.
- Each distribution requires its own explanation.
- Variables may or may not have overlapping distributions.
- If variables have an overlapping distribution, shared history is one plausible explanation. Call this a ***Predictive Areality Theory***, holding for a specific regional distribution.

What is areality?

- Any Predictive Areality Theory must be grounded in what we know from population history through archaeology, genetics, ecology, geography, economics, demography, etc.
- Under this approach, areality is not a typological fact, but a predictor variable predicting typological distributions. (This is the exact opposite of what areality was under classical approaches!)
- IV = Areality, DVs = the typological variables
- The more the theory's predictions are statistically supported, the more robust is the theory.

What is areality?

The AUTOTYP geographical factor metadatabase

geogr_factors (MacOS X Server G3)

Browse

Layout: factor defi

Record: 7

Total: 48

Unsorted

Label	Description	Definition	fa…	factor_type.def::factor_type	Map
NW_OW	New World vs. Old World	1=WN America (CID=7) or	1	Population movement	
Macrocont	Macro-Continents	1=Africa (CID=1)	6	Geography-based	
NonEurasia_0	Continent-sized macroareas outside Eurasia	1=Africa (CID=1)	6	Geography-based	
QuasiDryer	Equivalent of Dryer's Test (6-way breakdown, some	3=S/SE Asia (CID=4) or	6	Geography-based	
PR_Rest	Strict (i.e., coastal) Pacific Rim vs. rest	2=SEA (AID=21) or WN	1	Population movement	
Eurasia_Rest	Eurasia vs. rest of the world	2=(Macrocont=2)	1	Population movement	
CircumP_Rest	Circum-Pacific (coastal and interior) vs. rest	2 = Circumpacific =	1	Population movement	
PR_ASall_0	Pacific Rim vs. Ancient Sunda	1=(PR_Rest=2)	1	Population movement	
EEn1_0	Eurasian Enclavehood (Eurasia including Pacific	1=(Macrocont=2) and not	4	Enclave (accretion zone	
EEnH1_0	Eurasian Enclavehood of Himalayas (Eurasia	1=(Macrocont=2) and not	4	Enclave (accretion zone	
EEnC1_0	Eurasian Enclavehood of Caucasus (Eurasia	1=(Macrocont=2) and not	4	Enclave (accretion zone	
PR_ASallEncl_0	Pacific Rim (Coastal) vs. Ancient Sunda (including	1=(PR_Rest=2)	4	Enclave (accretion zone	
PR_ASallHimal_0	Pacific Rim vs. Ancient Sunda (including N.	3=(PR_Rest=2)	4	Enclave (accretion zone	
PR_ASallCauc_0	Pacific Rim vs. Ancient Sunda (including N.	5=(PR_Rest=2)	4	Enclave (accretion zone	
CircPacEncl_0	Circum-Pacific vs. Eurasian enclaves	1=(EurasEncl_0=2)	4	Enclave (accretion zone	
CircPacHimal_0	Circum-Pacific vs. Himalayas	1=Himalaya	4	Enclave (accretion zone	
SilkEurasia_0	Greater Silk Road Area (without Mesopotamia and	1=Europe (AID=7) or Inn	1	Population movement	
SilkEurasia2_0	Greater Silk Road Area (including Mesopotamia, but	1=Europe (AID=7) or Inn	1	Population movement	
SilkCaucasus_0	Caucasus Enclave vs. Greater Silk Road Area	1=(EurasCaucas_0=2)	4	Enclave (accretion zone	
SilkEncl_0	Eurasian Enclaves vs. Greater Silk Road Area	1=(EurasEncl_0=2)	4	Enclave (accretion zone	
SSEA_0	South and Southeast Asia vs. rest of Eurasia	1=S/SE Asia (CID=4)	5	Multi-isotype linguistic area	
CoastalOW_0	Coastal Old World (Western Pacific Rim)	1=Oceania (AID=18) or N	1	Population movement	
MacroSudaBelt_0	Macro-Sudan Belt (as per Güldemann 2003)	1=N Savannah (AID=27)	5	Multi-isotype linguistic area	
WithinAmericas_0	Areas within Americas	1=WN America (CID=7) or	6	Geography-based	
WestPac	West Pacific (Western half of Circum-Pacific)	2=N Coast Asia (AID=14)	1	Population movement	
WestPacAm_0	West Pacific vs. Americas (Eastern vs Western	2=N Coast Asia (AID=14)	1	Population movement	
CPLatitude_0	Northern vs Southern Circum-Pacific	1=N Coast Asia (AID=14)	1	Population movement	

150 Browse

What is areality?

The AUTOTYP geographical factor database

backbone

geography

Records: 682

Sorted

LID	Language	CID	::Continent	AID	areas.def::Area	Subar...	::Subarea	Latitude	Longitude	Stock	Major branch	NW_OW	Macrocont	QuasiDryer	PR_Rest	Eurasia
40	Burushaski	4	S/SE Asia	9	Indic	2	Himalaya	36	75	isolate		2	2	3	1	2
375	Tibetan (Standard	4	S/SE Asia	9	Indic	2	Himalaya	29.5	91	Sino-Tibetan	Bodish	2	2	3	1	2
35	Belhare	4	S/SE Asia	9	Indic	2	Himalaya	26.57	87.18	Sino-Tibetan	Kiranti	2	2	3	1	2
206	Nepali	4	S/SE Asia	9	Indic	2	Himalaya	28	84	Indo-European	Indo-Iranian	2	2	3	1	2
169	Maithili	4	S/SE Asia	9	Indic	2	Himalaya	26.2	86	Indo-European	Indo-Iranian	2	2	3	1	2
434	Gurung	4	S/SE Asia	9	Indic	2	Himalaya	28	83	Sino-Tibetan	Bodish	2	2	3	1	2
468	Newar (Dolakha)	4	S/SE Asia	9	Indic	2	Himalaya	27.5	86	Sino-Tibetan	? Mahakiranti	2	2	3	1	2
552	Lepcha	4	S/SE Asia	9	Indic	2	Himalaya	27.1	88.3			2	2	3	1	2
626	Kinnauri	4	S/SE Asia	9	Indic	2	Himalaya	31.6	78.5	Sino-Tibetan	West Himalayish	2	2	3	1	2
627	Rangpas (Rang-Pas)	4	S/SE Asia	9	Indic	2	Himalaya	30.6	79.5	Sino-Tibetan	West Himalayish	2	2	3	1	2
628	Byangsi	4	S/SE Asia	9	Indic	2	Himalaya	30	80.3	Sino-Tibetan	West Himalayish	2	2	3	1	2
629	Chantyal	4	S/SE Asia	9	Indic	2	Himalaya	28.8	83.5	Sino-Tibetan	Tamangic	2	2	3	1	2
630	Lhomi	4	S/SE Asia	9	Indic	2	Himalaya	28	87.5	Sino-Tibetan	Bodish	2	2	3	1	2
631	Balti	4	S/SE Asia	9	Indic	2	Himalaya	35	76.2	Sino-Tibetan	Bodish	2	2	3	1	2
632	Hayu	4	S/SE Asia	9	Indic	2	Himalaya	27.5	86.1	Sino-Tibetan	Kiranti	2	2	3	1	2
633	Kashmiri	4	S/SE Asia	9	Indic	2	Himalaya	34	75	Indo-European	Indo-Iranian	2	2	3	1	2
636	Shina (Eastern)	4	S/SE Asia	9	Indic	2	Himalaya	35.2	75.5	Indo-European	Indo-Iranian	2	2	3	1	2
637	Yamphu	4	S/SE Asia	9	Indic	2	Himalaya	27.5	87.3	Sino-Tibetan	Kiranti	2	2	3	1	2
640	Newar (Kathmandu)	4	S/SE Asia	9	Indic	2	Himalaya	27.7	85.3	Sino-Tibetan	? Mahakiranti	2	2	3	1	2
662	Apatani	4	S/SE Asia	9	Indic	2	Himalaya	27.3	93.45	Sino-Tibetan	Tani	2	2	3	1	2
720	Tibetan (Kyirong)	4	S/SE Asia	9	Indic	2	Himalaya	28.28	85.16	Sino-Tibetan	Bodish	2	2	3	1	2
723	Tibetan (Dege)	4	S/SE Asia	9	Indic	2	Himalaya	31.50	98.40	Sino-Tibetan	Bodish	2	2	3	1	2
724	Tamang	4	S/SE Asia	9	Indic	2	Himalaya	28	85	Sino-Tibetan	Bodish	2	2	3	1	2
25	Armenian (Eastern)	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	40	45	Indo-European	Greek-Armenian	2	2	2	1	2
325	Ossetic	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	43.1764	44.2944	Indo-European	Indo-Iranian	2	2	2	1	2
114	Ingush	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	42.9694	44.7719	Nakh-Daghestanian	Nakh	2	2	2	1	2
413	Xinalug	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	41.1	48.05	Nakh-Daghestanian	Lezghian?	2	2	2	1	2
389	Udi	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	41	48	Nakh-Daghestanian	Lezghian	2	2	2	1	2
162	Lezghi	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	41.5842	47.7842	Nakh-Daghestanian	Lezghian	2	2	2	1	2
145	Kubachi	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	42.0869	47.5953	Nakh-Daghestanian	Dargi	2	2	2	1	2
155	Lak	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	42.1	47.1	Nakh-Daghestanian	isolate	2	2	2	1	2
7	Abkhaz	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	43.0	41.0333	Northwest		2	2	2	1	2
124	Karachay-Balkar	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	43.3	42	Turkic	Common Turkic	2	2	2	1	2
49	Chechen	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	43.13	45.5433	Nakh-Daghestanian	Nakh	2	2	2	1	2
86	Georgian	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	41.7178	44.7844	Kartvelian	Georgian-Zan	2	2	2	1	2
458	Circassian (West)	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	44.1	39.0831	NW Caucasian	Circassian	2	2	2	1	2
481	Svan	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	43.0475	42.7236	Kartvelian		2	2	2	1	2
530	Hunzib	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	42.1	46.15	Nakh-Daghestanian	Tsezic	2	2	2	1	2
610	Armenian (Western)	2	Europe - Near East	4	Cauc-Mesop	1	Caucasus	40	41	Indo-European	Greek-Armenian	2	2	2	1	2
199	Nama (Khoekhoe)	1	Africa	19	S Afr			-26	18	Kwadi-Khoe (Central	Khoekhoe	2	1	1	1	1
148	!Kung (!Xu, Ju/'hoan)	1	Africa	19	S Afr			-20	20	Ju (Northern		2	1	1	1	1
94	Hadza	1	Africa	19	S Afr			-3.5	35	isolate		2	1	1	1	1
347	Sandawe	1	Africa	19	S Afr			-6	36	isolate		2	1	1	1	1
151	Kwadi	1	Africa	19	S Afr			-16	12	Kwadi-Khoe (Central	Kwadi	2	1	1	1	1
323	Orig	1	Africa	27	N Savannah			13	31	Kordofanian		2	1	1	1	1
75	Ewe	1	Africa	27	N Savannah			7	3	Kwa		2	1	1	1	1
172	Mandinka	1	Africa	13	N Afr			15	-15	Mande		2	1	1	1	1
80	Fula	1	Africa	27	N Savannah			13	-9	Atlantic	North Atlantic	2	1	1	1	1

100 Browse

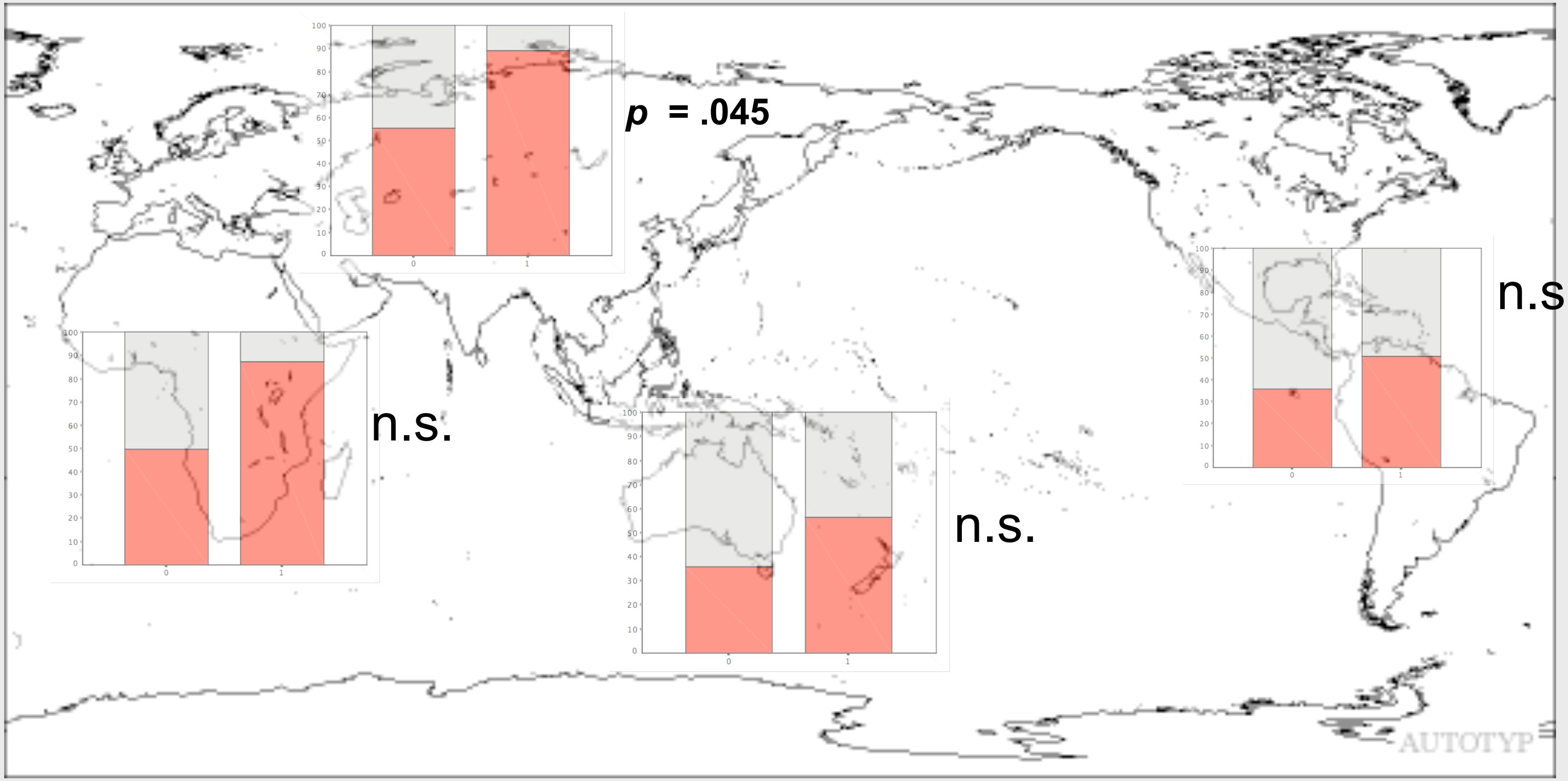
Core claims of any Predictive Areality Theory

Overlapping typological distributions result from:

- independently hypothesized shared history, involving
  - (any kind of) contact-induced change
  - nonreconstructible shared genealogy (inheritance)
- but — *crucially* — not:
  - universal preference
  - reconstructible shared genealogy
  - chance

1 - How to factor out universals

- Test the distribution for area-independent (‘universal’) preferences.
- Example: DM&OV/free (or AN&OV, cf. Dryer 1992)



N = 179, Source: AUTOTYP (locus) and Dryer/WALS (word order)

2 - How to factor out genealogy

- Nonreconstructible genealogy cannot be factored out.
- Need a notion of ***historical relatedness*** that does not distinguish between isoglosses arising from nonreconstructible shared descent and from contact.
- But reconstructible genealogy can and must be factored out.

2 - How to factor out genealogy

- Textbook solution: sample stratification, with equally-sized random samples per stratum (stock, genus)
- But often there are too many (eg AN, IE) or too few datapoints (isolates) to allow random sampling and independently sampled cases!
- And often we want to hand-select cases, eg we don't want Rumantsch as the sole representative of Romance when testing Europe as an area.

➜ Samples do not — and should not — meet the random sampling ("independence of cases") criterion of classical statistics.

2 - How to factor out genealogy

- Alternative: sample at a genealogically higher level than individual languages: genus (Dryer 1989) or major branch (AUTOTYP). Call this a ***genealogical sample***.

- Determine the datapoint for each genus/branch by representative or known or reconstructed languages.

- Run all stats on these datapoints, not on languages!

3 – How to factor out chance

- Classical stats does not work on genealogical samples (Janssen, Bickel & Zúñiga 2006):
  - These samples are technically *exhaustive*: they aim at containing a datapoint for *each* genus or branch, not for a random sample of these! (eg. all genera in Europe)
  - Exhaustive sampling contradicts the very logic of classical, distribution-based statistics (including classical nonparametric statistics like the χ^2-Test).
- Alternative (in use since about 10 years): ***Permutation tests*** (Exact and Monte-Carlo methods)

  Permute a table 10000 (or all) times: how often do you get tables at least as skewed as the observed one (as measured by χ^2 or F, or whatever)? If 100 in 10'000, then p=.01.

3 – How to factor out chance

Advantages:

- very simple test logic, no distribution theory (df etc.)
- can also handle very heterogenous factor levels
- if exact, *p*-values reflect strength of association (Gries & Stefanowitsch 2003)

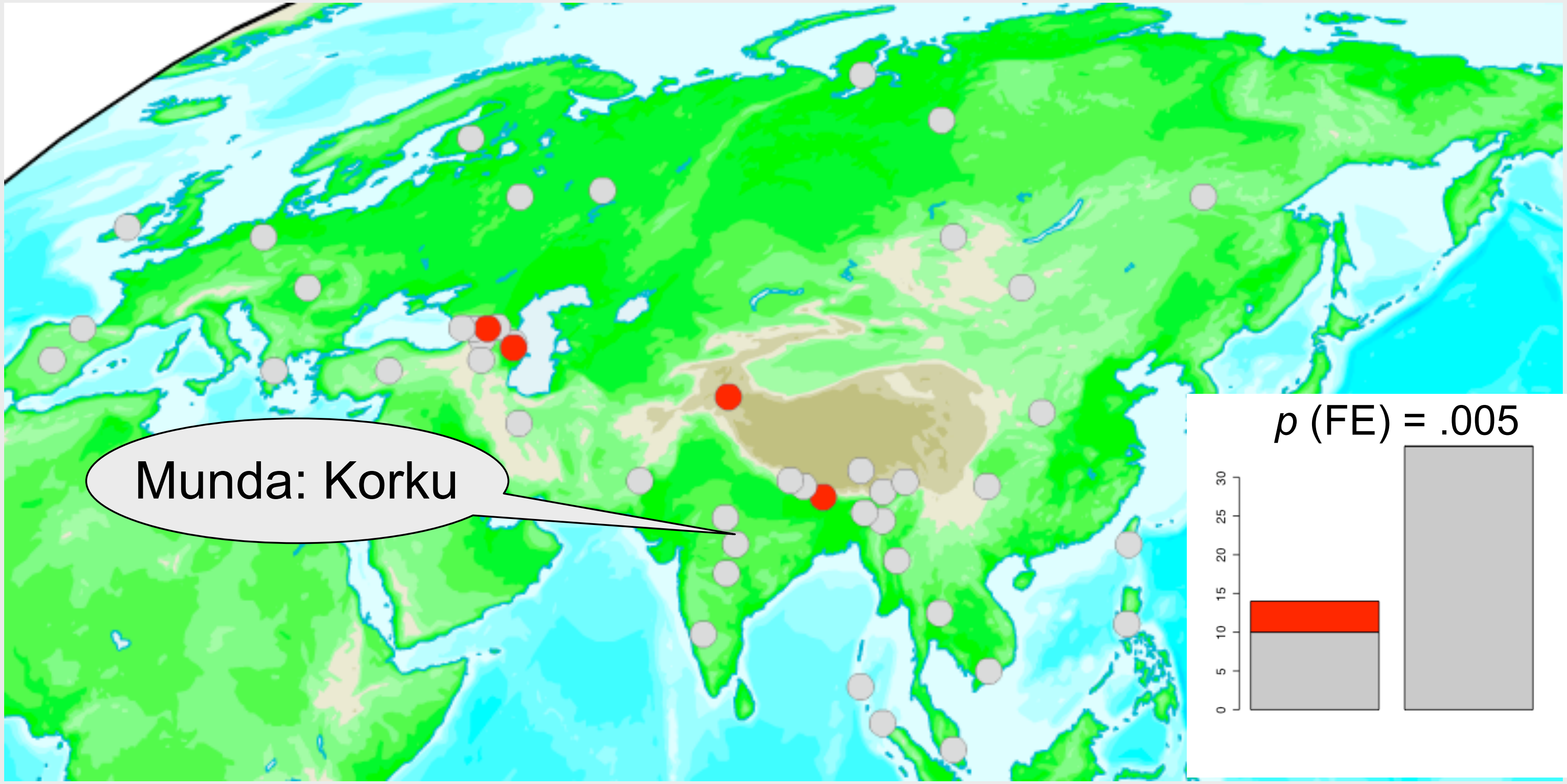
Disadvantage:

- All inference to underlying populations (the populations that cause the observed distribution) is a theoretical, not a statistical issue!
- But, since we moved from speakers to languages to reconstructible units, our inferences are theoretical anyway (e.g. we need to argue why our datapoints are representative).

3 – How to factor out chance

The Missampling Risk: in a small genus/stock sample, what if we had picked other representative languages?

Example: Possessive classes (Bickel & Nichols 2005/LSA)



Source: AUTOTYP database: NP structure module; N = 48

3 – How to factor out chance

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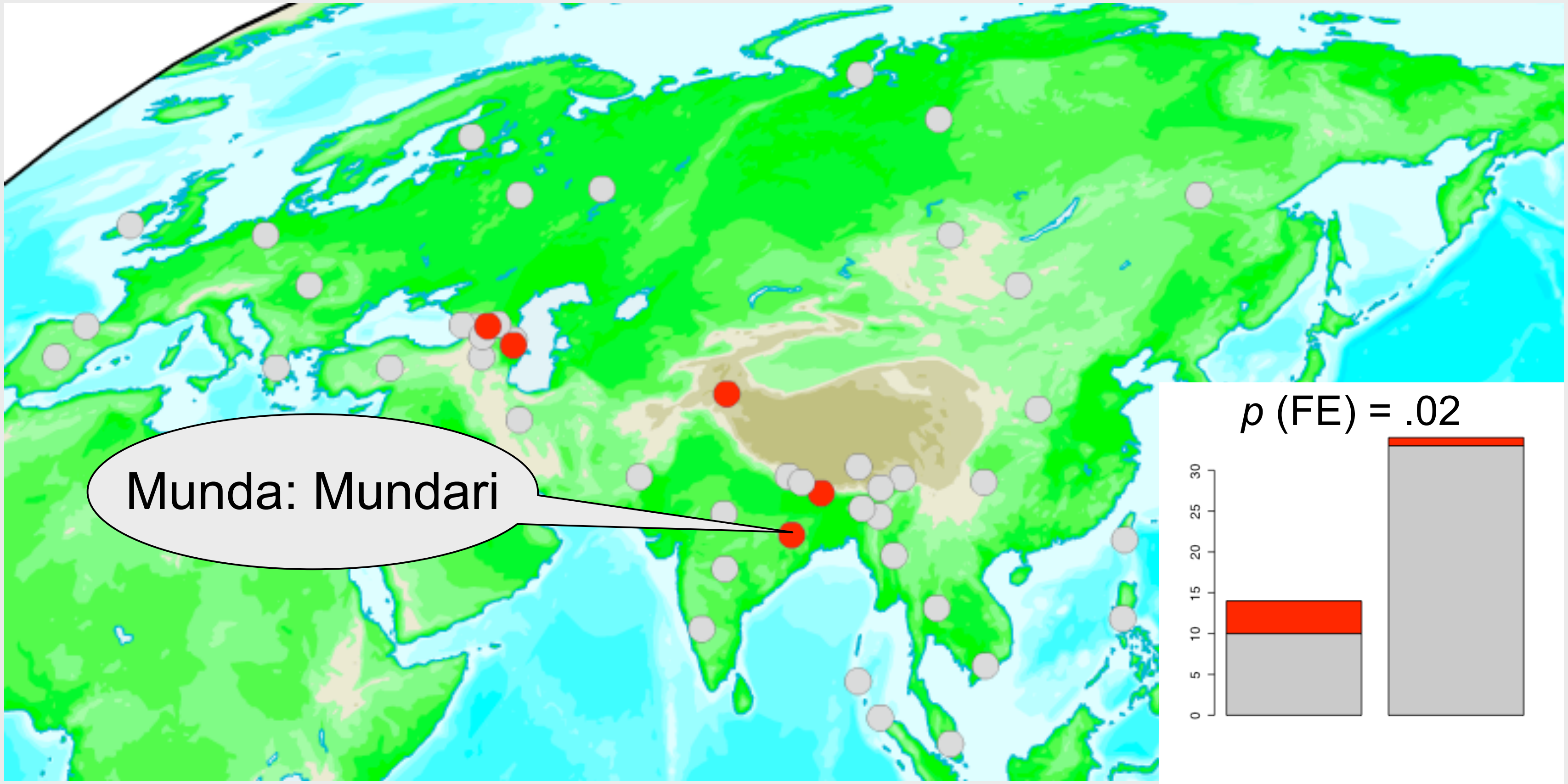


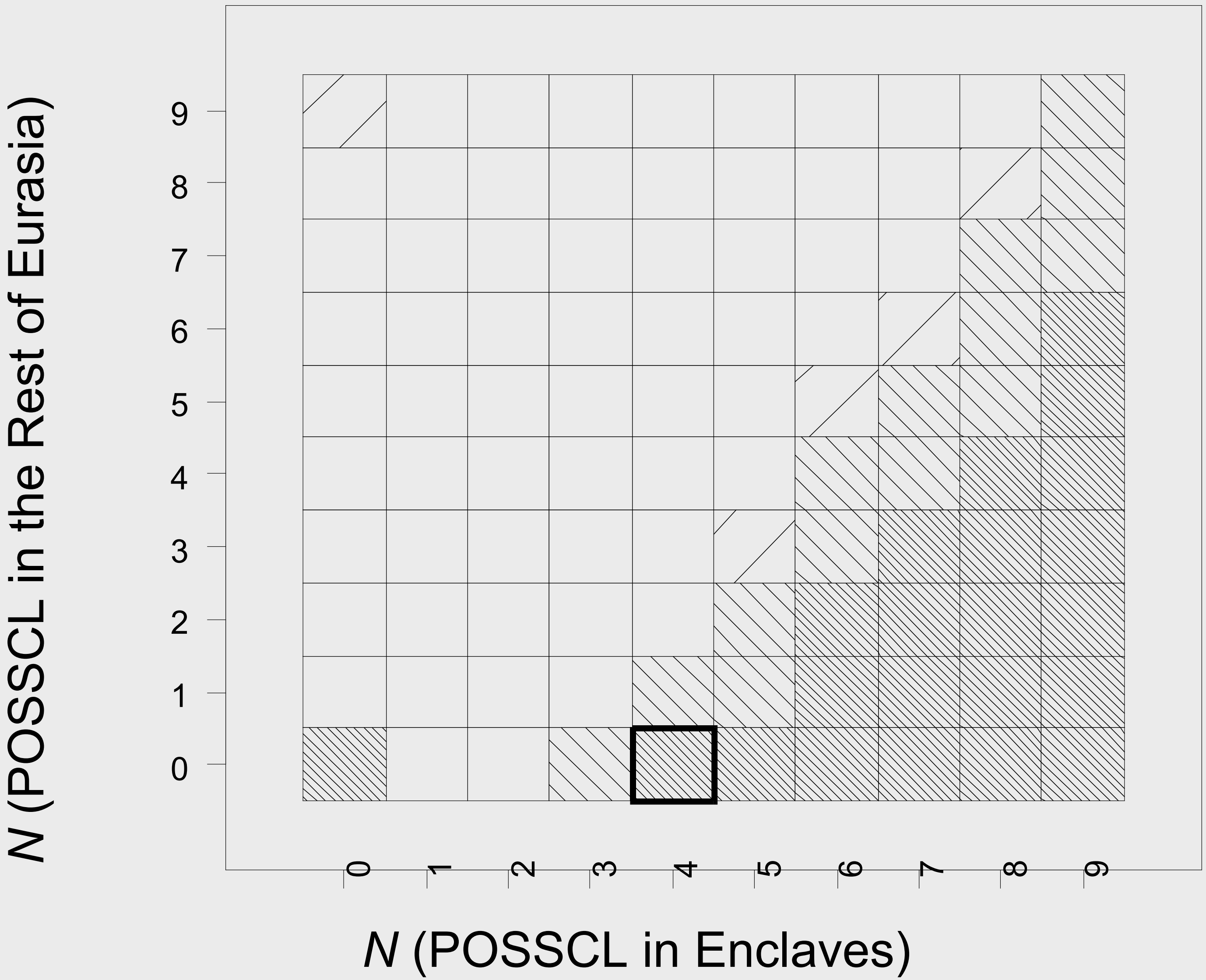
Source: AUTOTYP database: NP structure module; N = 48

3 – How to factor out chance

Solution to the Missampling Risk (Janssen, Bickel & Zuñiga 2005):

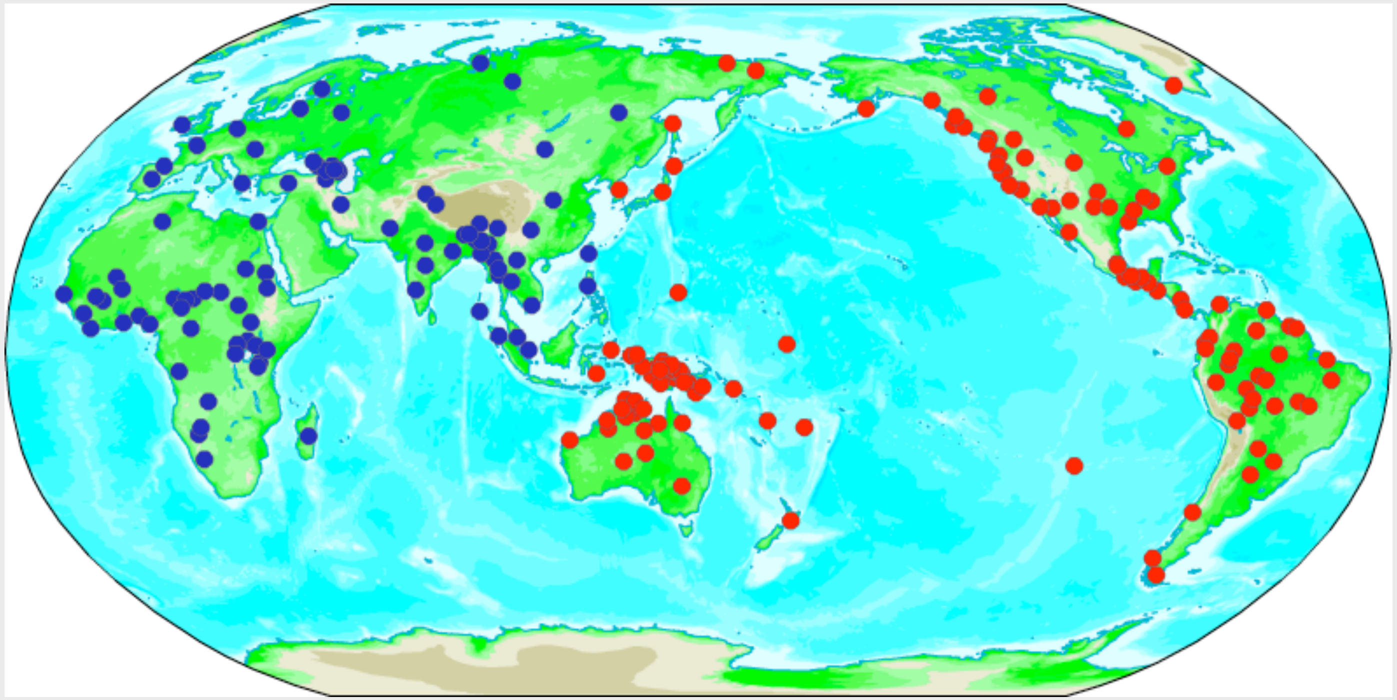
Reliability testing by simulating alternative type distributions (re-sampling tables with the same size but different totals) and determining how far samples can vary while keeping a given significance level.

3 – How to factor out chance



An example: the CP area

- PA-Theory: CP spreads (Nichols 1992)
- Predictions (Bickel & Nichols 2006/BLS32):
  - CP vs. Rest
  - CP vs. Eurasia (i.e. CP vs rest is not caused by Africa alone)
- Two versions of CP (SEA with W or E):



An example: the CP area

- Tested on genealogical samples drawn on AUTOTYP (“GEN”) and WALS (“WALSG”)
- Only variables with no more than 30% missing values
- WALS variables recoded where necessary (e.g. take out ‘n/a’s, reduce types) and possible: 32 variables

An example: the CP area

Variable		(Re-)Coding	Sample	Actual size	SEA west		SEA east	
					CP vs rest	CP vs EURAS	CP vs rest	CP vs EURAS
AUWEPI	Epistemic possibility	(not recoded)	WALSG	163	chi2=47.03,p=1e-04	chi2=39.86, p = 1e	chi2=47.03,p=1e-04	chi2=33.0,p=1e-04
AUWEPI2	Epistemic possibility	binary ±verbal st	WALSG	146	p=5.43e-11	p=2.09e-09	p=1.02e-08	p=4.13e-07
BAECSY01	Case syncretism	removed "no case	WALSG	64	chi2=9.40,p=.009	p=.01	chi2=10.99,p=.004	p=.004
COMALN5	N alignment	collapsed subtype	WALSG	160	chi2=14.59,p=.003	p=.001	chi2=14.14,p=.004	p=.0001
DRYRAO0	AdjN and OV combination	removed free ord	WALSG	143	chi2=14.08,p=.002	chi2=9.72, p =.019	chi2=9.78,p=.020	chi2=20.68,p=2e-04
DRYSBV0	SV/VS	removed free ord	WALSG	168	p=.013	p=.015	p=.016	p=.016
HAAEVD2	Evidentials	binary, ± evident	WALSG	166	p=.002	ns	p=.019	ns
LOCUS_P	Object locus (simple locus, as def	Removed "no ma	GEN	202	chi2=37.72, p=1e-04	chi2=32.99, p=1e-	chi2=26.57, p=1e-04	chi2=20.81, p = .001
LOCUS POSS	Poss locus (simple locus, as defin	Removed "NA" la	GEN	244	chi2=33.48, p=1e-04	chi2=20.54, p =5e-	chi2=22.64, p = 2e-04	chi2=11.27, p= .015
MADFRV2	Front rd vowel	binary ± front rd	WALSG	170	p=.010	p=0003	p=.008	p=.0001
MADLAT2	Laterals	binary ±laterals	WALSG	171	p=4.0e-06	p=4.9e-05	p=6.8e-05	p=.0006
MADVOI2	Voicing	binary ±voicing	WALSG	171	p=1.6e-14	p=1.8e-11	p=1.5e-11	p=9.1e-09
POSSCL	Poss classes	binary ±posscl	GEN	236	p=9.7e-07	p=1.5e-10	p=.001	p=3.8e-06
SIEPAS	Passive	binary ±passive	WALSG	174	p=.0004	p=.001	p=5.02e-05	p=.0001
SYN	Verb synthesis	scalar: fpw+cpw	GEN	202	F=23.81, p=1e-04	F=19.39, p = 1e-04	F=11.72, p=6e-04	F=7.86, p=.0063
SYN_INCORP	syntactic incorporation	binary	GEN	218	p=9.5e-05	p=.005	p=2.36e-05	p=.002
VINIT2	V-initial or free order	binary ± v-initial	GEN	227	p=.013	p=.02	p=.022	p=.047
CORSEX01	Sex-based genders	binary, ± gender	WALSG	143	p=.023	p=.07	p=.003	p=.012
CYSIND2	Incl/excl	binary, ± incl/exc	WALSG	169	p=.050	p=.09	p=.006	p=.011
MADTON02	Tones	binary ±tone	WALSG	165	p=.003	ns	p=.058	p=.005
POLYAGR	Obligatory agr with A and P	binary	GEN	276	p=4.08e-09	p =.0002	p=1.02e-05	p=.076
ANDANG	Velar nasal	(not recoded)	WALSG	164	chi2=7.44,p=.024	chi2=5.25, p=.08	ns	chi2=6.17, p=.05
CORNUM (scal	No. genders	(not recoded)	WALSG	143	F=3.46, p=.080	ns	F=7.92, p=.005	F=5.27, p=.022
DRYPOS2	Px	binary, ±poss. af	WALSG	148	p=.009	p=.007	ns	ns
SIEZER2	V-Subj agr.	binary ±subject a	WALSG	176	p=.001	p=.009	ns	ns
CLF	classifiers	binary	GEN	194	p=.09	ns	p=3.5e-05	p=.008
ANDANG2	Velar nasal	binary ± velar na	WALSG	164	p=.0073	p=.07	ns	ns
AUWHOR	Hortative	(not recoded)	WALSG	150	chi2=7.01,p=.074	ns	chi2=11.94,p=.006	ns
AUWIMP	Imperative	(not recoded)	WALSG	166	ns	ns	ns	ns
AUWIMP2	Dedicated imperative	binary, ± dedicat	WALSG	166	ns	ns	ns	ns
AUWPRH	Prohibitive	(not recoded)	WALSG	151	ns	ns	ns	ns
AUWPRH22	Prohib. morphology	binary ± based o	WALSG	151	ns	ns	ns	ns
BAKADP01	Adposition agr.	binary ± with per	WALSG	149	ns	ns	ns	ns
DOBOPT	Optative	(not recoded)	WALSG	153	ns	ns	ns	ns
DRYNEG2	Double neg.	binary ± double n	WALSG	162	ns	ns	ns	ns
DRYTAA2	TA inflection	binary ±TA infl	WALSG	162	ns	ns	ns	ns
HAJNAS	Vowel nasalization	(not recoded)	WALSG	145	ns	ns	ns	ns
IGGNUM0	case	binary ±case	WALSG	147	ns	ns	ns	ns
IGGNUM	No. cases	removed "border	WALSG	147	ns	ns	ns	ns
MADUVU2	Uvulars	binary ± uvulars	WALSG	171	ns	ns	ns	ns
SONNON2	Periphrastic causative	binary ± periphra	WALSG	154	ns	ns	ns	ns

➜ Some evidence for CP in 27 out 40 variables (Bickel & Nichols 2006/BLS32)

By way of concluding: the core proposals

- Predictive Areality Theory based outside linguistics, not linguistically defined areality
- Permutation Tests on genealogical samples, not classical statistics or no statistics
- In addition, Reliability Tests on small samples (don't despair about uncertainty, but measure it!)

Acknowledgments

- **The AUTOTYP research team (as of February 2006)**
  - Johanna Nichols (Co-Director, Berkeley)
  - Balthasar Bickel (Co-Director, Leipzig)
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  - Kristine Hildebrandt (Research Associate, Manchester)
  - Fernando Zúñiga (Research Associate, Santiago)
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