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Correlating borrowing events across concepts to derive a data-driven source of evidence for loanword etymologies

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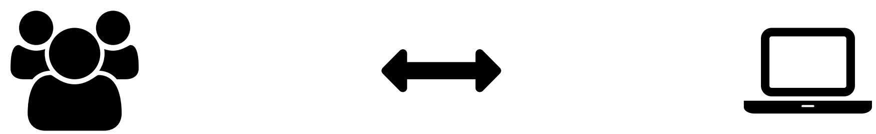
Motivation



- Historical linguistics often relies on heuristics based on the shared experience of experts
- To integrate this into theoretical frameworks that can be used in conjunction with computational methods:
  How can we formalize and statistically validate such reasoning patterns in historical linguistics?

Motivation: Automated loanword detection

- Usually based on exceptions from sound laws
- What if we don't know the sound laws already / if there aren't any useful exceptions?

LAT mɛn**t**a DEU mɪn**t͡s**ə

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- If some language has already been established as a donor language for some words, it becomes more likely as a candidate donor for other words
- Assumption that words from the same semantic field get borrowed together
- Historical/cultural knowledge

Can we model these in a *data-driven* way?

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Data: WOLD

World loanword database
(Haspelmath and Tadmor, 2009)

- 41 (recipient) languages
  (26 families)
- 1,500 concepts
  (24 semantic fields)
- Loanword status:
  1. clearly borrowed
  ... 5. no evidence of borrowing

Borrowability

1. Religion/belief
2. Clothing/grooming
3. The house
4. The law

...

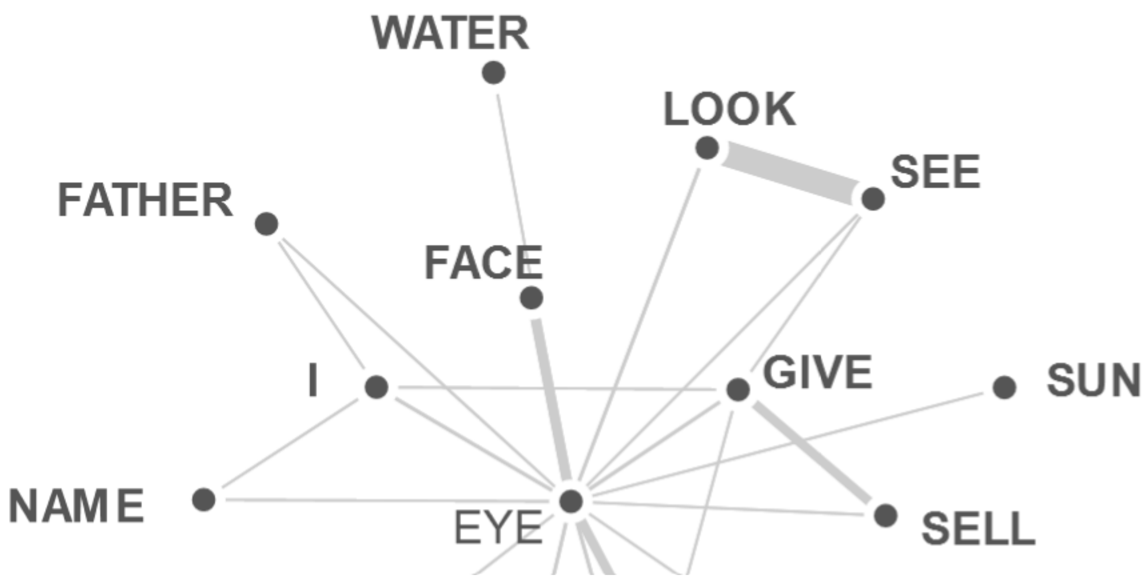
21. Kinship
22. The body
23. Spatial relations
24. Sense perception

(Tadmor, 2009, p. 64)

Data: CLICS^2

Cross-linguistic colexifications (List et al., 2018)

- 1,200 languages
- 2,500 concepts
- Network: two concepts share an edge if 3+ unrelated languages use the same lexical unit for both concepts



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Method

- 14,000 clearly/probably borrowed loanwords that do not have inherited synonyms and were borrowed at least 3x

TO BORROW	Hausa	<	Arabic
	Sakha	<	Hausa
	...		...
THE HAND	Thai	<	Sanskrit
	Malagasy	<	Malay
	...		...

Method: Implication strength

Given concepts $\textsc{x}$ and $\textsc{y}$, does $\textsc{x}$ being a loanword imply that $\textsc{y}$ was borrowed by and from the same languages?

$$\text{impl\_strength}(\textsc{x},\textsc{y}) = \frac{\text{\# of donor-target pairs that borrowed } \textsc{x} \text{ and } \textsc{y}}{\text{\# of donor-target pairs that borrowed } \textsc{x}}$$

Method: Implication strength

Given concepts X and Y, does X being a loanword imply that Y was borrowed by and from the same languages?

$$\text{impl\_strength}(\textsc{x},\textsc{y}) = \frac{\text{\# of donor-target pairs that borrowed X and Y}}{\text{\# of donor-target pairs that borrowed X}}$$

- THE EAST: borrowed 7x (**aqc < ava**, **kap < ava**, **rif < ara**, rmc < ces, sjd < gmq, **swa < ara**, **vie < cmn**)
- THE CAUSE: borrowed 15x (**aqc < ava**, eng < fra, gwd < amh, hau < ara, ind < ara, **kap < ava**, knc < ara, qvi < spa, **rif < ara**, ron < fra, sah < xgn, sjd < rus, **swa < ara**, tha < san, **vie < cmn**)

$$\text{implication\_strength}(\text{THE EAST, THE CAUSE}) = 5/7 \approx 71\%$$
$$\text{implication\_strength}(\text{THE CAUSE, THE EAST}) = 5/15 \approx 33\%$$

Method: NPMI

Co-occurrence

- What if the concepts were borrowed at very different rates?
- Normalized pointwise mutual information (+1 complete co-occurrence ... 0 independence ... -1 no co-occurrence)

$$\mathrm{NPMI}(x, y) = \frac{\ln \frac{p(x,y)}{p(x)p(y)}}{-\ln p(x, y)}$$

$$\begin{aligned} p(\textsc{the east, the cause}) &= 5/41 \\ p(\textsc{the east}) &= 7/41 \\ p(\textsc{the cause}) &= 15/41 \\ \mathrm{NPMI}(\textsc{the east, the cause}) &\approx 0.32 \end{aligned}$$

Method: Intra-pair similarity

How semantically similar are the concept pairs?

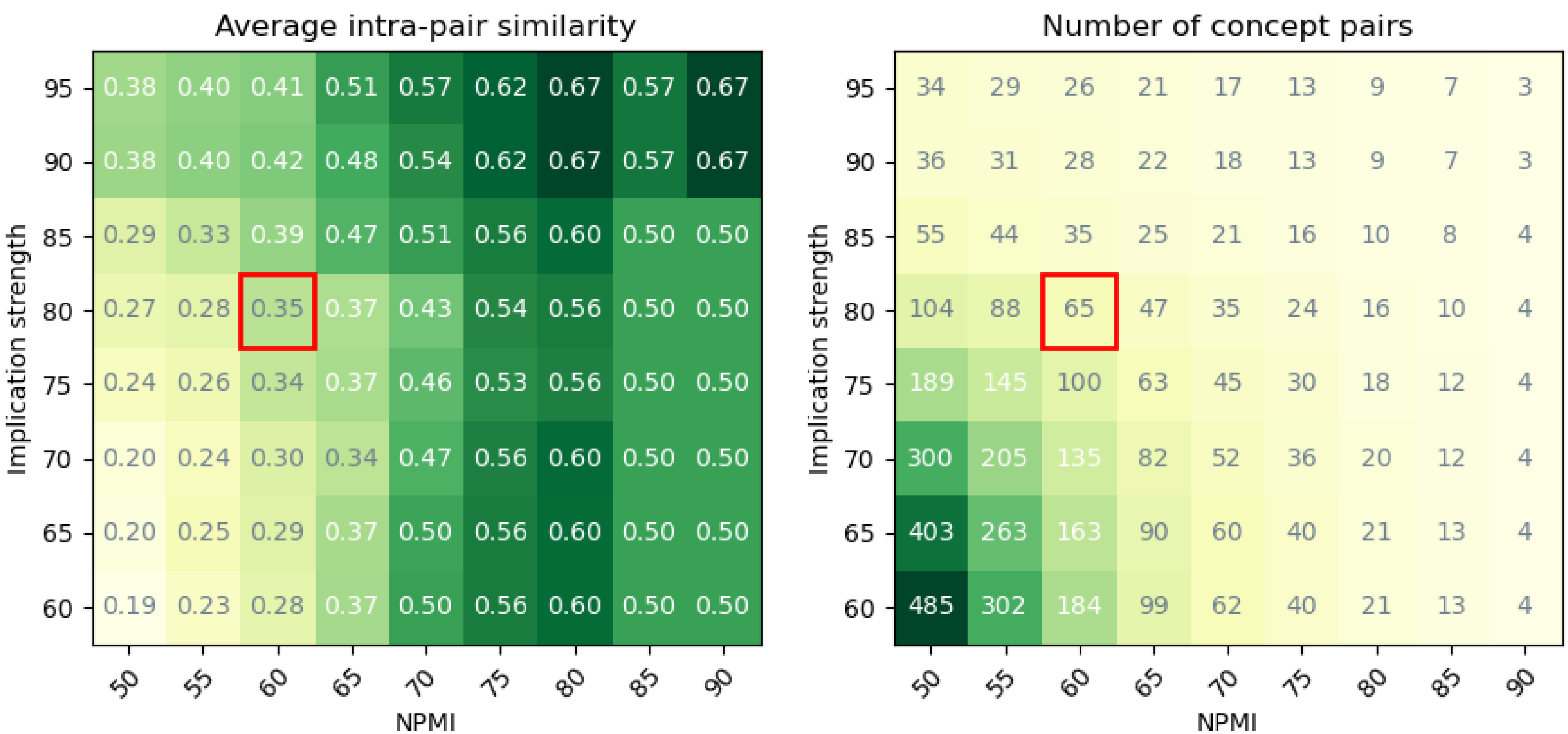
- Inverse correlation with CLICS node distance

Distance (in edges)	Similarity
1 (colexified)	1
2	0.5
3	0.33
4+	0

Method: Thresholds

Thresholds (determined a posteriori)

- High implication strength (≥ 0.8) that still shows meaningful connections (NPMI ≥ 0.6)



Method: Bootstrapping

1,000 bootstrap samples of language sets (with replacement; one-sided 95 % confidence interval)

- ‘Noisy’ observations that describe only a small number of instances tend to vary more and tend to get filtered out
- Higher implication and correlation scores

	implication strength	
	before	after bootstrapping
THE PARENTS -> TO PEEL	0.5	0.42
THE ARM -> THE LIP	0.8	0.8

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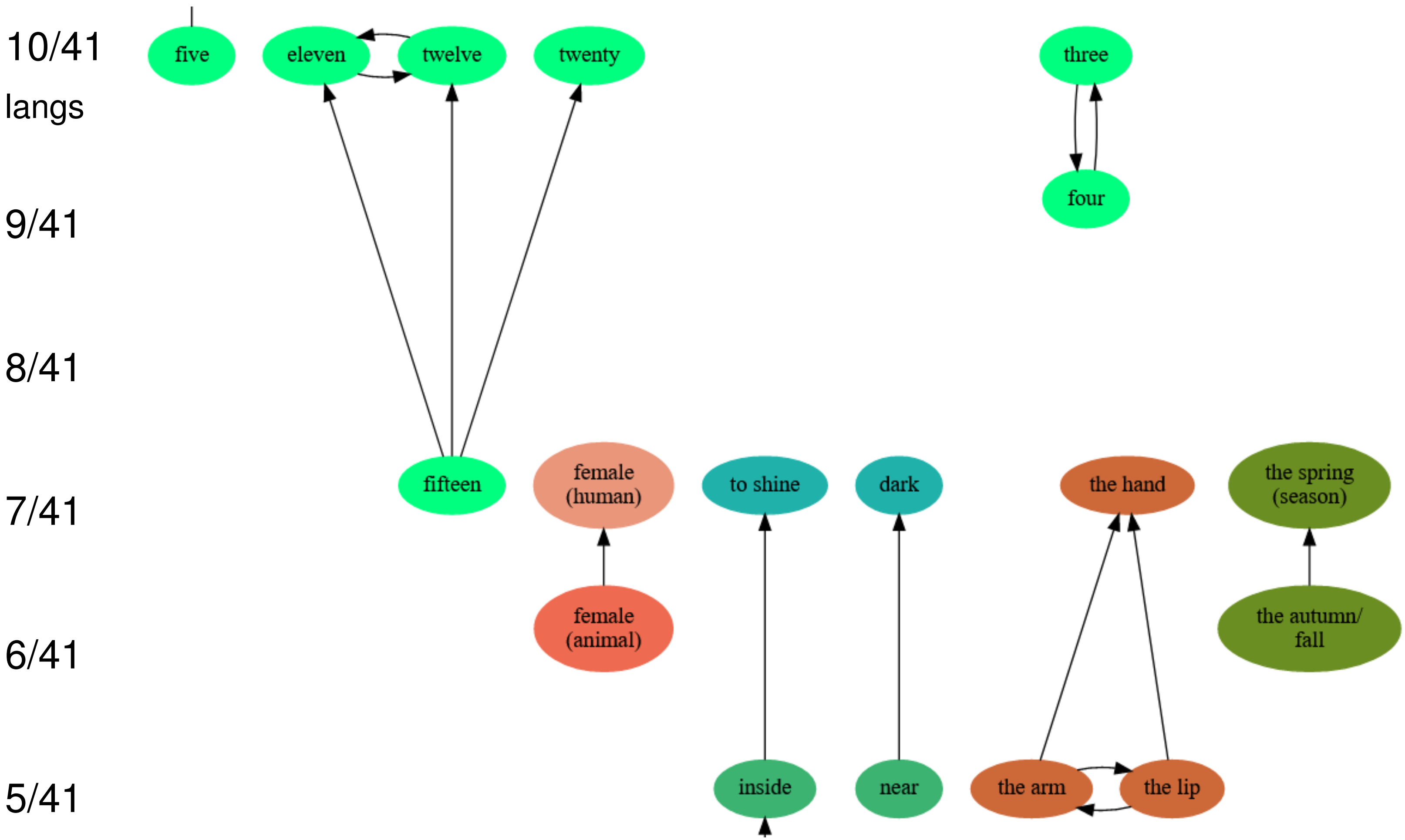
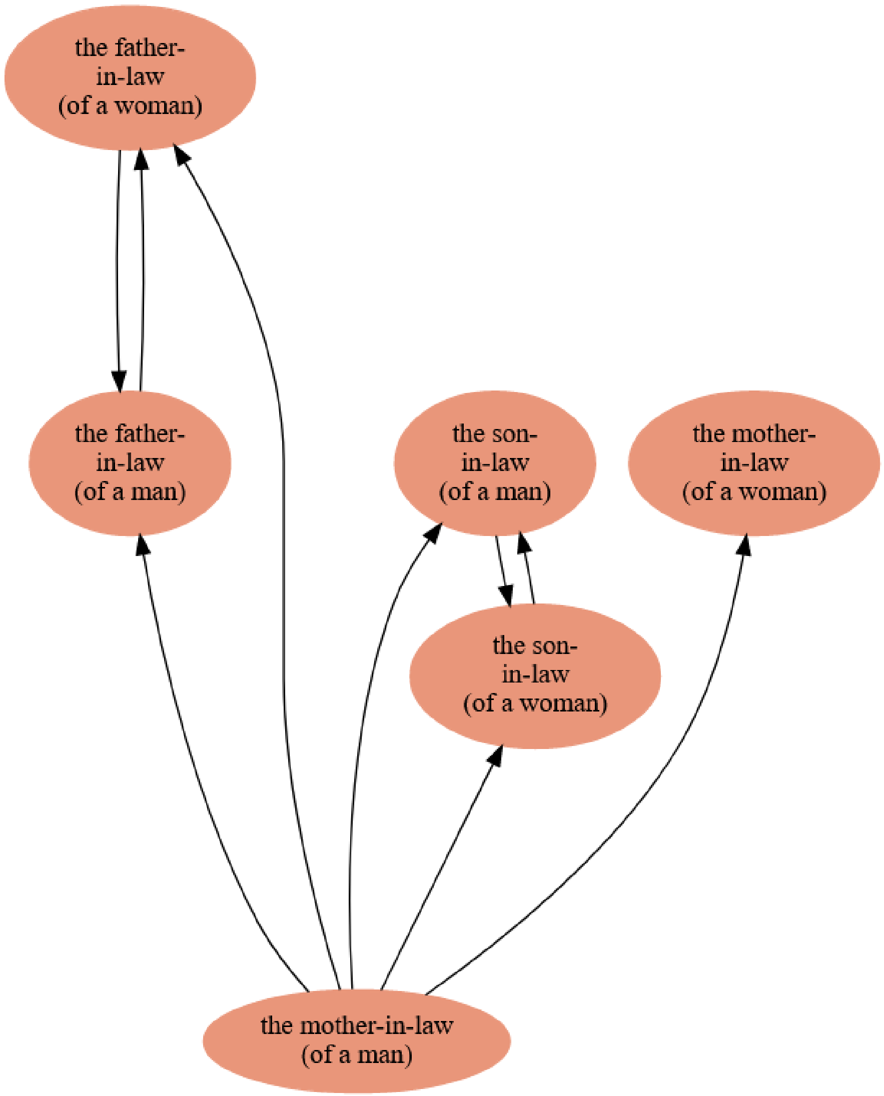
Results


10/41 langs
9/41
8/41
7/41
6/41
5/41
five
eleven
twelve
twenty
three
four
fifteen
female (human)
to shine
dark
the hand
the spring (season)
female (animal)
the autumn/ fall
inside
near
the arm
the lip

Results

65 concept pairs

- 45 of these are within-domain correlations
- Common semantic fields:
  - ▷ KINSHIP (!)
  - ▷ QUANTITY (!)
  - ▷ THE BODY
  - ▷ SPATIAL RELATIONS
- ...specifically the rarely-borrowed fields!
- Clusters ('package deals')



Results

Only 20 cross-domain pairs

- 2 largely due to colexification

female(2) (ANIMALS)	>	female(1) (KINSHIP)
the knife(1) (FOOD/DRINK)	>	the knife(2) (BASIC ACTIONS/TECHNOLOGY)

- Some are somewhat plausible, but most appear to be random

to kneel (MOTION)	>	the defeat (WARFARE/HUNTING)
the beeswax (ANIMALS)	>	the kidney (THE BODY)
...		...
to make (BASIC ACTIONS/TECHNOLOGY)	>	inside (SPATIAL RELATIONS)
sometimes (TIME)	>	to sneeze (THE BODY)

To be investigated...

- In some cases, the concept pairs are colexified concepts—how often is that?
- More languages, language families
- How much is there to the cross-domain relations?

Future plans

Incorporate correlation information into model for etymological inference to combine measures of:

- Adherence to soundlaws
- Language contact
- Borrowing frequency by concept, in general and given other borrowed concepts

Conclusion

- Even with a limited sample of languages, we can extract some meaningful borrowing patterns.
- Kinship terms and numerals are not borrowed very often, but when they are, there exist some ‘package deals.’

`https://github.com/verenablaschke/borrowing-correlations`

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References

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Tadmor, U. (2009). Loanwords in the world's languages: Findings and results. *Loanwords in the world's languages: A comparative handbook*, 55:75.

Appendix: Bootstrapping

- Sample the set of languages 1,000 times with replacement
- Calculate implication strength and NPMI for each sample
- The scores are the lower bounds of the corresponding (one-sided, right-open, 95%) confidence intervals:

$$\bar{a} - \frac{1.64485s}{\sqrt{1000}}$$

where

- $\bar{a}$ is the arithmetic mean of the given score in all 1,000 samples
- s is the standard deviation of the mean

Appendix: Etymological inference

$$sem\_corr(c, L_D, L_R) = \frac{\sum_{c' \in C} P\_borr(c', L_D, L_R) \cdot sem\_sim(c, c')}{|C|}$$

$$lang\_corr(c, L_D, L_R) = \frac{\sum_{c' \in C} P\_borr(c', L_D, L_R)}{|C|}$$

$$event\_corr(c, L_D, L_R) = \frac{\sum_{c' \in C} P\_borr(c', L_D, L_R) \cdot borr\_impl(c', c)}{|C|}$$

$$\begin{aligned} P\_borr(c, L_D, L_R) = f(&soundlaws(c, L_R), \\ &borr\_freq(c), \\ &sem\_corr(c, L_D, L_R), \\ &lang\_corr(c, L_D, L_R), \\ &event\_corr(c, L_D, L_R)) \end{aligned}$$