A comprehensive view on inflectional classification

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Inflection classes

- Classification of lexemes according to inflectional behavior.

	1st declension		2nd declension	
Case	SINGULAR	PLURAL	SINGULAR	PLURAL
NOMINATIVE	*rosa*	*rosae*	*dominus*	*dominī*
VOCATIVE	*rosa*	*rosae*	*domine*	*dominī*
ACCUSATIVE	*rosam*	*rosas*	*dominum*	*dominōs*
GENITIVE	*rosae*	*rosarum*	*dominī*	*dominōrum*
DATIVE	*rosae*	*rosis*	*dominō*	*dominīs*
ABLATIVE	*rosa*	*rosis*	*dominō*	*dominīs*

Table : Latin declension classes

What is this talk about ?

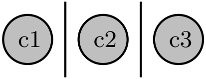
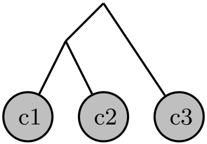
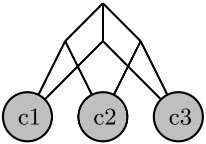
(1) Partition	(2) Tree	(3) Lattice
		

Table : Several types of classification structures

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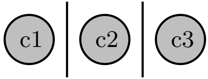	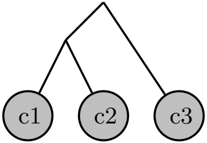	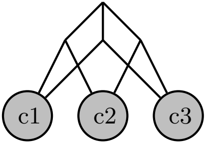

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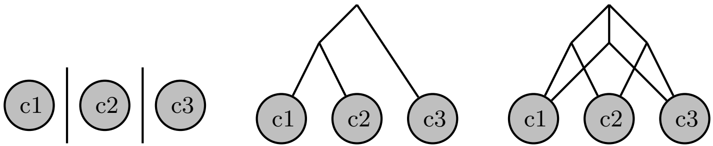

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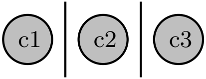	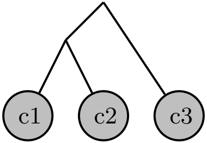	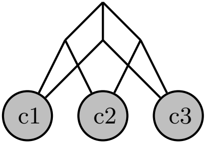

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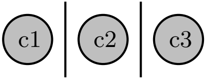	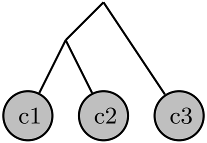	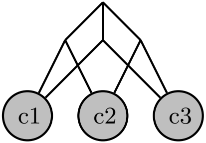

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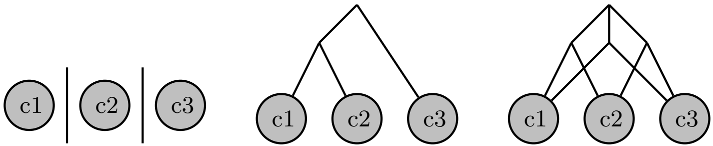

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- "Inflection classes" usually refers to either (1) or (2).
- We argue that these overlook important relations between lexemes,
- and hide structural properties that are in fact pervasive.
- Taking advantage of automation to work on large datasets,
- we argue that lattices (3) are a more faithful model of IC.

Outline

1. Specificities of this approach
2. Background on Inflection Classes
3. How to model IC system as lattices
4. Towards a typology of IC lattices

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Inflectional realizations as patterns

- We take **inflectional behaviour** to be relations between word-forms, or **alternation patterns** (not morphemes). (Blevins, 2006)

XɒCn̩ ⇌ XɛCɪŋ

/ fəgɒtn̩ /
PPART 'forgotten'

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- Patterns take surface alternation at face value and do not require to choose between stem or exponent alternation.
- We infer those automatically.
  - We wrote an language-independent algorithm which relies on phonology-aware alignment (Frisch, 1997) of wordform pairs, inspired by Albright and Hayes, 2006.

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Inflectional paradigms

lexeme	PAST	PPART	PRES	PRES3S	PRESPART
DRIVE	drəʊv	drɪvn̩	draɪv	draɪvz	draɪvɪŋ
RIDE	rəʊd	rɪdn̩	raɪd	raɪdz	raɪdɪŋ
BITE	bɪt	bɪtn̩	baɪt	baɪts	baɪtɪŋ
FORGET	fəgɒt	fəgɒtn̩	fəgɛt	fəgɛts	fəgɛtɪŋ

Table : Inflectional paradigm for some English verbs.

The pattern table

Lexemes are characterized by their collection of patterns (All pairwise alternations).

lexeme	PAST⇌PPART	PAST⇌PRES3S	PRES3S⇌PRESNOT3S	PPART⇌PRESNOT3S	PPART⇌PRESPART
DRIVE	XəʊC ⇌ XɪCn̩	XəʊC_ ⇌ XaɪCz	Xz ⇌ X	XɪCn̩ ⇌ XaɪC	XɪCn̩ ⇌ XaɪCɪŋ
RIDE	XəʊC ⇌ XɪCn̩	XəʊC ⇌ XaɪCz	Xz ⇌ X	XɪCn̩ ⇌ XaɪC	XɪCn̩ ⇌ XaɪCɪŋ
BITE	X⇌ Xn̩	XɪC ⇌ XaɪCs	Xs ⇌ X	XɪCn̩ ⇌ XaɪC	XɪCn̩ ⇌ XaɪCɪŋ
FORGET	X ⇌ Xn̩	XɒC ⇌ XɛCs	Xs ⇌ X	XɒCn̩ ⇌ XɛC	XɒCn̩ ⇌ XɛCɪŋ

lexeme	PAST⇌PRESNOT3S	PPART⇌PRES3S	PRESNOT3S⇌PRESPART	PAST⇌PRESPART	PRES3S⇌PRESPART
DRIVE	XəʊC ⇌ XaɪC	XɪCn̩ ⇌ XaɪCz	X ⇌ Xɪŋ	XəʊC ⇌ XaɪCɪŋ	Xz ⇌ Xɪŋ
RIDE	Xəʊ ⇌ Xaɪ	XɪCn̩ ⇌ XaɪCz	X ⇌ Xɪŋ	XəʊC ⇌ XaɪCɪŋ	Xz ⇌ Xɪŋ
BITE	XɪC ⇌ XaɪC	XɪCn̩ ⇌ XaɪCs	X ⇌ Xɪŋ	XVt ⇌ XaɪtVŋ	Xs ⇌ Xɪŋ
FORGET	XɒC ⇌ XɛC	XɒCn̩ ⇌ XɛCs	X ⇌ Xɪŋ	XɒC ⇌ XɛCɪŋ	Xs ⇌ Xɪŋ

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DRIVE	XəʊC ⇌ XaɪC	XɪCn̩ ⇌ XaɪCz	X ⇌ Xɪŋ	XəʊC ⇌ XaɪCɪŋ	Xz ⇌ Xɪŋ
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Automated approach

- Patterns and classification are generated by language-independent algorithms.
- This approach requires formal and quantifiable definitions of linguistic concepts,
- and allows us to work on large lexical databases,
- which paves the way for quantitative typological analysis of Inflection classes.

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Inflection Classes: identity or similarity ?

- "a set of lexemes whose members each select the same set of inflectional realizations".

  Aronoff (1994, p.64),Carstairs-McCarthy (1994, p.639)

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  Aronoff (1994, p.64),Carstairs-McCarthy (1994, p.639)
- Applied to realistic datasets, this leads to a large number of (mostly) very small classes.
- In practice, Carstairs-McCarthy and many other authors focus on larger but not fully coherent classes.

Varying degrees of similarity

- Dressler and Thornton's (1996) terminology:

lexeme	PAST	PPART	PRES	PRES3S	PRESPART
DRIVE	drəʊv	drɪvn̩	draɪv	draɪvz	draɪvɪŋ
RIDE	rəʊd	rɪdn̩	raɪd	raɪdz	raɪdɪŋ
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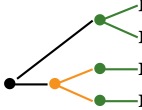
    (see Beniamine, Bonami, and Sagot, 2015 for automatical inference of macroclasses)
- Can form levels in a tree-shaped hierarchy.
  - Corbett and Fraser, 1993; Dressler and Thornton, 1996; Brown and Evans, 2012



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Typology of inflection classes

- Evaluate the variation in IC systems relatively to a canonical point of comparison.
- "Canonical IC are fully comparable and are distinguished as clearly as possible".

  Corbett's (2009), Principle I

  - Internally homogeneous
  - Structurally identical
  - Maximally different

Internal homogeneity

Within a canonical inflectional class each member behaves identically.

Corbett (2009), criterion 3

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- By definition, it is always true of microclasses.
- By definition, it is always false of any other classes.
- A system where microclasses and macroclasses coincide is the most canonical.

Identical structure

Canonical inflectional classes realize the same morphosyntactic or morphosemantic distinctions (they are of the same structure).

Corbett (2009), criterion 2

- Two main deviations:

lexeme	PAST	PPART	PRES	PRES3S	PRESPART
beware	-	-	bɪwɛə	-	-
abide	əbaɪdɪd; əbəʊd	əbaɪdɪd; əbaɪdn̩	əbaɪd	əbaɪdz	əbaɪdɪŋ

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- **Defective** microclasses lack forms for certain cells in the paradigm.
- **Overabundant** microclasses have several forms for certain cells in the paradigm.

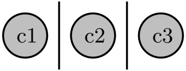
lexeme	PAST	PPART	PRES	PRES3S	PRESPART
beware	-	-	bɪwɛə	-	-
abide	əbaɪdɪd; əbəʊd	əbaɪdɪd; əbaɪdn̩	əbaɪd	əbaɪdz	əbaɪdɪŋ

Pattern sharing

In the canonical situation, forms differ as consistently as possible across inflectional classes, cell by cell.

Corbett (2009), criterion 1

- A canonical system is a partition of microclasses.



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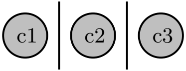

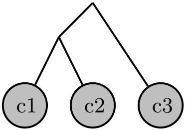

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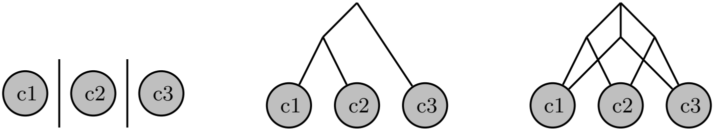
- The typological extreme is a system where microclasses display maximal sharing of patterns.



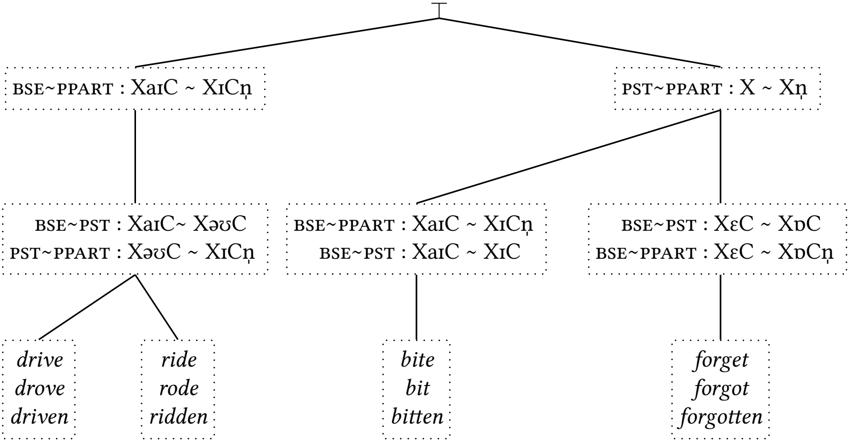
Pattern sharing: Heteroclisis

> *"a small number of items showing combinations of forms from other classes can be treated as heteroclites"*
>
> *Corbett, 2009*

- How to assess what small and big means quantitatively is uncertain.

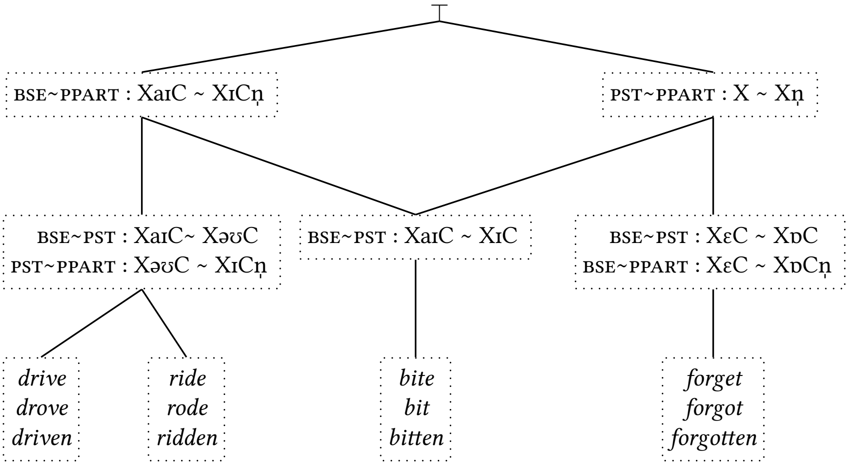
Pattern sharing: Heteroclisis

- a microclass that shares patterns with at least two microclasses.



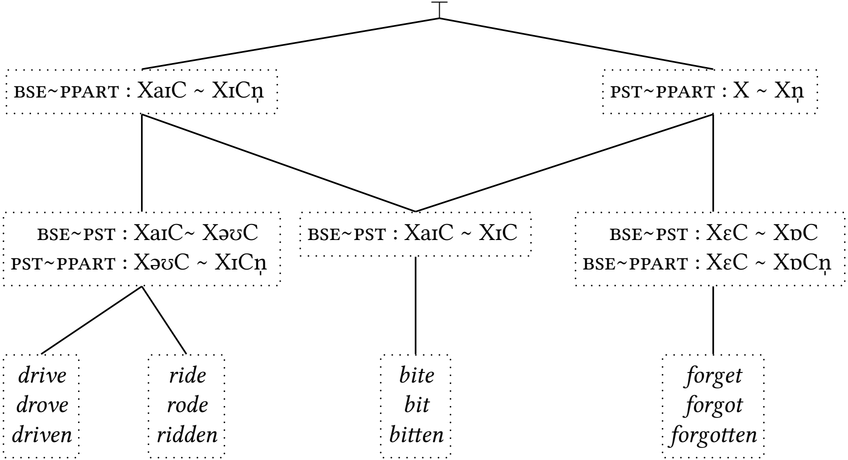
Pattern sharing: Heteroclisis

- better represented by a **lattice** structure than by a tree.



Pattern sharing: Heteroclisis

- better represented by a **lattice** structure than by a tree.
- subtype of **overlapping**. Classes can also be overlapping because of overabundance.



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1. Specificities of this approach

2. Background on Inflection Classes

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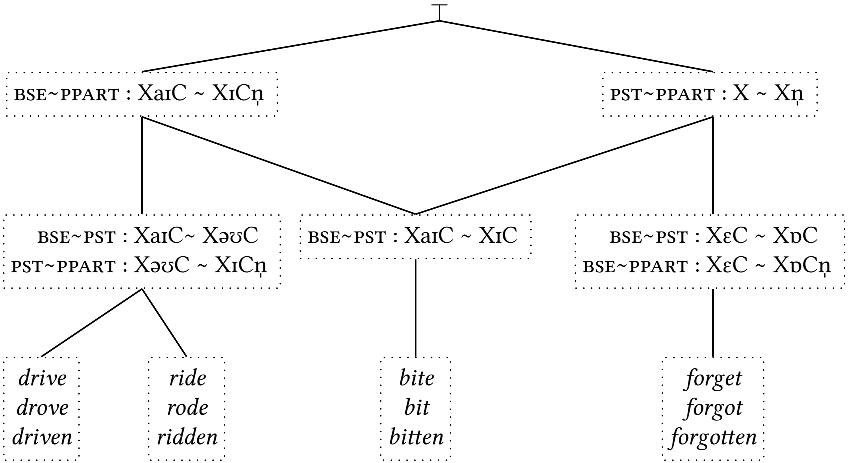
4. Towards a typology of IC lattices

Lattices

- More accurate representation of non canonical phenomena.
- Every node in the lattice is an IC.



Formal concept analysis: context

- Formal concept analysis: a branch of applied mathematics which deals with lattices. (Wille, 1984; Ganter, 1998; Bank, 2013-2016)
- **Context**: incidence table between objets and attributes.

Context:

	BSE~PPART		BSE~PST			PST~PPART	
	XaɪC~XɪCn̩	XɛC~XɒCn̩	XaɪC~XəʊC	XaɪC~XɪC	XɛC~XɒC	XəʊC~XɪCn̩	X~Xn̩
drive	×		×			×	
ride	×		×			×	
bite	×			×			×
forget		×			×		×

Formal concept analysis: concept

- **Concept**: A set of objects and a set of attributes, all objects have in common exactly these attributes, all attributes are shared by exactly these objects.

Concept: ⟨{bite, forget}, {X~Xn̩ }⟩

Context:

	BSE~PPART		BSE~PST			PST~PPART	
	XaɪC~XɪCn̩	XɛC~XɒCn̩	XaɪC~XəʊC	XaɪC~XɪC	XɛC~XɒC	XəʊC~XɪCn̩	X~Xn̩
drive	×		×			×	
ride	×		×			×	
bite	×			×			×
forget		×			×		×

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Context:

	BSE~PPART		BSE~PST			PST~PPART	
	XaɪC~XɪCn̩	XɛC~XɒCn̩	XaɪC~XəʊC	XaɪC~XɪC	XɛC~XɒC	XəʊC~XɪCn̩	X~Xn̩
drive	×		×			×	
ride	×		×			×	
bite	×			×			×
forget		×			×		×

Formal concept analysis: concept

- **Concept**: A set of objects and a set of attributes, all objects have in common exactly these attributes, all attributes are shared by exactly these objects.

Concept: ⟨{drive, ride, bite}, {XaɪC~XɪCn̩}⟩

Context:

	BSE~PPART		BSE~PST			PST~PPART	
	XaɪC~XɪCn̩	XεC~XɒCn̩	XaɪC~XəʊC	XaɪC~XɪC	XεC~XɒC	XəʊC~XɪCn̩	X~Xn̩
drive	×		×			×	
ride	×		×			×	
bite	×			×			×
forget		×			×		×

Formal concept analysis: concept

- **Concept**: A set of objects and a set of attributes, all objects have in common exactly these attributes, all attributes are shared by exactly these objects.

Concept: ⟨{bite}, {XaɪC~XɪCn̩, XaɪC~XɪC, X~Xn̩ }⟩

Context:

	BSE~PPART		BSE~PST			PST~PPART	
	XaɪC~XɪCn̩	XɛC~XɒCn̩	XaɪC~XəʊC	XaɪC~XɪC	XɛC~XɒC	XəʊC~XɪCn̩	X~Xn̩
drive	×		×			×	
ride	×		×			×	
bite	×			×			×
forget		×			×		×

Formal concept analysis: concept

- **Concept**: A set of objects and a set of attributes, all objects have in common exactly these attributes, all attributes are shared by exactly these objects.

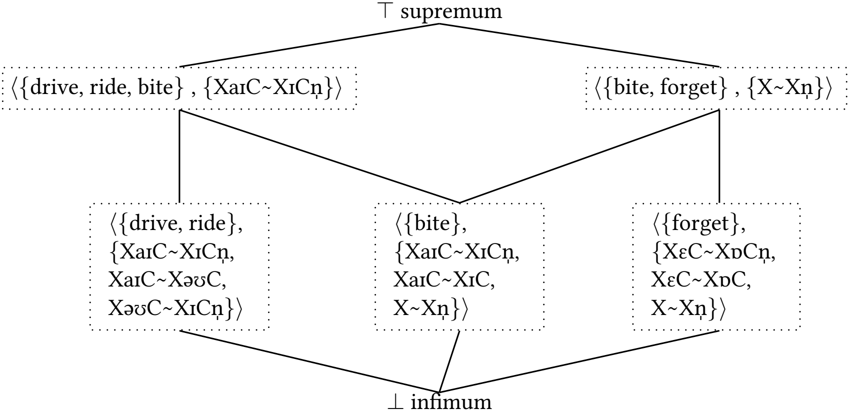
Concept: ⟨{forget}, {XɛC~XɒCn̩, XɛC~XɒC, X~Xn̩ }⟩

Context:

	BSE~PPART		BSE~PST			PST~PPART	
	XaɪC~XɪCn̩	XɛC~XɒCn̩	XaɪC~XəʊC	XaɪC~XɪC	XɛC~XɒC	XəʊC~XɪCn̩	X~Xn̩
drive	×		×			×	
ride	×		×			×	
bite	×			×			×
forget		×			×		×

Formal concept analysis: lattice

- Lattice: Set of concepts ordered by inclusion:
  $\langle x, y \rangle < \langle x_1, y_1 \rangle$ iff $x \subset x_1 \Leftrightarrow y \supset y_1$



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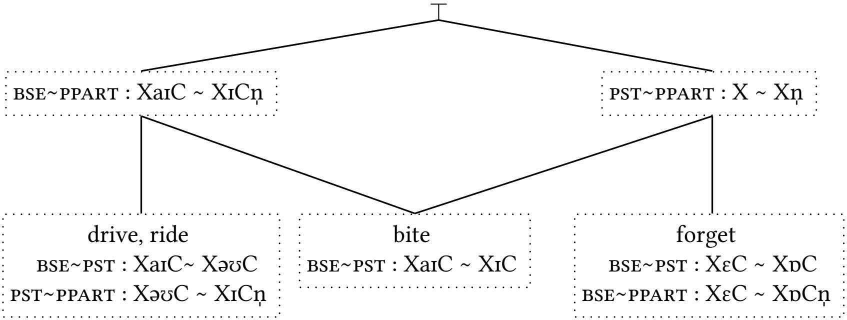
- For legibility, we usually omit the **infimum** (but not the **supremum**) and label nodes without repeating information.



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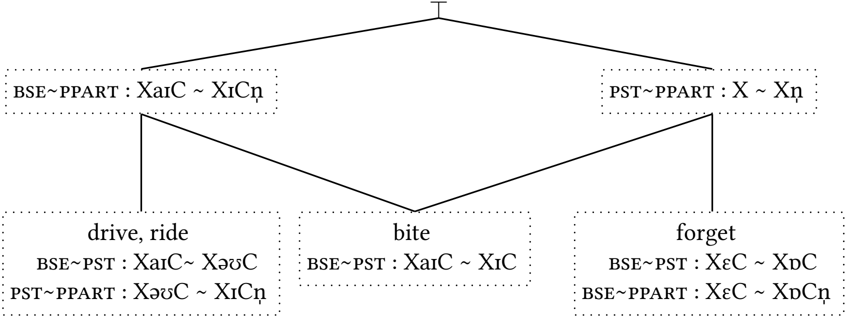
- For legibility, we usually omit the **infimum** (but not the **supremum**) and label nodes without repeating information.
- This reads like a monotonic multiple inheritance hierarchy.



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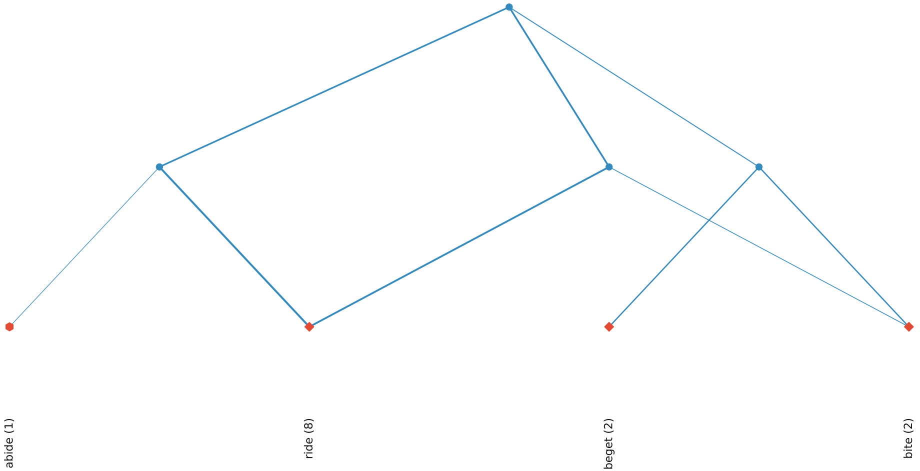
Datasets

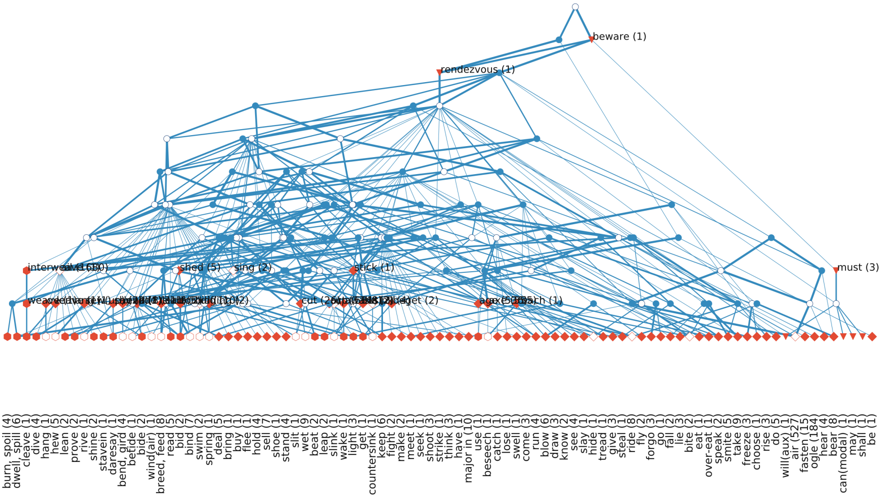
- Data: Paradigm tables contain phonemically transcribed forms.
- **English**: CELEX2 dataset (Baayen, Piepenbrock, and Gulikers, 1995), with partial manual validation (6064 verbal entries).
- **French**: Flexique (Bonami, Caron, and Plancq, 2014) (5258 verbal entries).

The lattices

Excerpt of the English data for: bite, forget, beget, ride, drive, abide



The lattices



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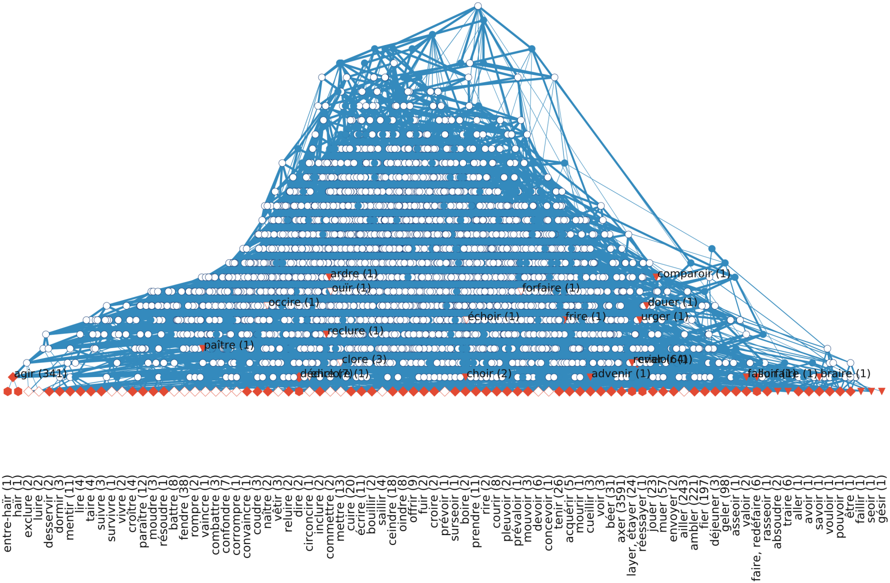

Identical structure

Canonical inflectional classes realize the same morphosyntactic or morphosemantic distinctions (they are of the same structure).

Corbett (2009), criterion 2

- **Defective** classes might otherwise be identical to other microclasses and thus be placed higher in the hierarchy.

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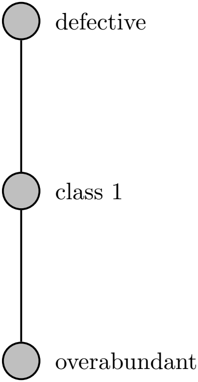
- **Defective** classes might otherwise be identical to other microclasses and thus be placed higher in the hierarchy.
- **Overabundant** classes might share these patterns with other microclasses, and thus be placed lower in the hierarchy.

Chains and atoms

- An IC system that only deviates from the canonical ideal by presenting overabundance and/or defectivity can take the form of a **chain**.

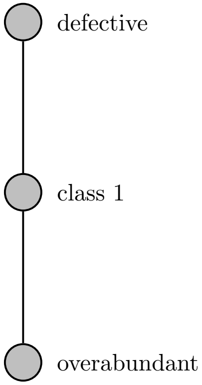
	p1	p2	p3	p2'	p3'
class1	×	×	×		
defective	×				
overabundant	×	×	×	×	×



Chains and atoms

- An IC system that only deviates from the canonical ideal by presenting overabundance and/or defectivity can take the form of a **chain**.
- **atoms** : nodes that are right above the infimum.
  Because of overabundance and defectivity, microclasses are not always atoms.

	p1	p2	p3	p2'	p3'
class1	×	×	×		
defective	×				
overabundant	×	×	×	×	×



Microclasses

- Proportion of microclasses that are atoms

Data	*Lexemes*	*Microclasses*	*Atoms*	*Defective*	*Overabundant*
English	6064	123	91	9	88
French	5258	109	85	39	35

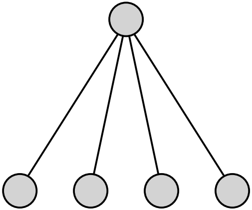
Pattern sharing

In the canonical situation, forms differ as consistently as possible across inflectional classes, cell by cell.

Corbett (2009), criterion 1

- Canonical situation: a partition of microclasses (plus supremum).

Canonical inflection classes



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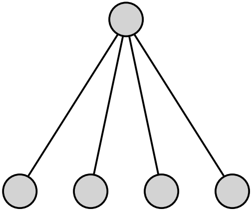
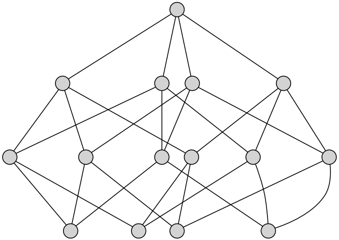
- Canonical situation: a partition of microclasses (plus supremum).
- The maximum possible lattice given some atoms corresponds to the power set over the atoms.

Canonical inflection classes

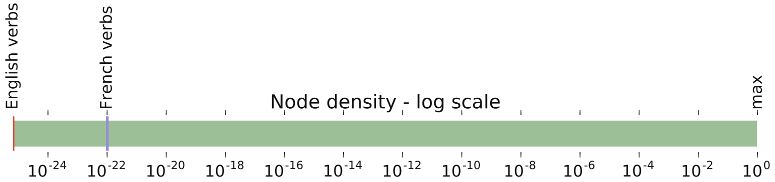


Maximum pattern sharing across classes



Pattern sharing: node density

- We evaluate the amount of sharing across microclasses by counting the number of nodes in the lattice.



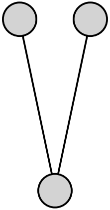
Data	Atoms	nodes	Min	Max	density
English	91	256	93	$> 2 \times 10^{27}$	6.58×10^{-26}
French	85	4027	87	$> 3 \times 10^{25}$	1.01×10^{-22}

Pattern sharing: structural properties

In the canonical situation, forms differ as consistently as possible across inflectional classes, cell by cell.

Corbett (2009), criterion 1

- **Overlapping**: A node of the lattice that inherits patterns from at least two nodes that are not themselves in hierarchical relation.



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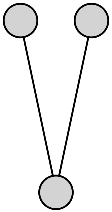
- **Overlapping**: A node of the lattice that inherits patterns from at least two nodes that are not themselves in hierarchical relation.
- **Heteroclite**: A node with overlapping for patterns of distinct pairs of cells.



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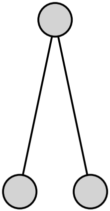
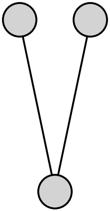
- **Overlapping**: A node of the lattice that inherits patterns from at least two nodes that are not themselves in hierarchical relation.
- **Heteroclite**: A node with overlapping for patterns of distinct pairs of cells.
- Sharing without overlapping is tree-shaped





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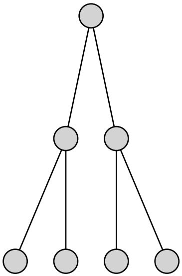
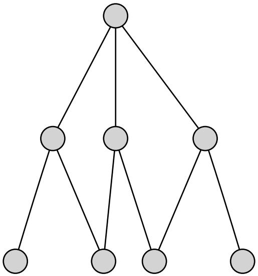




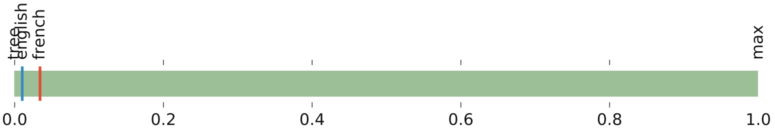
Microclasses

- For each microclass: is it canonical, part of a chain, a tree or overlapping ?

Data	*Microclasses*	*Canonical*	*Chain*	*Tree*	*Overlapping*
English	125	0	0	3	122
French	109	0	0	2	107

A quantitative interpretation: overlapping

- A tree has exactly one parent for each node (indegree: 1), and 0 for its root.
- We quantify the difference between the shape of our lattices and that of a tree by counting the mean indegree (with scaling, assuming constant number of nodes).
- The English datasets has 227 more arcs than if it was a tree.
- The French datasets has 11230 more arcs than if it was a tree.



Conclusion

- This view of IC is comprehensive and belongs to the **abstractive** perspective on morphology (Blevins, 2006).

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  - This converges with research on inflectional complexity, see Carstairs-McCarthy (1991), Ackerman and Malouf (2015) and Blevins (2006).

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  - This converges with research on inflectional complexity, see Carstairs-McCarthy (1991), Ackerman and Malouf (2015) and Blevins (2006).
- Perspective: use our tools on a wide range of data to elaborate a typological analysis.

Thank You !

References I

Ackerman, Farrell and Robert Malouf (2015). "The No Blur Principle Effects as an Emergent Property of Language Systems". In: *Proceedings of the 41st Annual Meeting of the Berkeley Linguistics Society.*

Albright, Adam and Bruce Hayes (2006). "Modeling productivity with the gradual learning algorithm: The problem of accidentally exceptionless generalizations". In: *Gradience in grammar: Generative perspectives*, pp. 185–204.

Aronoff, M. (1994). *Morphology by Itself: Stems and Inflectional Classes.* Linguistic inquiry monographs. MIT Press. ISBN: 9780262510721.

Baayen, R, R Piepenbrock, and L Gulikers (1995). *CELEX2.* Philadelphia: Linguistic Data Consortium.

Bank, Sebastian (2013-2016). *Concepts (python3 package).* V0.7.10. URL: `https://github.com/xflr6/concepts`.

Beniamine, Sarah, Olivier Bonami, and Benoît Sagot (2015). "Information-theoretic inflectional classification". International Quantitative Morphology Meeting 1 (IQMM1).

Blevins, James P. (2006). "Word-based morphology". In: *Journal of Linguistics* 42 (03), pp. 531–573. ISSN: 1469-7742. DOI: 10.1017/S0022226706004191.

Bonami, Olivier, Gauthier Caron, and Clément Plancq (2014). "Construction d'un lexique flexionnel phonétisé libre du français". In: *Actes du quatrième Congrès Mondial de Linguistique Française*. Ed. by Franck Neveu et al., pp. 2583–2596. DOI: 10.1051/shsconf/20140801223.

Brown, D. and A. Hippisley (2012). *Network Morphology: A Defaults-based Theory of Word Structure.* Cambridge Studies in Linguistics. Cambridge University Press. ISBN: 9781107005747. DOI: 10.1017/CBO9780511794346.

References II

Brown, Dunstan and Roger Evans (2012). "Morphological complexity and unsupervised learning: validating Russian inflectional classes using high frequency data". In: *(Ir)regularity, analogy and frequency, selected papers from the 14th International morphology meeting, Budapest, 13?16 May 2010*. Ed. by Kiefer Ference, Mária Ladányi, and Péter Siptár. Current Issues in Morphological Theory. Amsterdam: John Benjamins Publishing Co., pp. 135–162. DOI: 10.1075/cilt.322.07bro.

Carstairs-McCarthy, Andrew (1991). "Inflection classes: Two questions with one answer." In: *Paradigms: The Economy of Inflection*. Ed. by F. Plank. Empirical Approaches to Language Typology [EALT]. De Gruyter, pp. 213–253. ISBN: 9783110889109. DOI: 10.1515/9783110889109.213.

— (1994). "Inflection Classes, Gender, and the Principle of Contrast". In: *Language* 70.4, pp.737–788. ISSN: 00978507. DOI: 10.2307/416326.

Chomsky, N. and M. Halle (1968). *The Sound Pattern of English*. Studies in language. New York, NY: Harper & Row.

Corbett, Greville G. (2009). "Canonical Inflectional Classes". In: *Selected Proceedings of the 6th Décembrettes: Morphology in Bordeaux*. Ed. by Gilles Boyé Fabio Montermini and Jesse Tseng. Vol. 1-11. Somerville, MA, USA: Cascadilla Proceedings Project.

Corbett, Greville G. and Norman M. Fraser (1993). "Network Morphology: a DATR account of Russian nominal inflection". In: *Journal of Linguistics* 29 (01), pp. 113–142. ISSN: 1469-7742. DOI: 10.1017/S0022226700000074.

Corbett, Greville G and Norman M Fraser (2002). "Default genders". In: *Mouton Classics: From Syntax to Cognition. From Phonology to Text*, p. 297.

Dressler, Wolfgang U. and Anna M. Thornton (1996). "Italian Nominal Inflection". In: *Wiener Linguistische Gazette* 55-57, pp. 1–26.

References III

Flickinger, Dan (1987). "Lexical rules in the hierarchical lexicon". PhD thesis. Stanford University.

Frisch, Stefan (1997). "Similarity and frequency in phonology". PhD thesis. Northwestern University.

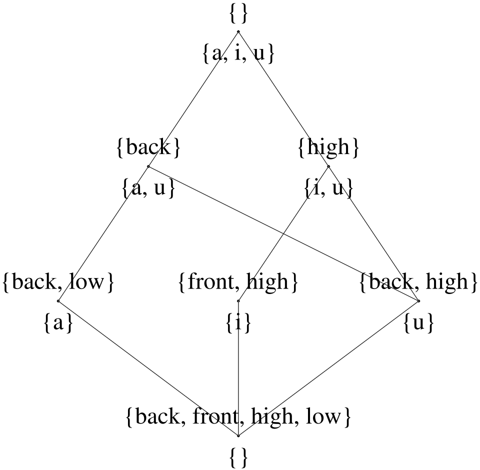
Ganter, Bernhard (1998). *Formal concept analysis : Mathematical foundations.* 1st ed. Springer-Verlag. ISBN: 3540627715. URL: http://www.worldcat.org/isbn/3540627715.

Ginzburg, Jonathan and Ivan Sag (2000). *Interrogative investigations.* Stanford: CSLI publications.

Wille, Rudolf (1984). *Finite distributive lattices as concept lattices.* Techn. Hochsch., Fachbereich Math.

Multiple inheritance hierachies

- Phonological hierarchies of natural classes (Chomsky and Halle, 1968; Frisch, 1997).



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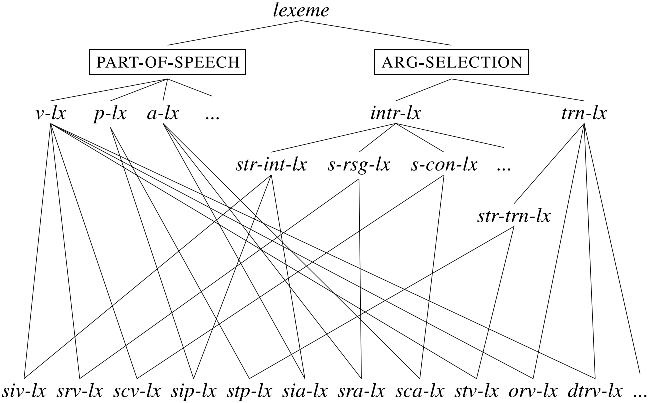
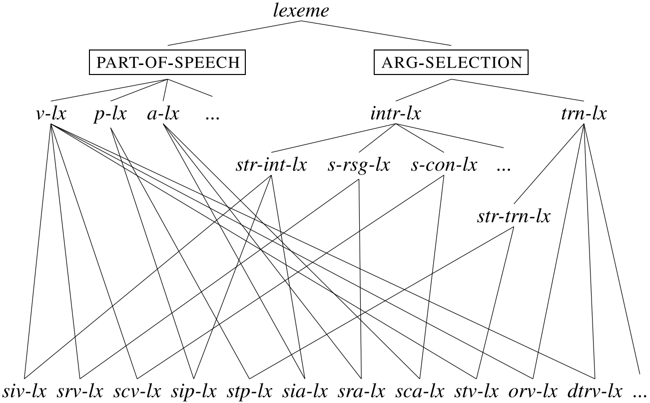


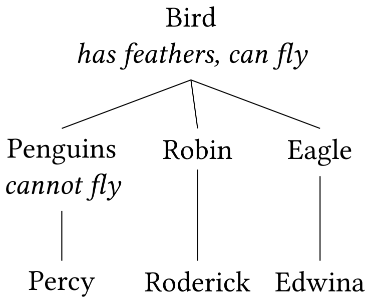
Multiple inheritance hierachies

- Phonological hierarchies of natural classes (Chomsky and Halle, 1968; Frisch, 1997).
- HPSG type hierarchies (Flickinger, 1987; Ginzburg and Sag, 2000).
- Nodes are ordered: (semi)-Lattices.



Comparison with default hierarchies

- Default hierarchies (Brown and Hippisley, 2012, ex. from Corbett and Fraser, 2002).



Comparison with default hierarchies

- Default hierarchies (Brown and Hippisley, 2012, ex. from Corbett and Fraser, 2002).
- Monotonic hierarchies: Attributes shared by all descendants, all relevant sets are explicit.