Segmentation strategies for inflection class inference

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Université Paris Diderot

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Concept of Inflection Classes widely used to analyse inflectional systems

The definition of IC is crucial for many linguistic and psycholinguistic studies, yet they are often taken for granted.
Quantitative typology of inflectional classification

- Concept of Inflection Classes widely used to analyse inflectional systems
  - The definition of IC is crucial for many linguistic and psycholinguistic studies, yet they are often taken for granted.
- No consensus on how to obtain the classification
Concept of Inflection Classes widely used to analyse inflectional systems

- The definition of IC is crucial for many linguistic and psycholinguistic studies, yet they are often taken for granted.

- **No consensus** on how to obtain the classification

- **We explore the concept through computational means:** Brown and Evans, 2012; Lee and Goldsmith, 2013; Bonami, 2014

  - Formal definitions of the concept
  - Large datasets
  - Reproducible classifications
  - Commensurable across languages
  - Basis for theoretical and typological comparisons
**Inflection classes**

Groups of lexemes that inflect alike.

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Groups of lexemes that inflect **alike**.

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What is needed to infer IC from paradigmatic data*.

1. What form should an IC system take?
2. What Inflectional Realisations should we infer from the data?
3. How do we measure which lexemes inflect alike?
4. How do we find the best classes among all possible ones?
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1. What form should an Inflection class (IC) system take?

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5. Results and discussion

6. Conclusion
Inflection classes: Cohesive or distinctive?

- Insight from Canonical Typology (Corbett, 2009). An ideal inflection class system is a partition of the set of lexemes that is:

  - Cohesive: Maximal homogeneity within classes
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  - favouring distinc**tion**: fewer large classes with exceptions

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  - Combined in a hierarchy. (Corbett and Fraser, 1993; Dressler and Thornton, 1996; Brown and Evans, 2012)

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The example of French verbal inflection

- School grammar (Bescherelle):
The example of French verbal inflection

- School grammar (Bescherelle)
- Kilani-Schoch and Dressler, 2005: different microclasses, some dropped, two macroclasses (dual route).
Inflection classes: Macro and microclasses?

- **Micro-classes**
  - Homogenous: *Numerous small, similar classes.*
  - Inventories vary across accounts.
  - Empirically motivated

- **Macro-classes**
  - Heterogenous: *Fewer large classes with "exceptions".*
  - High variation across accounts.
  - Empirical motivation in question:
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*Are macroclasses a descriptive artefact?*
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- **Stem and exponents**
  - Captures differences between cells under the assumption of a *constant stem*.
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- Both rely on a segmentation of forms.
  - global segmentation over the whole paradigm.
  - local segmentation over pairs of forms.
### Segmentation strategies

- **Global**: On the basis of a whole paradigm.
- **Local**: On each pair of cells.

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There are many well-known solutions in computer science to address such problems.

All of them require two things:

- A criterion to evaluate the quality of clusters (classes).
- An algorithm to explore the search space of all possible groupings.
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  → Greedy bottom-up algorithm
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Minimum description length (Rissanen, 1984): Choose the model allowing for the shortest description of the data.

A partition of the set of lexemes is better than another one if it leads to a more economical description of the system. (Sagot and Walther, 2011; Walther, 2013)

\[
DL(\text{system}) =
\]

\[
\text{number of symbols} \times - \sum_{x \in \text{symbols}} P(x) \times \log_2 (P(x))
\]

entropy
Description length of a partition of the set of lexemes

- We break down the description length into four components:

Toy imaginary dataset with three cells A, B and D.
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\[ DL = M + C + P + R \]
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(a) Begin with a partition into microclasses.
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Clustering algorithm, ex. on European Portuguese conjugation.

(a) Begin with a partition into microclasses.
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(a) Begin with a partition into microclasses.
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(c) Repeat until there is only 1 class.
(d) Run several times, merge variations.
Defining macroclasses

- This allows for an intuitive formal definition of macroclasses.
- Macroclasses: The partition that best optimises the description length.
  - As we merge clusters, we first expect the DL to decrease.
  - Macroclasses are reached when DL stops decreasing.
- It is an empirical issue whether a system has macroclasses or not.

*We demonstrate their existence in French and European Portuguese conjugation systems.*
Table of Contents

1. What form should an Inflection class (IC) system take?

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3. How do we assess which lexemes inflect alike?

4. How do we find the best classes among all possible ones?

5. Results and discussion

6. Conclusion
Datasets

- Paradigm tables contain phonemically transcribed forms.
- **French**: Flexique (Bonami, Caron, and Plancq, 2014) (5406 verbal entries).
- Comparing **local and global** segmentation strategies
Global strategy (stem & exponents): Produces scattered classes with no relationship to conventional knowledge of Portuguese verbal IC.
Local strategy (alternation patterns): finds generalisations that display interesting relationship with traditional accounts.
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French classification, global patterns

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  - French: haïr, finir, -ure, uire
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- We find groupings that were overlooked:
  - French: -yer, -oir
  - French: haîr, finir, -ure, uire
  - Portuguese: two “irregular” groups.
## Comparison to other works

<table>
<thead>
<tr>
<th></th>
<th>Generalisations</th>
<th>Criterion</th>
<th>Algorithm</th>
</tr>
</thead>
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<tr>
<td>Brown and Evans, 2012</td>
<td>raw paradigms</td>
<td>Compression distance</td>
<td>CompLearn</td>
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<tr>
<td>Bonami, 2014</td>
<td>Affixes</td>
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</tr>
<tr>
<td>Bonami, 2014</td>
<td>Patterns</td>
<td>Hamming distance</td>
<td>UPGMA</td>
</tr>
<tr>
<td>Lee and Goldsmith, 2013</td>
<td>Sets of characters</td>
<td>DL variant</td>
<td>greedy bottom-up</td>
</tr>
<tr>
<td>This work</td>
<td>Local patterns</td>
<td>DL</td>
<td>greedy bottom-up</td>
</tr>
<tr>
<td>This work</td>
<td>Global patterns</td>
<td>DL</td>
<td>greedy bottom-up</td>
</tr>
</tbody>
</table>

Features of our approach:

- Principled notion of Inflectional Realization.
- Using a measure that evaluates the quality of the system allows us to infer macroscopic generalisations.
- No parameters to adjust: **Occam’s razor** is the only criterion.
Table of Contents

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CONCLUSION

- **Main properties:**
  - Based on information-theoretic measures.
  - Relies on automatically inferred generalisations.
  - Aims at cross-linguistic applications.
  - Formal definition of macroclasses and microclasses.

- An analysis into macroclasses can be empirically motivated.
- **Local segmentation** better captures the structure in inflection systems than global segmentation.
  - Supports the relevance of local patterns of alternation in abstractive approaches (Blevins, 2006).
  - Complementary to work on information-theoretic modelling of implicative structure (Ackerman, Blevins, and Malouf, 2009; Ackerman and Malouf, 2013; Bonami and Beniamine, 2015)
Code available on my webpage:
http://www.llf.cnrs.fr/fr/Gens/Beniamine
References I


SEGMENTATION STRATEGIES

Both can be used in an abstractive approach:

\[
\begin{align*}
\text{Xo} & \iff \text{Xa} \\
\text{/gordo/ M.SG} & \iff \text{/gorda/ F.SG} \\
\text{Xo} & \iff \text{Xos} \\
\text{/gordos/ M.PL} & \iff \text{/gordas/ F.PL} \\
\text{Xos} & \iff \text{Xas} \\
\text{Xa} & \iff \text{Xas}
\end{align*}
\]

Global segmentation

Spanish adjective GORDO ‘fat’.
SEGMENTATION STRATEGIES

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\[
\begin{align*}
\text{Xo} & \iff \text{Xa} & \text{Xo} & \iff \text{Xa} \\
/gordo/ \text{ M.SG} & \iff/gorda/ \text{ F.SG} \\
\text{Xo} & \iff \text{Xos} & \text{Xa} & \iff \text{Xas} \\
\text{X} & \iff \text{Xs} & \text{X} & \iff \text{Xs} \\
/gordos/ \text{ M.PL} & \iff/gordas/ \text{ F.PL} \\
\text{Xos} & \iff \text{Xas} & \text{XoY} & \iff \text{XaY}
\end{align*}
\]

**global segmentation vs local segmentation**

Spanish adjective GORDO ‘fat’.
Non Determinism
Local strategy (alternation patterns): finds generalisations that are in line with traditional accounts.
Local strategy (alternation patterns): finds generalisations that are in line with traditional accounts.