Modeling the learning of the Person Case Constraint

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SCiL
January 2, 2020
Grammars and their representations

(1) * Me le recomendó
   1.SG.ACC 3.SG.DAT recommend.PST
   ‘S/he recommended me to her/him’
Grammars and their representations

\[ g_1 \]

\[ H \]
Grammars and their representations

\[ g_1 \]

\[ H \]
Grammars and their representations

$H_1$

\[ g_1 \]

\[
\begin{array}{c}
\ast \\
\vdash \\
3 \\
\vdash \\
1 \\
\vdash \\
\ldots
\end{array}
\]

$H_2$

\[ g_1 \]

\[
\begin{array}{c}
\ast \\
\vdash \\
\left[ -\text{Part} \right] \\
\vdash \\
\left[ +\text{Part} \right] \\
\vdash \\
\ldots
\end{array}
\]
Grammars and their representations

\[ g_1 \]

\[ H_1 \]

\[ g_1 \]

\[ H_2 \]
Grammars and their representations

\[ H_1 \]
\[ g_1 \]
\[ g_2 \]
\[ g_3 \]
\[ g_4 \]
\[ g_5 \]

\[ H_2 \]
\[ g_1 \]
\[ g_2 \]
\[ g_3 \]
\[ g_4 \]
\[ g_5 \]
\[ g_6 \]
\[ g_7 \]
Grammars and their representations

$H_1$

$g_1$

$g_2$

$g_5$

$g_3$

$g_6$

$g_4$

$H_2$

$g_1$

$g_2$

$g_5$

$g_3$

$g_4$

$g_6$

$g_5$

$g_7$
“this kind of learnability evaluation [...] does not care about whether a [...] theory is appropriately restrictive or economical” (Pearl et al. 2017: 312).

For other similar approaches, see also Pearl & Sprouse (2013), Rasin & Katzir (2017), Pearl & Sprouse (2019).
Roadmap

1. Introduction

2. The Person Case Constraint (PCC)

3. Learning implications

4. Evaluating two theories of the PCC
   4.1 A simple theory of the PCC
   4.2 A feature-based theory of the PCC

5. The learning model

6. Simulations
Clitics

- Clitics are bound morphemes (*i.e.*, affixal morphemes).

(2) \text{Me lo cuentas}

1.SG.DAT 3.SG.ACC tell

‘(You) tell it to me’

- Direct object = \textit{lo}, indirect object = \textit{me}
Restrictions on clitics

▶ When two arguments are realized as clitics, not all combinations are possible.

(1)  * Me le recommendó
     1.SG.ACC 3.SG.DAT recommend.PST
     ‘S/he recommended me to her/him’

▶ Direct object = *me, indirect object = le
The Person Case Constraint (PCC)

These sorts of restrictions are part of a broader phenomenon called the PCC (Bonet 1991, 1994).

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Table: Me-First PCC (Romanian, Spanish, etc.)
The Person Case Constraint (PCC)

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**Table:** Me-First PCC (Romanian, Spanish, etc.)

(2) Me lo cuentas
1.SG.DAT 3.SG.ACC tell
‘(You) tell it to me’
These sorts of restrictions are part of a broader phenomenon called the PCC (Bonet 1991, 1994).

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‘S/he recommended me to her/him’
The Person Case Constraint (PCC)

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(a) Strong PCC (Greek, Spanish, etc.)

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<tr>
<td>3</td>
<td>*</td>
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(b) Ultrastrong PCC (Classical Arabic, Spanish, etc.)

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(c) Weak PCC (French, Catalan, Spanish, etc.)

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(d) Me-First PCC (Romanian, Spanish, etc.)
Learning evaluation

- Proof of concept that learning implications are useful for telling apart theories and their representations.

![Diagram showing points $g_1$, $g_2$, $g_3$, $g_4$, $g_5$, $g_6$, and $g_7$ within two regions $H_1$ and $H_2$.]
## Evaluating two theories of the PCC

### Simple theory

(3)

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<tr>
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<tr>
<td>b.</td>
<td>(2 = 2)</td>
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<tr>
<td>c.</td>
<td>(3 = 3)</td>
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### Feature-based theory

(4)

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<tr>
<td>b.</td>
<td>(2 = \begin{bmatrix} -\text{Auth} \ +\text{Part} \end{bmatrix})</td>
</tr>
<tr>
<td>c.</td>
<td>(3 = \begin{bmatrix} -\text{Auth} \ -\text{Part} \end{bmatrix})</td>
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A simple theory of the PCC

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Weak PCC

| ... | ... | ... | ... | ... | ... | ... | ... |

Me-First PCC

| ... | ... | ... | ... | ... | ... | ... | ... |

Ultrastrong PCC

| ... | ... | ... | ... | ... | ... | ... | ... |

Strong PCC

| ... | ... | ... | ... | ... | ... | ... | ... |
| SG₈₁ | *   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| SG₈₂ | *   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| SG₈₃ | *   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| SG₈₄ | *   | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |

SG₁₂₈ | *   | *   | *   | *   | *   | *   | *   |

Liter & Feldman
Modeling the learning of the Person Case Constraint
Person features are feature bundles, consisting of two binary feature values.

\[
\begin{align*}
1 &= \begin{bmatrix} +\text{Auth} \\
+\text{Part} \end{bmatrix} \\
2 &= \begin{bmatrix} -\text{Auth} \\
+\text{Part} \end{bmatrix} \\
3 &= \begin{bmatrix} -\text{Auth} \\
-\text{Part} \end{bmatrix}
\end{align*}
\]

PCC variants arise based on searching hierarchical syntactic representation for these features and restrictions on this search.
A feature-based theory of the PCC
Nevins (2007)

<table>
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Weak PCC
Me-First PCC
Ultrastrong PCC
Strong PCC
Evaluating two theories of the PCC

Simple theory

(6) 
- a. \( 1 = 1 \)
- b. \( 2 = 2 \)
- c. \( 3 = 3 \)

Feature-based theory

(7) 
- a. \( 1 = [ +\text{Auth} \] \)
  \[ +\text{Part} \]
- b. \( 2 = [ -\text{Auth} \] \)
  \[ +\text{Part} \]
- c. \( 3 = [ -\text{Auth} \] \)
  \[ -\text{Part} \]
Bayesian learning model

The generative model

\[ \vec{s} \vec{\theta} \]

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Modeling the learning of the Person Case Constraint

January 2, 2020
Bayesian learning model

The generative model

\[ g \rightarrow \theta \]

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Bayesian learning model

The generative model

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Bayesian learning model

Inferring the grammar

- Given \( \mathcal{S} \), our learning model uses Bayes’ rule to infer
  \( p(g \mid \mathcal{S}) \).
- In doing so, we integrate over \( \tilde{\theta} \); importantly, this
  leads to higher likelihoods for grammars that allow
  fewer clitic combinations (cf. Tenenbaum & Griffiths 2001).
Data for simulations
Aguirre (2003)

- Using the Aguirre Corpus (Aguirre 2003) from CHILDES (MacWhinney 2000), we estimated the frequency of clitic combinations in child-directed speech for a dialect of Spanish from Spain.
- 13,411 child-directed utterances extracted with PyLangAcq (Lee et al. 2016).
- Utterances parsed with spaCy (Honnibal & Montani 2017).
- 2% of utterances contained two clitics.
- Smoothing was applied to estimate $\tilde{\theta}$ for simulations.
Data for simulations

Aguirre (2003)

These are speakers of a Me-First PCC language.

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Data for simulations
Aguirre (2003)

- With smoothing:

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Simulations

- Hart & Risley (1995) estimate that children hear 1 million utterances in first 3 years of life, and ≈ 2% of utterances contain two clitics.

- The extracted counts, with smoothing, were used to simulate corpora with \( n \) PCC constructions for \( n = 66, n = 666, \) and \( n = 6,666 \).

- We trained Simple learning models and Feature-based learning models with 1,000 replications for each corpus size.
Results

- red = target grammar; black = non-target grammar

<table>
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<tr>
<th>Grammar</th>
<th>Mean posterior probability of grammar</th>
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<td>Simple theory</td>
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<tr>
<td>Feature-based theory</td>
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Results
Corpuse size: 6,666

- red = target grammar; black = non-target grammar

![Graph showing mean posterior probability of grammar for Simple theory and Feature-based theory with points at SG_{21} and FG_{3}]

Liter & Feldman
Modeling the learning of the Person Case Constraint
Results

Corpuse size: 666

- red = target grammar; black = non-target grammar

![Graph showing the mean posterior probability of grammar for Simple theory and Feature-based theory with points for SG21, SG85, and FG3]
Results

Corpus size: 66

- red = target grammar; black = non-target grammar

<table>
<thead>
<tr>
<th>Simple theory</th>
<th>Feature-based theory</th>
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Mean posterior probability of grammar

Grammar

Grammar: SG\_85, SG\_87, FG\_3, FG\_6, FG\_7
Discussion

- Both class of hypotheses learn the target grammar, but the simple model is led astray when there is less data.
- Simple theory does have larger hypothesis space, but even with only 66 data points, each theory is only assigning probability to a few grammars (i.e., not just about size of hypothesis space).
Discussion

▶ Both class of hypotheses learn the target grammar, but the simple model is led astray when there is less data.

▶ Simple theory does have larger hypothesis space, but even with only 66 data points, each theory is only assigning probability to a few grammars (i.e., not just about size of hypothesis space).

▶ Modeling learning in this way can therefore be informative for telling apart theories and their representations.

▶ Especially true with information on age of acquisition and/or patterns of variation across dialects.
Discussion

Age of acquisition

- Unfortunately little is known about PCC age of acquisition.
- Tsakali & Wexler (2010) report that 5-year-old Greek-acquiring children know the PCC.
- Blasco (2000) show that Spanish-acquiring children were correctly producing accusative and dative clitics by 2;2.
Discussion

Key takeaways

- Proof of concept for using learning considerations to tell apart different theoretical and representational assumptions in domain of person features and PCC.

- Similar learning models can be run for other more restrictive theories of the PCC (e.g., Béjar & Rezac 2003, Pancheva & Zubizarreta 2018, Graf 2019) and for other PCC variants.

- Would want to see if other restrictive theories are ever led astray toward unattested variants.
Discussion

Key takeaways

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Acknowledgments

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References II


References V


A feature-based theory of the PCC
Nevins (2007)

\( FG_1 = [ ] \)  
\( FG_2 = [ +\text{Part} ] \)  
\( FG_3 = [ +\text{Auth} ] \)  
\( FG_4 = [ +\text{Part} \quad +\text{Auth} ] \)  
\( FG_5 = [ \text{Auth}/[+\text{Part}] \quad \text{Part}/[-\text{Auth}] ] \)  
\( FG_6 = [ \text{Auth}/[+\text{Part}] ] \)  
\( FG_7 = [ \text{Auth}/[+\text{Part}] \quad +\text{Part} ] \)  
\( FG_8 = [ \text{Part}/[-\text{Auth}] ] \)  
\( FG_9 = [ \text{Part}/[-\text{Auth}] \quad +\text{Auth} ] \)
A feature-based theory of the PCC
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Search is subject to two conditions:

1. Any argument that occurs in between the probe that initiates the search and the target of the search must itself also be a target.

2. All arguments in the domain of the search must share the same value (⁺ or ⁻).
Consider the grammar $FG_2 = v[\ +\text{Part} ]$ (i.e., the Weak PCC) and *3 1.

This violates the first condition.

\begin{equation}
* 
\end{equation}
Consider the grammar $FG_6 = v[\text{Auth/} [+\text{Part}] ]$ (i.e., the Strong PCC) and *12.

This violates the second condition.

\[(18) \quad *\]

[Diagram of a syntactic tree showing the violation of the Person Case Constraint (PCC)]
Aguirre corpus parsing

- se was treated as a third person pronoun.
- The case information assigned by spacy to each clitic was the main basis for classifying the clitic as the direct or indirect object.
Aguirre corpus examples

1 3 ($n = 50$)

(19) ésta me la he comprado yo.

(20) oye, ese pez luego nos lo podemos subir para la bañera, vale?

(21) bueno nos la ponemos, vale?

...  

2 3 ($n = 148$)

(22) esto te lo has mojado.

(23) te la vas a comer a la gallina?

(24) a bañar, que en el baño te lo pasas muy bien también.

...  

3 2 ($n = 4$)

(25) ahora te le pongo.

(26) ése te le pongo mañana.

(27) te le vas a llevar el hipopótamo a la oficina.

(28) te le vas a meter el cepillo en el agua?

...  

3 3 ($n = 68$)

(29) se la has comprado tú?

(30) a dónde se la has dado?

(31) a ver como se lo dices tú.

...