Root Infinitives and the Acquisition of Morphological Marking

Sarah Brogden Payne
sarah.payne@stonybrook.edu

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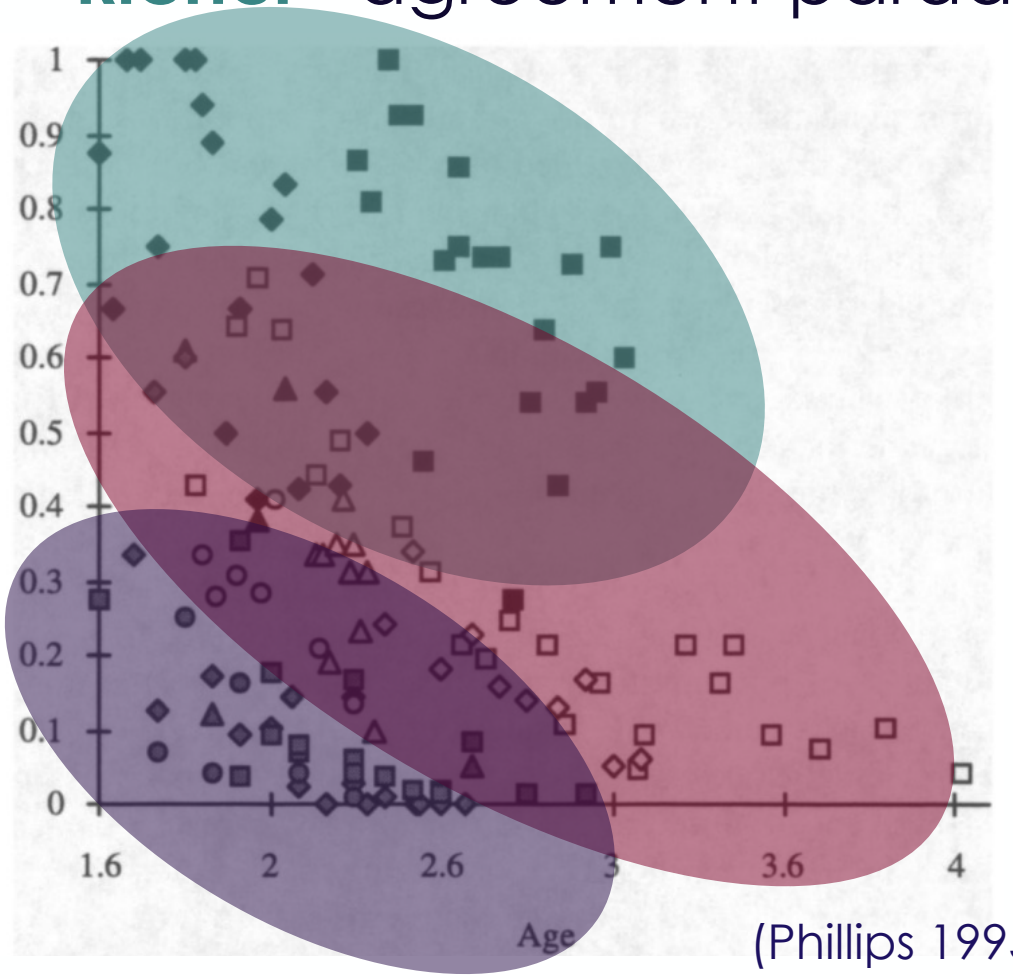
Background: Root Infinitives (RIs)

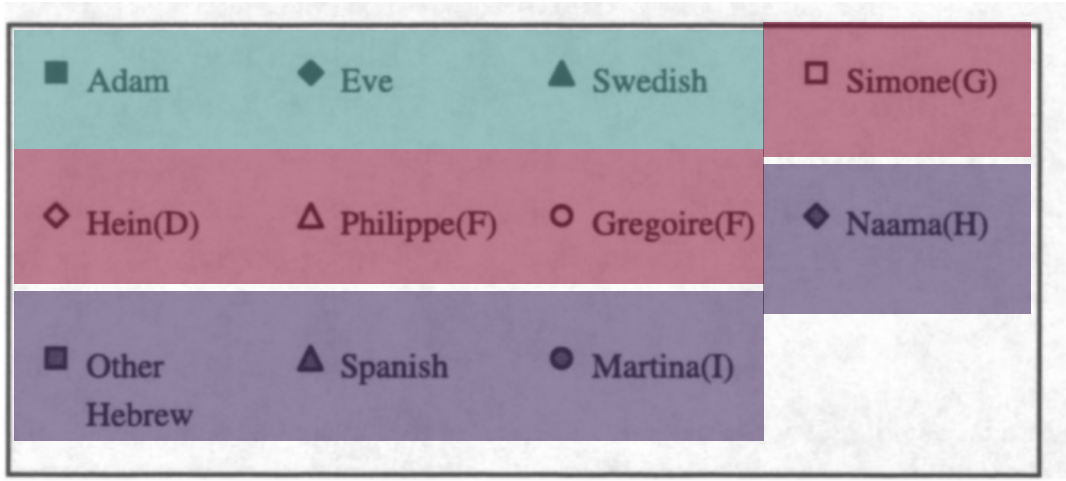
- Use of a non-finite verb in the matrix position:
  - **English:** Papa **have-INF** it
  - **Swahili:** mbaza …aza ku-ni-chund-a
    Mbaza **INF-OA$_{1.SG}$-pinch-IND**
  - **French:** Dormir petit bébé
    sleep-INF little baby
  - **German:** mein Kakao hinstelln
    my cocoa **put-INF**
  - **Hebrew:** Lashevet al ha-shulxan
    sit-INF on the-table

(examples from Legate & Yang 2007, Deen 2005)

Background: Cross-Linguistic Differences

- **"Richer"** agreement paradigms ⇒ **shorter & less frequent** RI





(Phillips 1995, Legate & Yang 2007)

Background: a Morphological Problem?

- Are RIs just the **failure to apply a morphological process** at PF?
  - Apply nothing in the absence of productive rule?
- No: **form-position correlations!**

Finite Clauses	Non-Finite Clauses

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	Finite Clauses	Non-Finite Clauses
German:	V → T → C: **verb high**	V → T: **verb-final**

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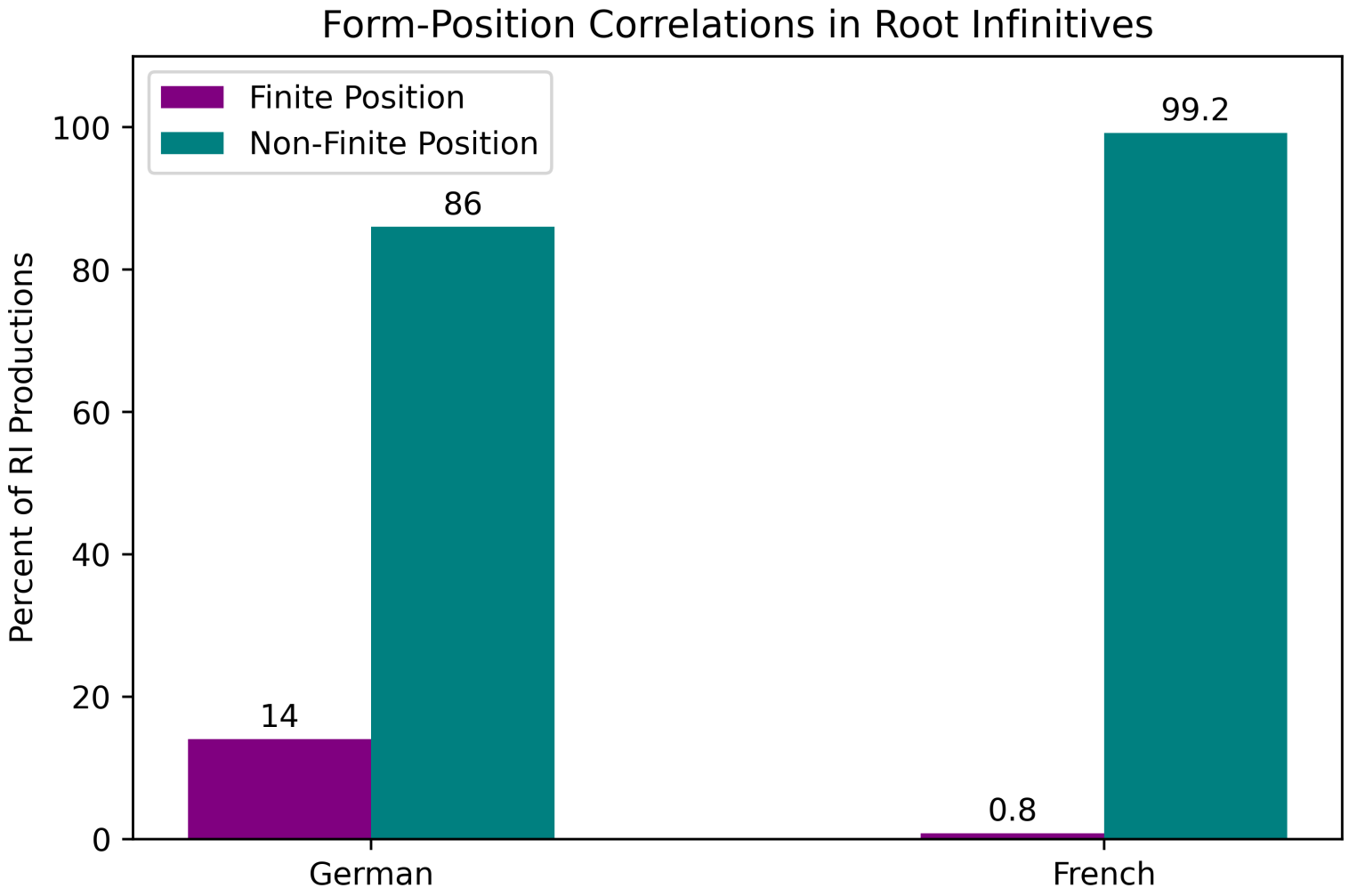
	Finite Clauses	Non-Finite Clauses
German:	V → T → C: **verb high**	V → T: **verb-final**
French:	V → T: **before negation**	V-in-situ: **after negation**

Background: a Morphological Problem?



(Poeppel & Wexler 1993, Pierce 1989 & 1992, Phillips 1995)

Proposal

- RIs = **byproduct of the acquisition of inflectional categories**
  - Child must learn ***which inflectional categories are marked***
    - English contrasts **±PAST** but Mandarin doesn't
    - Spanish contrasts **±1** but English doesn't
  - RIs emerge before the child learns that ***their language marks tense***
- More evidence for tense marking in high position ⇒ tense acquired earlier (Legate & Yang 2007)
- Focus: modeling **crosslinguistic differences** in overall **length & frequency** of RI

Proposal

- Model of the **acquisition of inflectional categories**
  - Matches ***developmental findings***
    - **Order of acquisition**
    - **Vocabulary size**
  - Correctly predicts ***cross-linguistic differences*** in RI stage

Preliminaries: Data

- Children learn **frequent forms earlier**
  - Use ***most frequent forms from CHILDES***
- Children use of **distributional cues** to learn meaning
  - Intersect CHILDES with UniMorph ***as a proxy for these cues***
- Input: **(lemma, inflected, features)**

Language	Lemma	Inflected	Features
English	*walk*	*walked*	{V, PAST, 3, SG}
Spanish	*amar*	*amaban*	{V, 3, PL, PAST, IMPFV}
French	/ʁə.gaʁ.de/	/ʁə.gaʁd/	{V, IMP, PRES, 2, SG}

(Goodman et al 2008, MacWhinney 2000, Kirov et al 2018)

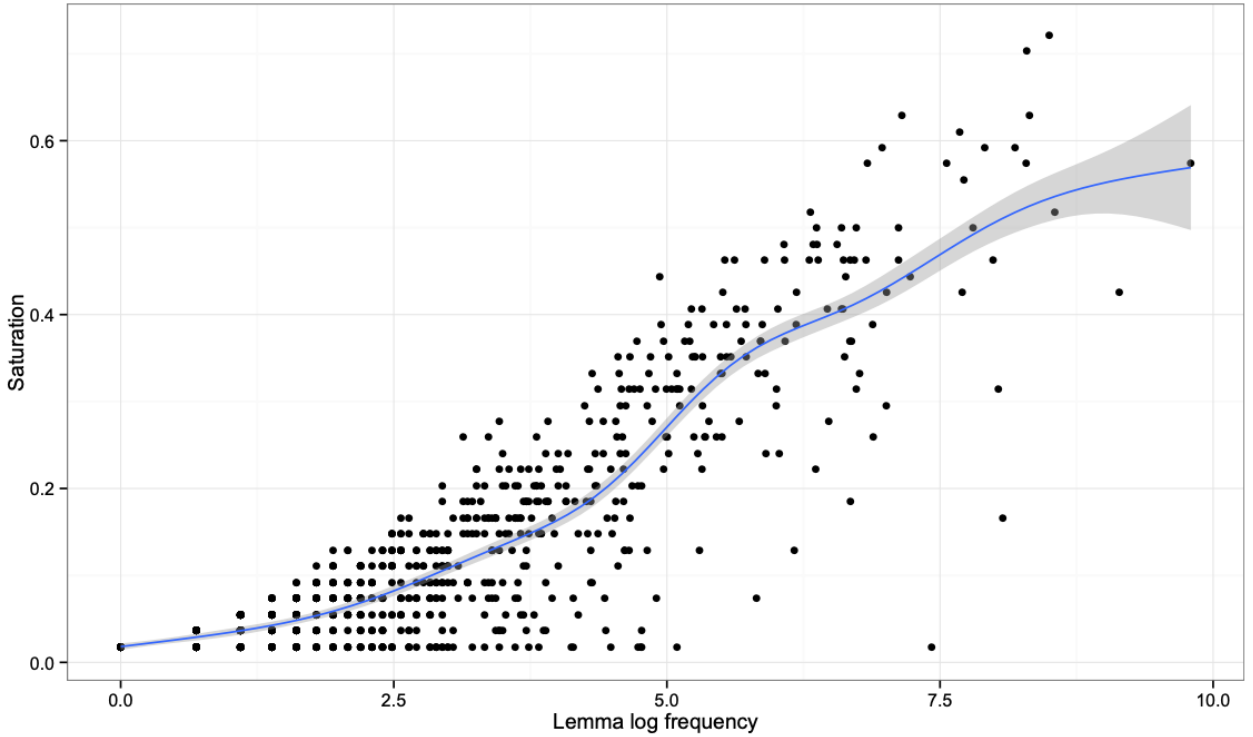
Model: Sufficient Contrast Learner

- **Principle of Contrast: distinct forms ⇒ distinct meanings**
  - e.g. ***walk*** and ***walked*** must mean something different
- **Collisions:** one lemma in multiple inflected forms
  - e.g. ***walk-walked*** ⇒ **±PAST** is marked
- **Infants sensitive to collisions:** can relate nonce words to their stems as early as 0;6

(Clark & MacWhinney 1987, Kim & Sundara 2021)

Model: The TSP

- Is a **single collision** enough to learn marking?
  - ***I am ~ you are*** ⇒ English marks 1 vs. 2 person?
- Should we require **all lemmas** to have collisions?
  - **Sparsity of the input:** morphological paradigm saturation
  - **Syncretisms:** e.g. ***put-put***



(Chan 2008, Lignos & Yang 2016)

Model: The Tolerance Principle

- When are there "**enough" collisions** to learn that an inflectional category is marked?
  - **Tolerance-Sufficiency Principle:** threshold for generalization based on ***computational efficiency***
  - Given ***N*** items, ***M*** of which we've seen doing ***X***, all do ***X*** iff:

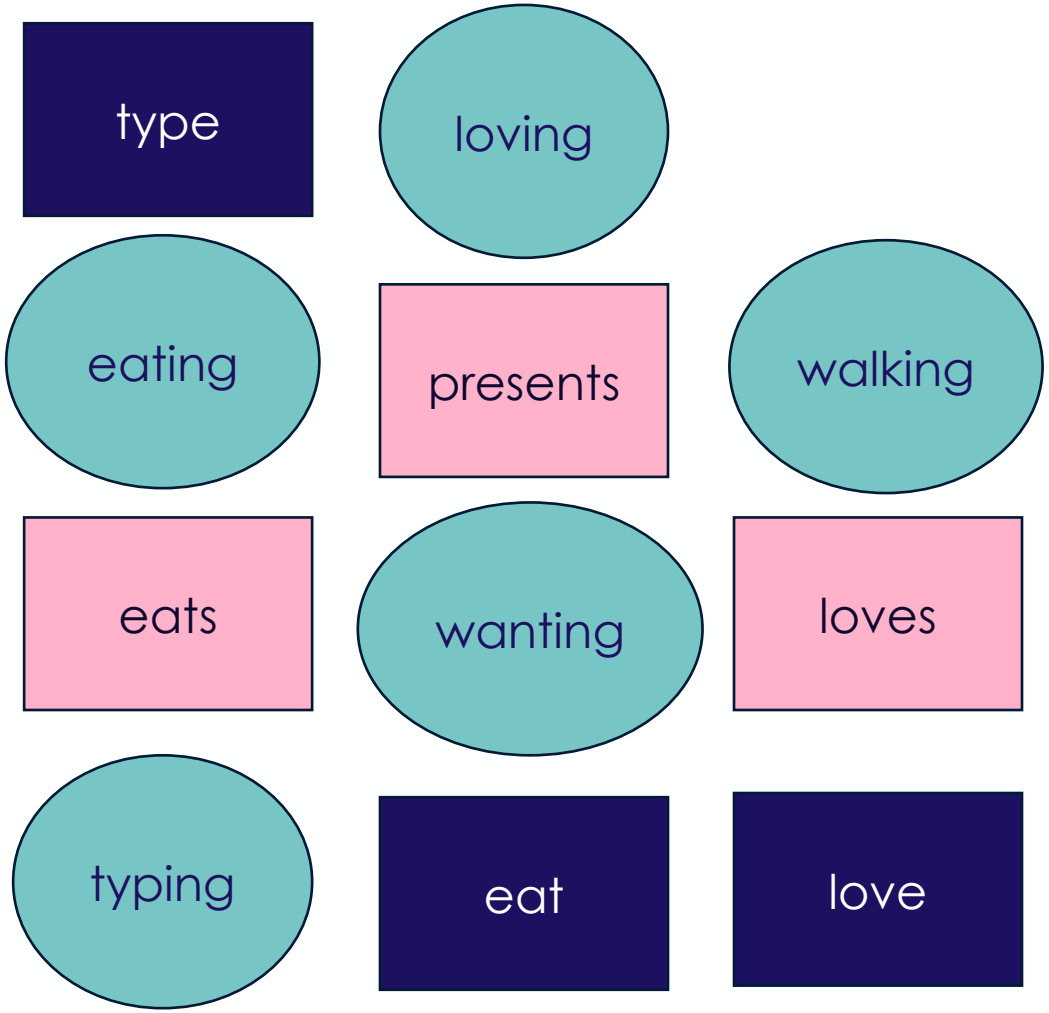
$$N - M \leq \theta_N = \frac{N}{\ln N}$$

(Yang, 2016)

Model: Recursive Subdivision

- Take in input **incrementally**
- If inflection ***A*** (less frequent) has a collision with inflection ***B*** (more frequent):
  - **Do enough $(A - \theta_A)$ verbs that appear in *A* appear in *B* in a different form than *A*?**
- If **enough** words have a collision (by TSP):
  - Subdivide the input based on the **feature difference between *A* and *B***
  - **Recurse** on each resulting set

Model: Toy Example



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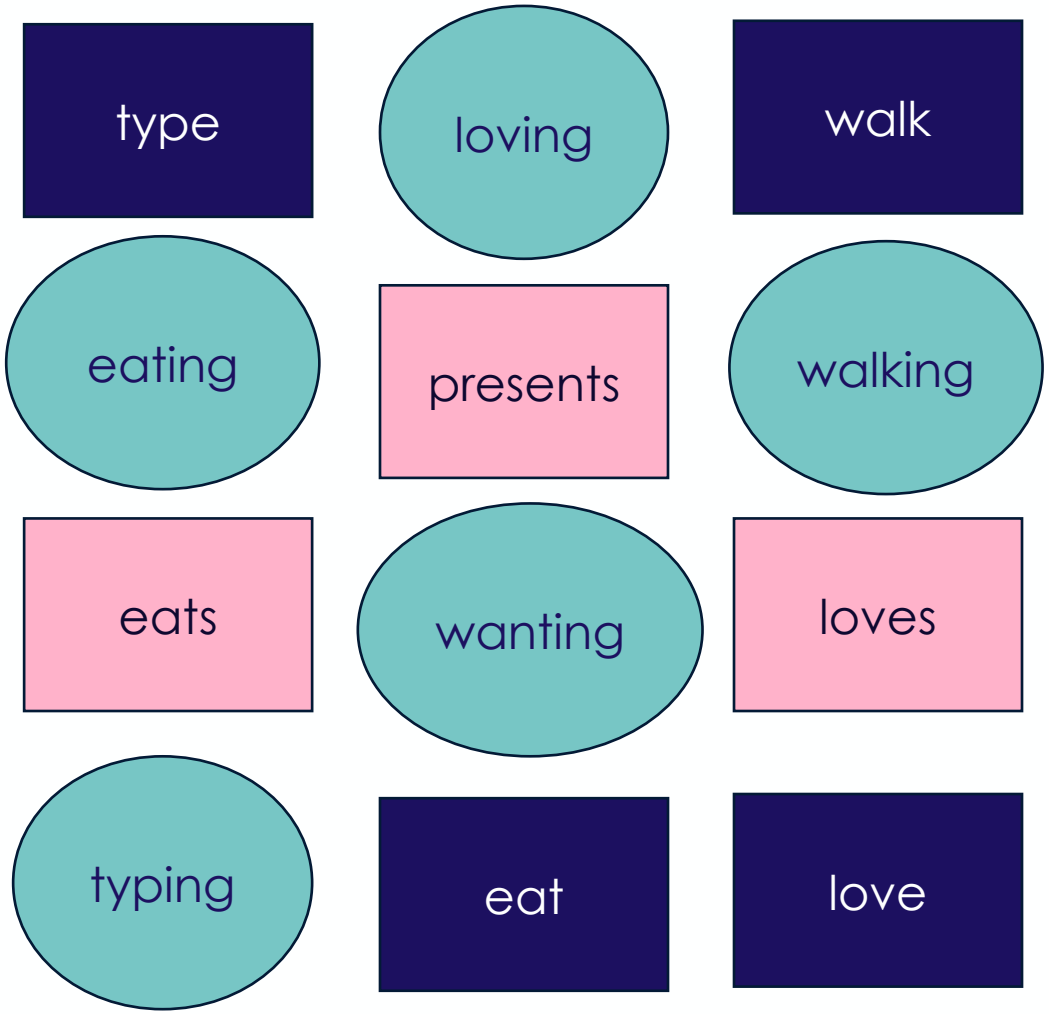

- Collision: ***walk*~*walking***
- **±PARTICIPLE** marked?

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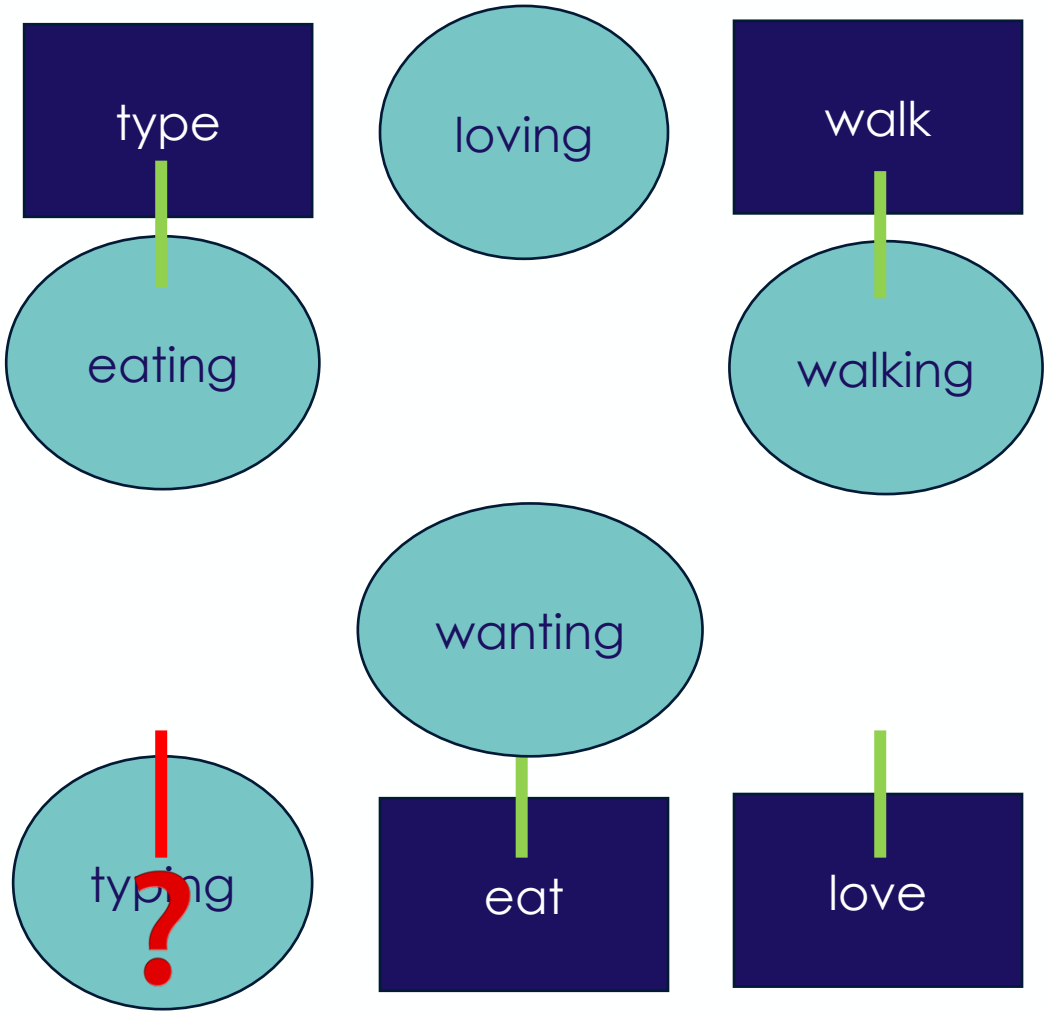

- Collision: ***walk*~*walking***
- **±PARTICIPLE** marked?
  - 5 participles, 4 collisions (not ***wanting***)
  - $N - M = 1 < \theta_5 = 3$ ✅
- Contrast 1 productive! **±PARTICIPLE marked**

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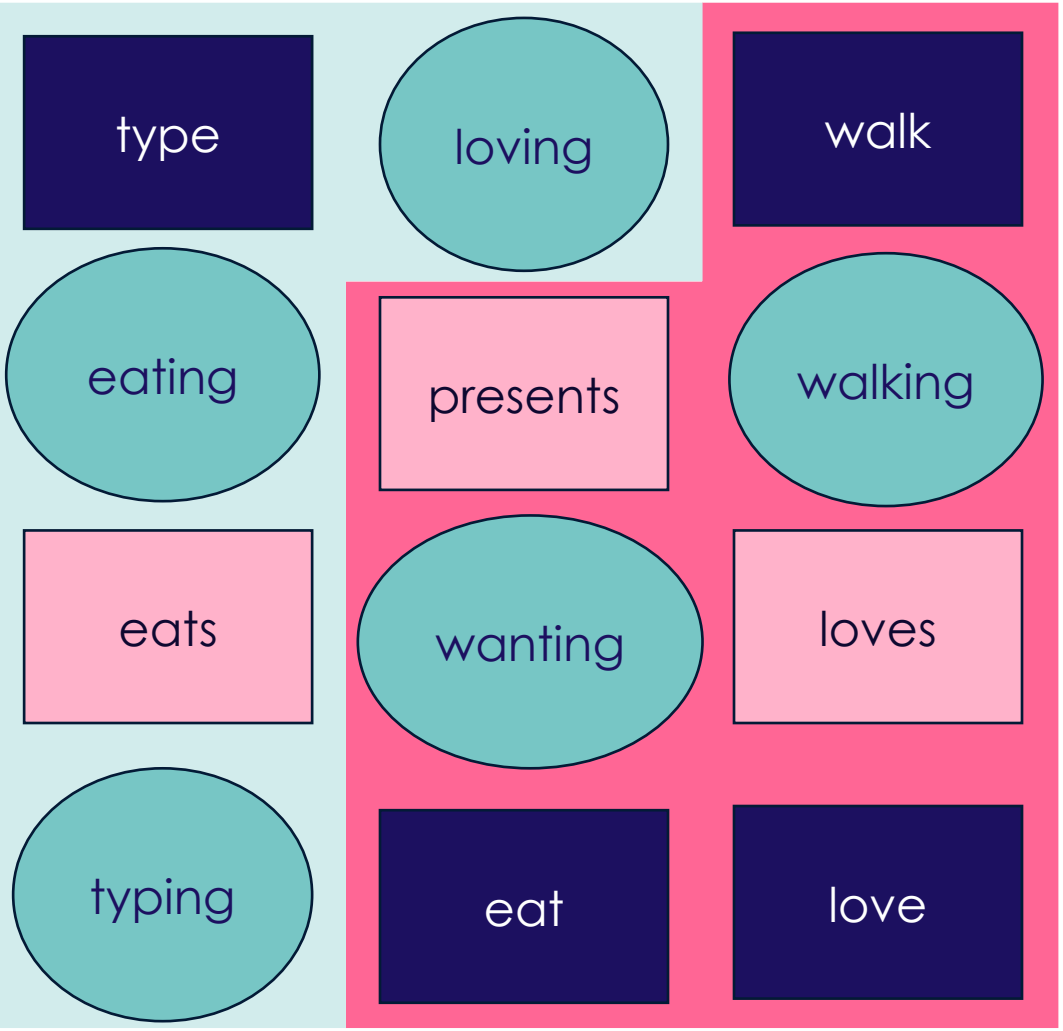

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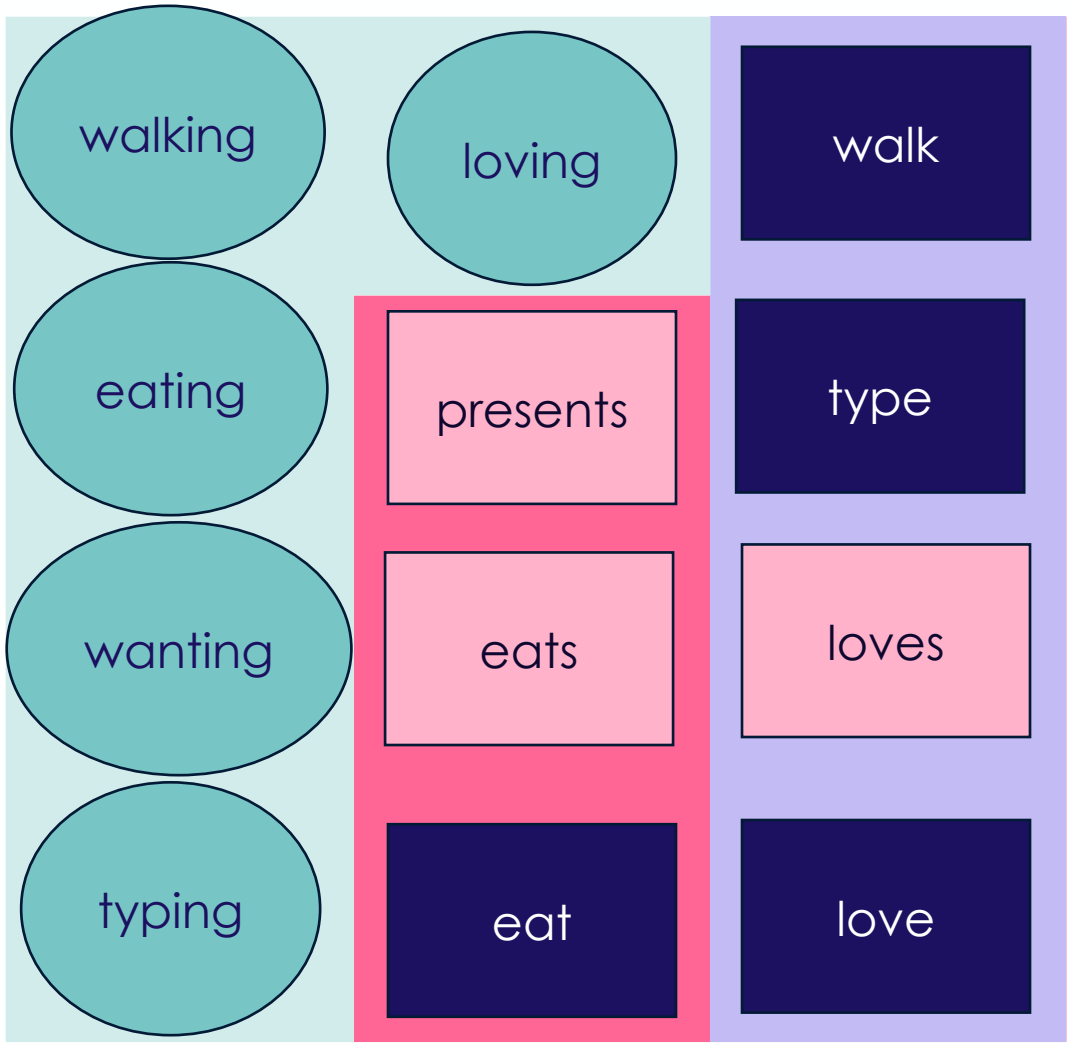


- Collision: ***walk*~*walking***
- ±PARTICIPLE marked?
  - 5 participles, 4 collisions (not ***wanting***)
  - $N - M = 1 < \theta_5 = 3$ ✅
- Contrast 1 productive! **±PARTICIPLE marked**
- **Subdivide** into **+PARTICIPLE** and **–PARTICIPLE** forms
- Recursively learn that **±3.SG** marked

Experiments

- **English vs. French vs. Spanish** verbs (following Legate & Yang 2007)
  - **English:** ***longest & most frequent*** RI
  - **French:** in the middle
  - **Spanish:** ***shortest & least frequent*** RI
- Does our model **match developmental findings**?
  - Order of acquisition
  - Vocabulary size
- Can it account for **cross-linguistic differences** in RI?

Predictions

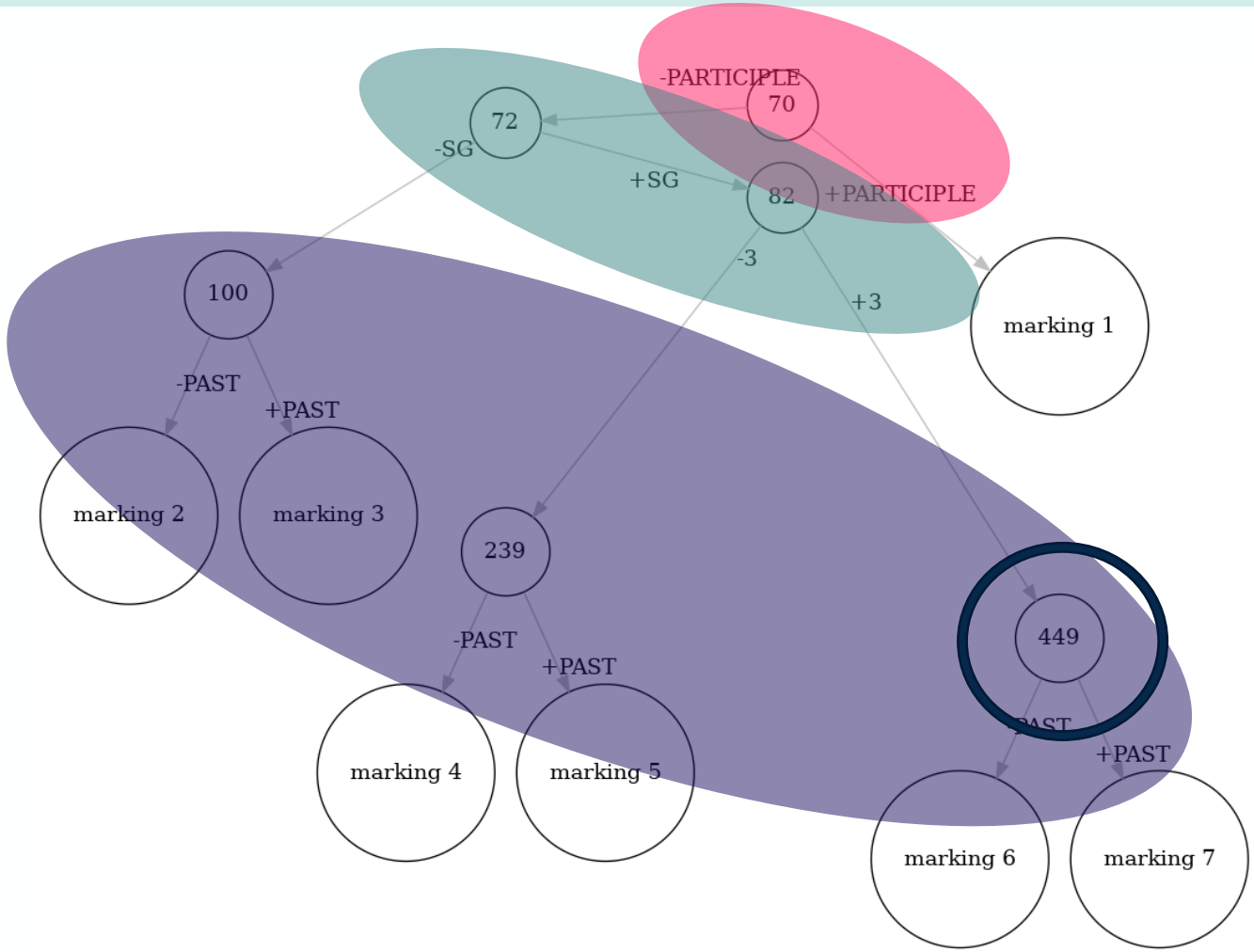
- All 3 languages: **subject agreement before tense**
- Richer agreement paradigm ⇒ **more subdivision**
- More subdivision ⇒ **smaller *Ns***
- Smaller *Ns* ⇒ **learn tense more quickly**
  - **TSP tolerates relatively more exceptions for smaller *N***
  - $\theta_{10} \approx 4 = \mathbf{40\%}$ but $\theta_{100} \approx 21 = \mathbf{21\%}$
- Learn tense more quickly ⇒ **shorter RI**

∴ **Richer agreement paradigm ⇒ shorter RI**

Results: English

- Order of acquisition:
  - **PARTICIPLE**
  - **3.SG**
  - **PAST**

  } Matches with developmental findings
- Vocabulary size:
  - At 3;0 know ≤ **250 verb stems**
  - Done learning at **188 stems**
- Tense emerges:
  - By **449 inflected** forms (**188 stems**)



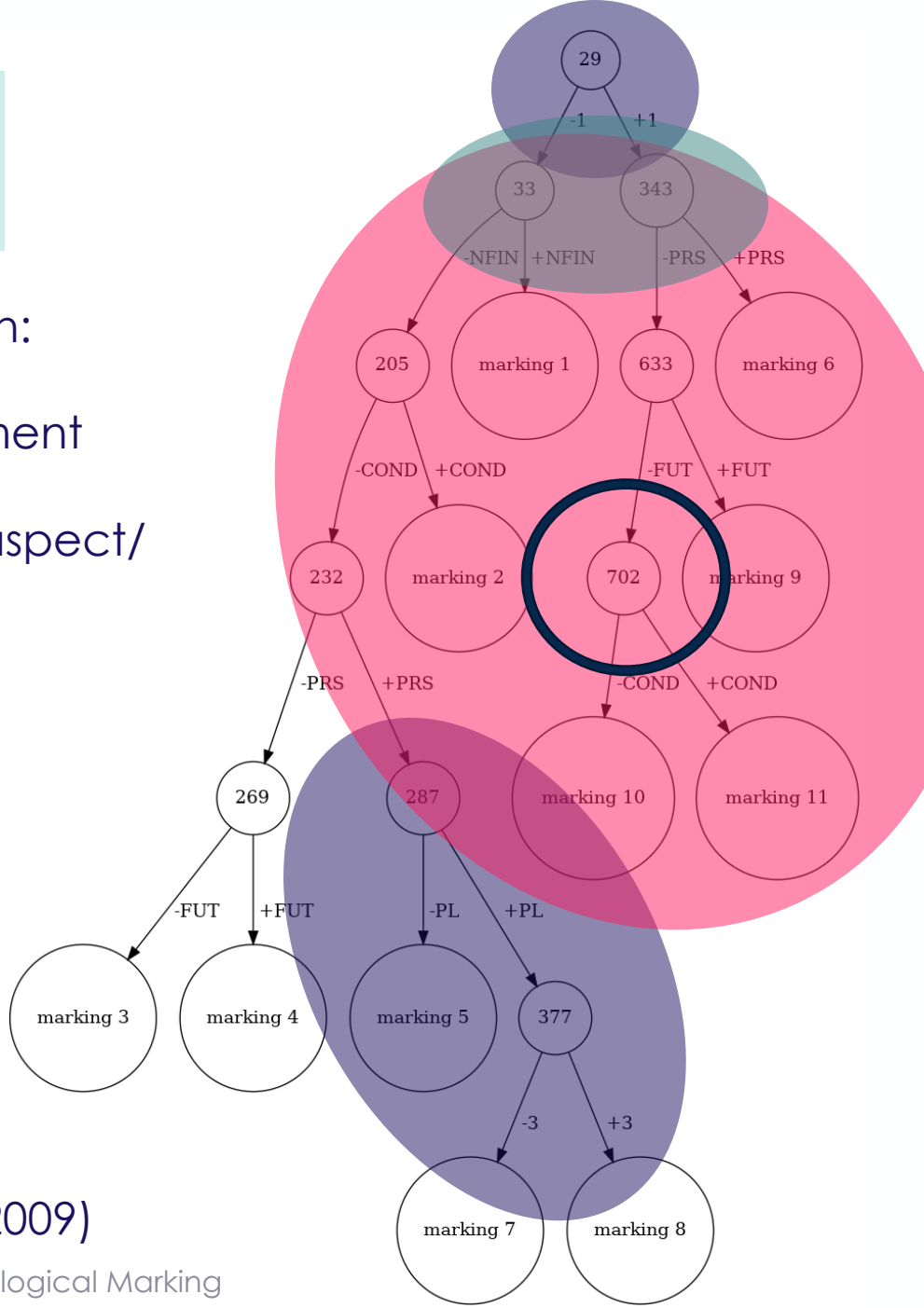
(Fenson et al. 1994, Bornstein et al. 2004, Berko 1958, Brown 1973)

Results: French

- Order of acquisition:
  - Subject agreement **early & late**
  - **Tense/aspect/mood** after ±1

Children: subject agreement before tense/aspect/ mood

- Vocabulary size:
  - At 1;8, children know **≤ 400 words**
  - Done learning at **232 stems**
- Tense emerges:
  - By **343 inflected** forms **(124 stems)**

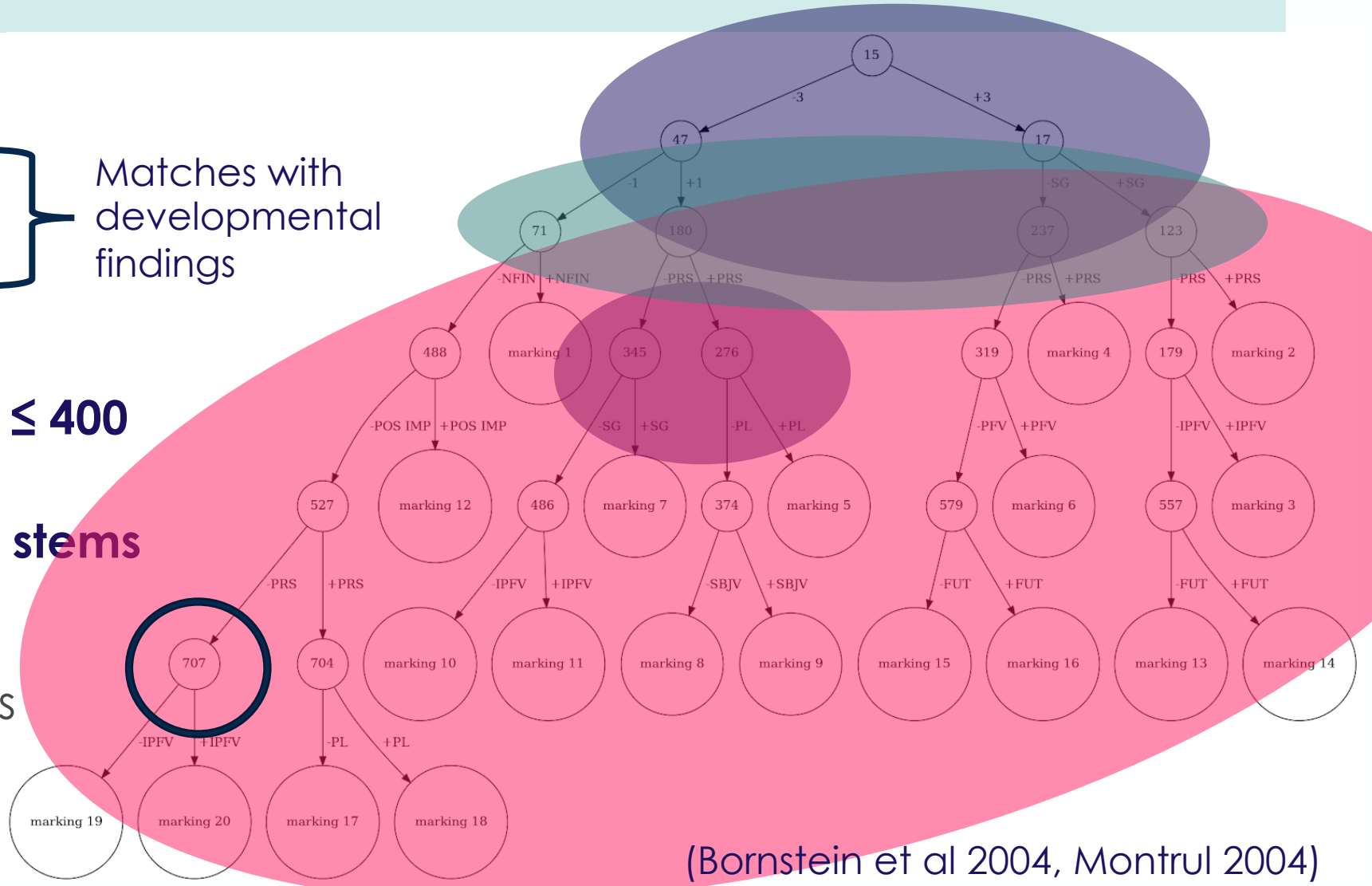


(Bornstein et al 2004, Prevost 2009)

Results: Spanish

- Order of acquisition:
  - **Subject agreement**
  - **Tense/aspect mood**

  } Matches with developmental findings
- Vocabulary size:
  - At 1;8, children know **≤ 400 words**
  - Done learning at **230 stems**
- Tense emerges:
  - By **237 inflected** forms **(103 stems)**



(Bornstein et al 2004, Montrul 2004)

Results: Cross-linguistic Differences

- Length of RI Stage in children:

Spanish < French < English

- Number of stems on which our model learns tense marking:

Spanish (103) < French (124) < English (188)

- Number of inflected forms on which our model learns tense marking:

Spanish (237) < French (343) < English (449)

Discussion

- Our model: **mechanistic account** of RI stage as a byproduct of the **acquisition of inflectional categories**
  - Relies only on **inequality between inflected forms**
- Future work:
  - Apply to **more languages**
  - Combine with **grounded/distributional models** to learn features
  - Investigate high vs. non-high in **French and German**

Thank you!!

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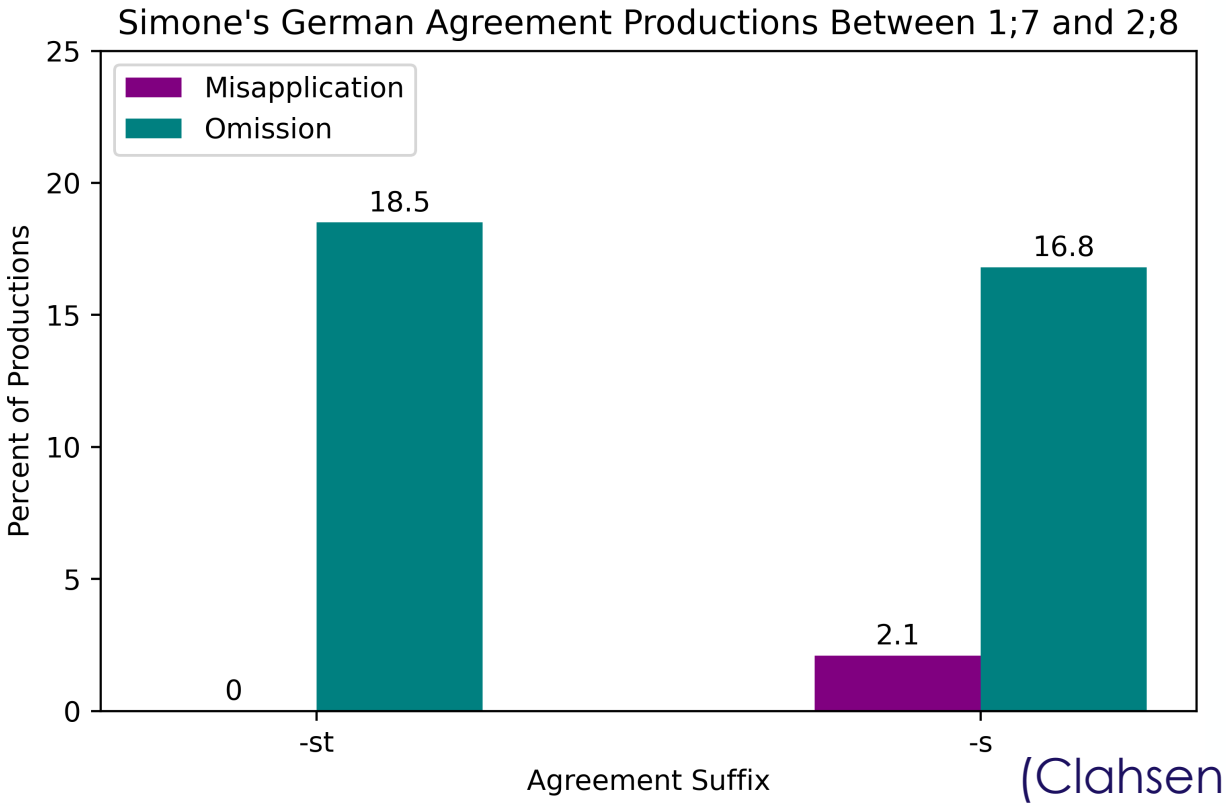
Background: a Syntactic Problem?

- Are RIs just **a failure of AGREE?**
  - Failure of φ-agreement ⇒ ***substitution errors*** (e.g. I has it)



(Clahsen & Penke 1992, Philips 1995)