There are patterns in child-directed speech that make first language learning possible

Sabine Stoll
University of Zurich
Department of Comparative Linguistics
Psycholinguistics Laboratory
@sabine_stoll
&
Center for the Interdisciplinary Study of Language Evolution (ISLE)
@ISLE_uzh
How do children learn language?
My sweet baby
Recursion
Recursion
Rule-based learning

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>house</td>
<td>houses</td>
<td>child</td>
<td>children</td>
<td></td>
</tr>
<tr>
<td>kid</td>
<td>kids</td>
<td>mouse</td>
<td>mice</td>
<td></td>
</tr>
<tr>
<td>dog</td>
<td>dogs</td>
<td>foot</td>
<td>feet</td>
<td></td>
</tr>
</tbody>
</table>
Rule-based learning

German

Table 1: The Eight German Plural Classes

<table>
<thead>
<tr>
<th>affix</th>
<th>-s</th>
<th>-(e)n</th>
<th>-e</th>
<th>-er</th>
<th>zero</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Umlaut</td>
<td>Auto-s</td>
<td>Bahn-en, Fahne-n</td>
<td>Fisch-e</td>
<td>Kind-er</td>
<td>Lehrer-0</td>
</tr>
<tr>
<td>+ Umlaut</td>
<td>--</td>
<td>--</td>
<td>Bänk-e</td>
<td>Räd-er</td>
<td>Kästen-0</td>
</tr>
</tbody>
</table>

Dinka

<table>
<thead>
<tr>
<th>SINGULAR</th>
<th>PLURAL</th>
<th>GLOSS</th>
<th>Marked Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>cën</td>
<td>cën</td>
<td>‘hand’</td>
<td>(marked singular)</td>
</tr>
<tr>
<td>jëec</td>
<td>jëec</td>
<td>‘belly’</td>
<td>(marked plural)</td>
</tr>
<tr>
<td>tëuk</td>
<td>tëuk</td>
<td>‘fruit of palm’</td>
<td>(both singular and plural marked)</td>
</tr>
</tbody>
</table>
Beyond structure
Beyond structure
Beyond structure
Learning mechanisms

Socio-cognitive abilities

Experiments
Learning mechanisms

Imitation → Creativity

Imitation

Creativity
Learning mechanisms

Socio-cognitive abilities

Pattern-detection abilities

Experiments
How is language learning possible?

- **Study 1**: An extreme case of language learning: A polysynthetic verb system.
- **Study 2**: Variation sets: How to learn about constructions and meaning.
- **Study 3**: Structural frames: how to detect nouns and verbs
- **Study 4**: Temporal cues: how to detect nouns and verbs
Study 1: An extreme case of language learning: thousands of verb forms in Chintang
### Verbal morphology

#### Chintang

<table>
<thead>
<tr>
<th></th>
<th>1s</th>
<th>3d</th>
<th>3p</th>
<th>3e</th>
<th>2s</th>
<th>2p</th>
<th>3s</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1s</td>
<td>lapoke</td>
<td>lapokeni</td>
<td>lapokesi</td>
<td>matu-pokyfacebook</td>
<td>tapo</td>
<td>tapokan</td>
<td>tapokan</td>
<td>matu-pokyfacebook</td>
</tr>
<tr>
<td>3d</td>
<td>lapok</td>
<td>lapokendu</td>
<td>lapokendu</td>
<td>matupokendu</td>
<td>tapak</td>
<td>tapakendu</td>
<td>tapakendu</td>
<td>matupokendu</td>
</tr>
<tr>
<td>3p</td>
<td>tapok</td>
<td>tapokendu</td>
<td>tapokendu</td>
<td>matupokendu</td>
<td>tapak</td>
<td>tapakendu</td>
<td>tapakendu</td>
<td>matupokendu</td>
</tr>
<tr>
<td>3e</td>
<td>tapo</td>
<td>tapokan</td>
<td>tapokan</td>
<td>matu-pokyfacebook</td>
<td>tapak</td>
<td>tapakendu</td>
<td>tapakendu</td>
<td>matu-pokyfacebook</td>
</tr>
<tr>
<td>2s</td>
<td>tapo</td>
<td>tapokan</td>
<td>tapokan</td>
<td>matu-pokyfacebook</td>
<td>tapak</td>
<td>tapakendu</td>
<td>tapakendu</td>
<td>matu-pokyfacebook</td>
</tr>
<tr>
<td>2p</td>
<td>tapo</td>
<td>tapokan</td>
<td>tapokan</td>
<td>matu-pokyfacebook</td>
<td>tapak</td>
<td>tapakendu</td>
<td>tapakendu</td>
<td>matu-pokyfacebook</td>
</tr>
<tr>
<td>3s</td>
<td>lapoke</td>
<td>lapokeni</td>
<td>lapokesi</td>
<td>matu-pokyfacebook</td>
<td>tapak</td>
<td>tapakendu</td>
<td>tapakendu</td>
<td>matu-pokyfacebook</td>
</tr>
</tbody>
</table>

---

### English

I walk
you walk
he walks
we walk
you walk
they walk
walked

### Chintang

jo-go-yan
na-khutt-i-ca-i-hatt-i-bir-i.


‘It (a cat) may steal everything from you and eat it all up!’ [story.cat.204]
## Verbal structure

<table>
<thead>
<tr>
<th></th>
<th>Affixes</th>
<th>Unique synthetic forms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English</strong></td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Chintang</strong></td>
<td>148</td>
<td>4745</td>
</tr>
</tbody>
</table>
How can such an extreme system be learned?
Verb form types in the input

Number of verb form types in 93,516 tokens of adult input
<table>
<thead>
<tr>
<th>English</th>
<th>Chintang</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image 118x538 to 147x569]</td>
<td>![Image 163x540 to 190x569]</td>
</tr>
<tr>
<td>![Image 204x538 to 233x569]</td>
<td>![Image 204x538 to 233x569]</td>
</tr>
</tbody>
</table>
English

Chintang

[]
[]
[]
Frequency distributions stems vs. affixes: Chintang (input)

Part of verb form:
- Dependents
- Heads

Stoll et al in prep.
Most frequent stems in one recording: Chintang (input)

10 most frequent heads in adult production in sample session

Stoll et al in prep.
Forms with the same stem in one recording session: Chintang (input)

Child-surrounding words from start to end of session

eat (n=29)  Stoll et al in prep.
Forms with same affixes in one recording session: Chintang input

Child-surrounding verbs from start to end of session

Stoll et al in prep.
Stem and affix combinations: Chintang (input)

- **English**
  - Heads: 453
  - Dependents: 571

- **Chintang**
  - Heads: 546
  - Dependents: 185
  - Both elements are singletons: 1357

Stoll et al in prep.
Stems vs. Affixes over time in children

Stoll et al in prep.
Conclusion

Chintang verbal morphology

The system can be learned via distributional learning, generalisation and abstraction.
How do children learn language?

How come children can learn any language in a few years time?
Challenge: diversity
Data

Semantic role clustering

Figure 4. NeighborNet and fuzzy clustering of predicate-specific roles in non-default case assignment to S (top) and A (bottom) arguments. (Roles are represented by predicates, but these are meant to refer to the respective arguments, e.g. break in the S class refers to 'that which breaks'.)

WALS

AUTOTYP

Stoll & Bickel 2013
Data: ACQDIV bank

New Corpora:
- Qaqet
- Nungon
- Pijanjatjara
- Ku Waru
- Tuatschin
- English
- Shipibo
- etc.

Stoll & Bickel 2013
ACQDIV core team

Steven Moran  
Damian Blasi  
Dagmar Jung  
Nick Lester

Géraldine Walther  
Jekaterina Mazara  
Guanghao You  
Claudia Cathomas  
André Müller

Anna Jansco  
Andreas Gerster  
Alexandra Bosshard  
Ruben Moegel  
Katherina Habel  
Areezoo Zandy

Fusce dapibus turpis nisi, vitae dapibus velit. Cras sit amet consequat nulla. Nam dui lectus, adipiscing id volutpat id, luctus in metus. Nunc a ante ut est viverra sagittis.

Proin ullamcorper, massa eu dictum viverra, lacus elit bibendum ligula, a cursus libero ligula ac dui. Praesent leo eros, lacinia at convallis nec, egestas at dolor. Mauris quis sapien sem, at ultrices erat. Proin ultricies, diam vel aliquam posuere, ipsum eros porttitor est, eget condimentum massa enim eu libero.

www.uzh.ch
13 October 2014
<table>
<thead>
<tr>
<th>language</th>
<th>corpus</th>
<th>session_id</th>
<th>utterance_id</th>
<th>word_id</th>
<th>morpheme_id</th>
<th>word</th>
<th>pos_word_stem</th>
<th>morpheme</th>
<th>pos</th>
<th>gloss</th>
<th>morpheme_language</th>
<th>speaker_label</th>
<th>age_in_days</th>
<th>gender</th>
<th>role</th>
<th>macrorole</th>
<th>languages_spoken</th>
<th>wai</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chintang</td>
<td>Chintang</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>habimijn</td>
<td>V</td>
<td>hap</td>
<td>V</td>
<td>cry</td>
<td>Chintang</td>
<td>GKR</td>
<td>14600</td>
<td>Female</td>
<td>None</td>
<td>Adult</td>
<td>nep bap ctn</td>
<td>NA</td>
</tr>
<tr>
<td>Cree</td>
<td>Cree</td>
<td>478</td>
<td>393608</td>
<td>987673</td>
<td>1600151</td>
<td>avän</td>
<td>PRODEM</td>
<td>NA</td>
<td>PRODEM</td>
<td>who</td>
<td>Cree</td>
<td>ADU</td>
<td>12842</td>
<td>Female</td>
<td>Speaker</td>
<td>Adult</td>
<td>cml</td>
<td>NA</td>
</tr>
<tr>
<td>Indonesian</td>
<td>Indonesian</td>
<td>503</td>
<td>410983</td>
<td>1023914</td>
<td>1616384</td>
<td>da</td>
<td>stem</td>
<td>da</td>
<td>stem</td>
<td>bye</td>
<td>Indonesian</td>
<td>MOT</td>
<td>NA</td>
<td>Female</td>
<td>Mother</td>
<td>Adult</td>
<td>xmm ind</td>
<td>NA</td>
</tr>
<tr>
<td>Indonesian</td>
<td>Indonesian</td>
<td>503</td>
<td>410983</td>
<td>1023916</td>
<td>161836</td>
<td>???</td>
<td>???</td>
<td>???</td>
<td>???</td>
<td>???</td>
<td>Indonesian</td>
<td>MOT</td>
<td>NA</td>
<td>Female</td>
<td>Mother</td>
<td>Adult</td>
<td>xmm ind</td>
<td>NA</td>
</tr>
<tr>
<td>Indonesian</td>
<td>Indonesian</td>
<td>503</td>
<td>410983</td>
<td>1023917</td>
<td>161838</td>
<td>Tante</td>
<td>stem</td>
<td>Tante</td>
<td>stem</td>
<td>aunt</td>
<td>Indonesian</td>
<td>MOT</td>
<td>NA</td>
<td>Female</td>
<td>Mother</td>
<td>Adult</td>
<td>xmm ind</td>
<td>NA</td>
</tr>
<tr>
<td>Inuktitut</td>
<td>Inuktitut</td>
<td>1500</td>
<td>3316259</td>
<td>4381281</td>
<td>507608</td>
<td>Na</td>
<td>PTCL</td>
<td>no</td>
<td>PTCL</td>
<td>no</td>
<td>Inuktitut</td>
<td>ALI</td>
<td>916</td>
<td>Male</td>
<td>Target Child</td>
<td>Target Child</td>
<td>ike</td>
<td>NA</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japanese_Miyata</td>
<td>1577</td>
<td>1731935</td>
<td>358931</td>
<td>4419047</td>
<td>issho</td>
<td>N</td>
<td>issho</td>
<td>N</td>
<td>together</td>
<td>Japanese</td>
<td>AMO</td>
<td>NA</td>
<td>Female</td>
<td>Speaker</td>
<td>Adult</td>
<td>und</td>
<td>NA</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japanese_Miyata</td>
<td>1577</td>
<td>1731960</td>
<td>358931</td>
<td>4419048</td>
<td>pikapika</td>
<td>IDEOPH</td>
<td>pikapika</td>
<td>IDEOPH</td>
<td>???</td>
<td>Japanese</td>
<td>AMO</td>
<td>NA</td>
<td>Female</td>
<td>Speaker</td>
<td>Adult</td>
<td>und</td>
<td>NA</td>
</tr>
<tr>
<td>Japanese</td>
<td>Japanese_Miyata</td>
<td>1577</td>
<td>1731985</td>
<td>358931</td>
<td>4419105</td>
<td>ne</td>
<td>PTCL</td>
<td>ne</td>
<td>PTCL</td>
<td>TAG</td>
<td>Japanese</td>
<td>AMO</td>
<td>NA</td>
<td>Female</td>
<td>Speaker</td>
<td>Adult</td>
<td>und</td>
<td>NA</td>
</tr>
<tr>
<td>Russian</td>
<td>Russian</td>
<td>1939</td>
<td>4783322</td>
<td>5470915</td>
<td>5470916</td>
<td>oj</td>
<td>INTJ</td>
<td>oj</td>
<td>INTJ</td>
<td>INTERJ</td>
<td>Russian</td>
<td>ALJ</td>
<td>625</td>
<td>Unspecified</td>
<td>Target Child</td>
<td>Target Child</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Russian</td>
<td>Russian</td>
<td>1939</td>
<td>4783322</td>
<td>5470917</td>
<td>5470918</td>
<td>Alja</td>
<td>N</td>
<td>alja</td>
<td>N</td>
<td>M-SG-NOM-AN</td>
<td>Russian</td>
<td>LEN</td>
<td>NA</td>
<td>Female</td>
<td>Aunt</td>
<td>Adult</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Russian</td>
<td>Russian</td>
<td>1939</td>
<td>4783322</td>
<td>5470918</td>
<td>5470918</td>
<td>ne</td>
<td>PTCL</td>
<td>ne</td>
<td>PTCL</td>
<td>PCL</td>
<td>Russian</td>
<td>LEN</td>
<td>NA</td>
<td>Female</td>
<td>Aunt</td>
<td>Adult</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Sesotho</td>
<td>Sesotho</td>
<td>2389</td>
<td>2637993</td>
<td>6816355</td>
<td>7494533</td>
<td>ere</td>
<td>V</td>
<td>er</td>
<td>V</td>
<td>say</td>
<td>Sesotho</td>
<td>MHL</td>
<td>NA</td>
<td>Female</td>
<td>Mother</td>
<td>Adult</td>
<td>sme</td>
<td>NA</td>
</tr>
<tr>
<td>Sesotho</td>
<td>Sesotho</td>
<td>2389</td>
<td>2637993</td>
<td>6816355</td>
<td>7494534</td>
<td>ere</td>
<td>V</td>
<td>e</td>
<td>sfx</td>
<td>m-\i</td>
<td>Sesotho</td>
<td>MHL</td>
<td>NA</td>
<td>Female</td>
<td>Mother</td>
<td>Adult</td>
<td>sme</td>
<td>NA</td>
</tr>
<tr>
<td>Sesotho</td>
<td>Sesotho</td>
<td>2389</td>
<td>2637993</td>
<td>6816356</td>
<td>7494535</td>
<td>mphe</td>
<td>V</td>
<td>m</td>
<td>pfx</td>
<td>om-\i</td>
<td>Sesotho</td>
<td>MHL</td>
<td>NA</td>
<td>Female</td>
<td>Mother</td>
<td>Adult</td>
<td>sme</td>
<td>NA</td>
</tr>
<tr>
<td>Turkish</td>
<td>Turkish</td>
<td>2667</td>
<td>2858439</td>
<td>NA</td>
<td>7824079</td>
<td>Na</td>
<td>PTCL</td>
<td>???</td>
<td>???</td>
<td>???</td>
<td>Turkish</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Turkish</td>
<td>Turkish</td>
<td>2667</td>
<td>2858439</td>
<td>NA</td>
<td>7824080</td>
<td>Na</td>
<td>PRODEM</td>
<td>???</td>
<td>???</td>
<td>???</td>
<td>Turkish</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Turkish</td>
<td>Turkish</td>
<td>2667</td>
<td>2858440</td>
<td>750473</td>
<td>7824081</td>
<td>kamera</td>
<td>N</td>
<td>kamera</td>
<td>N</td>
<td>???</td>
<td>Turkish</td>
<td>MOT</td>
<td>NA</td>
<td>Female</td>
<td>Mother</td>
<td>Adult</td>
<td>xmm ind</td>
<td>NA</td>
</tr>
<tr>
<td>Yucatec</td>
<td>Yucatec</td>
<td>2891</td>
<td>3108071</td>
<td>8185947</td>
<td>8123413</td>
<td>Lorena-e'</td>
<td>N</td>
<td>Lorena</td>
<td>N</td>
<td>???</td>
<td>Yucatec</td>
<td>MAR</td>
<td>21486</td>
<td>Male</td>
<td>Speaker</td>
<td>Adult</td>
<td>jav ind</td>
<td>NA</td>
</tr>
<tr>
<td>Yucatec</td>
<td>Yucatec</td>
<td>2891</td>
<td>3108071</td>
<td>8185947</td>
<td>8123414</td>
<td>Lorena-e'</td>
<td>N</td>
<td>Lorena</td>
<td>N</td>
<td>e'</td>
<td>TOP</td>
<td>Yucatec</td>
<td>MAR</td>
<td>21486</td>
<td>Male</td>
<td>Speaker</td>
<td>Adult</td>
<td>jav ind</td>
</tr>
<tr>
<td>Yucatec</td>
<td>Yucatec</td>
<td>2891</td>
<td>3108071</td>
<td>8185948</td>
<td>8123415</td>
<td>t\aan</td>
<td>???</td>
<td>???</td>
<td>???</td>
<td>Yucatec</td>
<td>MAR</td>
<td>21486</td>
<td>Male</td>
<td>Speaker</td>
<td>Adult</td>
<td>jav ind</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Yucatec</td>
<td>Yucatec</td>
<td>2891</td>
<td>3108071</td>
<td>8185949</td>
<td>8123416</td>
<td>u</td>
<td>???</td>
<td>u</td>
<td>???</td>
<td>Yucatec</td>
<td>MAR</td>
<td>21486</td>
<td>Male</td>
<td>Speaker</td>
<td>Adult</td>
<td>jav ind</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>
Study 2: Variation sets
Hypothesis

There are patterns in the input that make learning and generalisation possible.
Learning in interaction
Two hypothetical language learning situations.

<table>
<thead>
<tr>
<th>Alien message #1</th>
<th>Alien message #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1a) kedmalburafoloropesai</td>
<td>(1b) kedmalburafoloropesai</td>
</tr>
<tr>
<td>(2a) gianaber</td>
<td>(2b) rafuloro</td>
</tr>
<tr>
<td>(3a) manadukbiunel</td>
<td>(3b) manaloropesai</td>
</tr>
<tr>
<td>(4a) kiciorudanamjeisulcaz</td>
<td>(4b) kedmalbumanalaropesai</td>
</tr>
</tbody>
</table>
Variation sets in the input

*MOT: und jetzt rein in den schuh.
*MOT: und die schuhe?
*MOT: weg.
*MOT: so zumachen.
*MOT: eine schleife.
*MOT: oh 'n grossen schuh.
*MOT: bum.
*MOT: warte.
*MOT: du kriegst gleich dein'n schuh wieder.
*CHI: Mama.
*MOT: nein nich?
*MOT: wieder zu?
*CHI: zu.
*MOT: zu?
*CHI: &ja schuh &em.
*MOT: schuh?
*MOT: ein schuh?
*MOT: die puppe is zu klein für den grossen schuh?
Variation sets in the input

• Repetitive units in interactional units

• 17% - 30% of verbs and nouns in variation sets in child-directed speech

Are variation sets in input universally reliable patterns and how do they develop as a function of the age of the child?
Variation sets

Moran, Lester, Heath, Küntay Pfeiler, Allen & Stoll 2019
Variation sets

Moran, Lester, Heath, Küntay Pfeiler, Allen & Stoll 2019
Conclusion variation sets

Found in all of our maximally diverse languages
Language specific patterns in the development over time, not necessarily decreasing
Study 3: Frames to detect nouns and verbs
Frames

like
hate
hear
love
and
not

you
you
you
you

Moran, Blasi, Schikowski, Küntay, Pfeiler, Allen & Stoll, Cognition 2018
Frames

**Frame you__it**
put (28), want (15), do (10), see (7), take (6), turn (5), taking (5), said (5), sure (4), lost (4), like (4), leave (4), got (4), find (4), throw (3), threw (3), think (3), sing (3), reach (3), picked (3), get (3), dropped (3), seen (2), lose (2), know (2), knocked (2), hold (2), help (2), had (2), gave (2), found (2), fit (2), enjoy (2), eat (2), chose (2), catch (2), with (1), wind (1), wear (1), use (1), took (1), told (1), throwing (1), stick (1), share (1), sang (1), roll (1), ride (1), recognize (1), reading (1), ran (1), pulled (1), pull (1), press (1), pouring (1), pick (1), on (1), need (1), move (1), manage (1), make (1), load (1), liked (1), lift (1), licking (1), let (1), left (1), hit (1), hear (1), give (1), flapped (1), fix (1), finished (1), drop (1), driving (1), done (1), did (1), cut (1), crashed (1), change (1), calling (1), bring (1), break (1), because (1), banged (1)

**Frame a- ‘2S/A’ __ -o ‘3P’**

a. *theke a-kbind-o-ko?*
   why 2S/A-pull-3P-IND.NPST
   ‘Why do you pull it?’

b. *būi kābilti a-nept-o*
   DEM third.daughter 2S/A-step.on-3P
   ‘Kailli, you might step on it!’

c. *a-bid-o-ko?*
   2S/A-watch-3P-IND.NPST
   ‘Can you look after her?’

**Frame mai- ‘NEG’ __ -tb ‘NEG’**

a. *la mo mai-soŋ-th-a*
   INTERJ DEM.DOWN NEG-move-NEG-IMP
   ‘Don’t move down there!’

b. *e mai-kbaŋ-th-o-s-e ni*
   OK NEG see-NEG-3P-PRF-IND.PST EMPH
   ‘Yeah, s/he didn’t see it.’

c. *mo sotayma-ce pbidaŋ u-mai-let-th-a-ys-a-kha*
   DEM.DOWN S-.ns ginger 3nsS/A-NEG-plant-NEG-PST-PRF-PST-NMLZ
   ‘The Sotangma people have not yet planted ginger down in the field.’
Are *frames* in the input universally reliable patterns that could help in categorizing parts of speech?
Frames in ACQDIV bank

Word frames: no

<table>
<thead>
<tr>
<th>Language</th>
<th>Accuracy</th>
<th>SD</th>
<th>Completeness</th>
<th>SD</th>
<th>Frames</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chintang</td>
<td>0.57</td>
<td>0.24</td>
<td>0.04</td>
<td>0.02</td>
<td>33</td>
<td>90</td>
<td>2720</td>
</tr>
<tr>
<td>Inuiktut</td>
<td>0.98</td>
<td>0.11</td>
<td>0.03</td>
<td>0.01</td>
<td>37</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Japanese</td>
<td>0.82</td>
<td>0.21</td>
<td>0.02</td>
<td>0.02</td>
<td>97</td>
<td>67</td>
<td>915</td>
</tr>
<tr>
<td>Russian</td>
<td>0.44</td>
<td>0.22</td>
<td>0.04</td>
<td>0.03</td>
<td>48</td>
<td>234</td>
<td>1485</td>
</tr>
<tr>
<td>Sesotho</td>
<td>0.83</td>
<td>0.23</td>
<td>0.01</td>
<td>0.01</td>
<td>107</td>
<td>8</td>
<td>163</td>
</tr>
<tr>
<td>Turkish</td>
<td>0.62</td>
<td>0.20</td>
<td>0.08</td>
<td>0.08</td>
<td>15</td>
<td>34</td>
<td>318</td>
</tr>
<tr>
<td>Yucatec</td>
<td>0.78</td>
<td>0.28</td>
<td>0.01</td>
<td>0.01</td>
<td>133</td>
<td>3</td>
<td>41</td>
</tr>
</tbody>
</table>

Morpheme frames: yes

<table>
<thead>
<tr>
<th>Language</th>
<th>Accuracy</th>
<th>SD</th>
<th>Completeness</th>
<th>SD</th>
<th>Frames</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chintang</td>
<td>0.95</td>
<td>0.09</td>
<td>0.08</td>
<td>0.07</td>
<td>60</td>
<td>517</td>
<td>7940</td>
</tr>
<tr>
<td>Inuiktut</td>
<td>0.93</td>
<td>0.16</td>
<td>0.02</td>
<td>0.01</td>
<td>100</td>
<td>5</td>
<td>43</td>
</tr>
<tr>
<td>Japanese</td>
<td>0.98</td>
<td>0.04</td>
<td>0.02</td>
<td>0.03</td>
<td>187</td>
<td>83</td>
<td>1943</td>
</tr>
<tr>
<td>Sesotho</td>
<td>0.97</td>
<td>0.12</td>
<td>0.04</td>
<td>0.04</td>
<td>88</td>
<td>66</td>
<td>1358</td>
</tr>
<tr>
<td>Turkish</td>
<td>0.88</td>
<td>0.17</td>
<td>0.01</td>
<td>0.01</td>
<td>835</td>
<td>21</td>
<td>1000</td>
</tr>
<tr>
<td>Yucatec</td>
<td>0.90</td>
<td>0.18</td>
<td>0.01</td>
<td>0.02</td>
<td>153</td>
<td>20</td>
<td>584</td>
</tr>
</tbody>
</table>
Categorization of nouns and verbs via frames

Moran, Blasi, Schikowski, Küntay, Pfeiler, Allen & Stoll, Cognition 2018
Conclusion frames:

Nouns and verbs can be categorized via repetitive patterns in their morphological structure
Study 4: Temporal cues to detect nouns and verbs
Temporal cues before nouns and verbs
Temporal cues before nouns and verbs: adults

Seifart ... Bickel, PNAS 2018
Temporal cues for nouns and verbs: pauses in child-surrounding speech

Lester, Bickel & Stoll in prep.
Sprechgeschwindigkeit vor Nomen oder Verben

**Chintang**

- n.s.

**Japanese**

- n.s.

**POS**
- Noun
- Verb

**Speech rate in preword window (segments/sec)**

- Adult
- Child

Bar charts showing the speech rate in preword windows for Chintang and Japanese, comparing nouns and verbs for adults and children.
Temporal cues for nouns and verbs: speech rate in child-surrounding speech

Lester, Bickel & Stoll in prep.
Both pauses before nouns and verbs and the temporal duration of these units can serve as cues for syntactic categorization.
To conclude:

• The input is not chaotic and there are quite a number of patterns learners can rely on

• There are striking similarities in the information distribution in child-directed speech in maximally diverse languages

• Some cross-linguistic differences in the patterns

• We are only at the beginning at understanding the computational power underlying language development

• Children can apply distributional learning and make use of statistical patterns provided by the input
Thank you very much for your interest!