The Role of Children in the Emergence of Communication Systems

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1. How to study emergence of structured communication systems in the lab

2. Compare outcomes from adults and children
   a. during transmission
   b. during communication

3. Discuss potential agents of language change
<table>
<thead>
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<th>Levels of emergence</th>
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Emergence of Structured Communication Systems

MacWhinney, 2001; 2002
Emergence of Linguistic Structure in the Lab
Emergence of Linguistic Structure in the Lab

Iterated Artificial Language Learning

Kirby et al. (2015)
Emergence of Linguistic Structure in the Lab

Iterated Artificial Language Learning

Hierarchical compositional structure

Saldana et al. (2019)
Emergence of
Structured Communication Systems

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“...We can also use emergentist thinking to understand the changes that languages have undergone across the centuries...These changes emerge from a further complex interaction of the previous ... levels of emergence....”

cultural evolution of language

MacWhinney, 2001; 2002

Kirby et al., 2008; 2015
Emergence of Structured Communication Systems

Levels of emergence

- Genetic emergence
- Epigenetic emergence
- Developmental emergence
- Online emergence
- Socially grounded emergence
- Diachronic emergence

- Compressibility
- Expressivity
- Communication efficiency
- Learnability

MacWhinney, 2001; 2002
Kirby et al., 2008; 2015
## Levels of emergence

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### Compressibility
- Pressure → Learnability

### Expressivity
- Pressure → Communicative Efficiency

### Cultural Evolution of Language

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MacWhinney, 2001; 2002

Kirby et al., 2008; 2015
Why Children?

Linguistic Bioprogram Hypothesis (Bickerton, 1984)

Pidgins

Creoles

Colorless green ideas sleep furiously

Linguistic Bioprogram Hypothesis (Bickerton, 1984)
Why Children?

Evolved period of immaturity enables learning.

Locke & Bogin (2006)
"Less-Is-More"- Hypothesis:

- Limited working memory capacity promotes learning by restricting hypothesis space (Newport, 1990; Elman, 1993).

- Limited executive functioning is linked to regularization of unpredictable variation (Thompson-Schill, Ramscar & Chrysikou, 2010; Hudson Kam & Newport, 2005; 2009).
## Measurements

### Learnability

(1 - Transmission Error)
- Length-normalised Levenshtein Edit Distance:
- # of insertions, deletions, substitutions / length of longest string

\[ nLED = \frac{4}{8} = 0.5 \]

**Example:**

\[ ponekuki \rightarrow punikike \]

### Compositional Structure
- Correlation between similarity in signal pairs and similarity of corresponding meaning pairs
- Monte-Carlo process to determine likelihood of this correlation occurring by chance

\[ z \sim 15 \]

*Kirby et al. (2008)*
Iterated Language Learning in Children

Syllable Bank: šu, gu, di, ki, so, mo, bal, taz

2 x 3 x 2 meaning space

3 x 4 meaning space

6-12 years olds

Raviv & Arnon (2018)
Iterated Language Learning in Children

2 x 3 x 2 meaning space

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Syllable Bank: šu, gu, di, ki, so, mo, bal, taz

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Syllable Bank:
šu, gu, di, ki, so,
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Raviv & Arnon (2018)

Kirby et al. (2015)
Iterated Language Learning in Children

Homonymy filter!
Iterated Language Learning in Children

2 x 2 x 2 meaning space

3 x 4 meaning space

transmission error

Kempe, Gauvrit, Gibson & Jamieson (2019)
Learnability Constraints in Children

2 x 2 x 2 meaning space

3 x 4 meaning space

Kempe, Gauvrit, Gibson & Jamieson (2019)
With familiar signals, if structure emerges it does so more readily in adults.

Homonymy filter: + unique signals, - links to meanings. Children may not view variation as meaningful (Perfors, 2012b)

No homonymy filter → children regularize by salient feature, e.g. color (Raviv & Arnon, 2018)
  – retrieval difficulties (Schwab, Lew-Williams & Goldberg, 2018)
  – production biases (Ferdinand, Kirby & Smith, 2018).

→ No evidence that children are more likely to introduce structure.

Emergence of structure may depend on
  – Signal familiarity
  – Size and complexity of the meaning space
  – Token frequency (2 repetitions here vs. 6 in Kirby et al.)
  – Combinatorial affordances of the signals
Inventing Expressive Communication Systems

Experimental Semiotics

e.g. Fay, Garrod, Roberts & Swoboda (2010)

Lister & Fay (2017)
Inventing Expressive Communication Systems

- 12 dyads of 7-y.o. children
- 12 dyads of adults
- playing a Director-Matcher game for 5 rounds

Kempe, Gauvrit, Gibson & Jamieson (2019)
**Motivated Signs:** no magnitude symbolism in children

**Alignment:** not in children

**Refinement:** no reduction in signal length in children
child-child dyads (n=24), 6-7-y.o.
child-adult dyads (n=24), 6-7-y.o. vs. adult women
teen-teen dyads, on-going (n = 14), 12-13-y.o.
Inventing Expressive Communication Systems

1. **Motivated Signs**: no magnitude symbolism in children

2. **Alignment**: no alignment in children

Children acquire certain features from adults but fail to align.

3. **Refinement**: no reduction in signal length in children – ‘babbling’?

Kempe (in prep)
child-child dyads (n=24), 6-7-y.o.

- Digit span
- Non-word repetition
- High vs. low WM group
- 2 rounds

Kempe et al. (in prep)
Motivated Signs: no magnitude symbolism

Alignment: More alignment in high WM children

Ability to align signals is linked to greater WM capacity.
First find a small red spiky star.
Pragmatic Limitations?

“small, red, spiky” = 3 features

Kempe, Gauvrit, Gibson & Jamieson (2019)
Communication Experiments - Summary

• Pragmatic and cognitive limitations may prevent children from
  – identifying iconic affordances of the meaning and signal spaces (Spence, 2011; Fort et al., 2018).
  – identifying sources of ambiguity in the context (Rabagliatti & Robertson, 2017).
  – understanding labels/signs as negotiated conventions rather than attributes of referents (Krauss & Glucksberg, 1966; Sloutsky, Lo & Fisher, 2001).
  – tracking interlocutor signals as a pre-requisite for alignment.
Why Not Children?

- Pidgins = unpredictable variation; natural language = predictable variation $\rightarrow$ adults (e.g. Hudson Kam & Newport, 2009).
- Cognitive load $\rightarrow$ regularization (e.g. Perfors, 2012a).
- Children retreat from over-generalisation (Ambridge et al., 2018) - why should children’s regularizations (aka overgeneralizations) become conventionalized?
• Adolescents → innovation
  – Sociolinguistic evidence: vernacular change takes place in adolescence (Cedergren, 1988, Labov, 2001; Tagliamonte & D’Arcy, 2009)
  – Adolescents are more sensitive to social information (Gopnik et al., 2017)
Is adolescence the (critical?) period (Blakemore, 2018) of acute social awareness that enables negotiation of new in-group conventions, including linguistic ones?
If Not Children Then Who?

• Adolescents $\rightarrow$ innovation
  – Sociolinguistic evidence: vernacular change takes place in adolescence (Cedergren, 1988, Labov, 2001; Tagliamonte & D’Arcy, 2009)
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• Adults $\rightarrow$ input enhancement/pedagogical sampling (aka teaching)
  – English past-tense learning with staged input (Rumelhardt & McClelland, 1986)
  – Elman’s (1993) 2nd simulation: staged input
  – Recursion learning easier with staged input compared to randomised input (Conway et al., 2019; Poletiek et al., 2019)
  – CDS
Input Enhancement (Pedagogical Sampling)

Expressivity

Signal Length

Kempe, Cichon, Gauvrit & Tamariz (2017)
Emergent Processes over the Lifespan

We learn as children; we innovate as adolescents; we teach as adults.

Different constraints on emergence can operate at different life stages.

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