Phonological Complexity is Subregular:
Evidence from Sign Language

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Today’s Question

Do the computational properties of phonology hold across modalities?

Two Major Camps

▶ "Continuity View": phonology depends on/emerges from the properties of the phonetic system (grounded)
  ▶ Markedness, Feature geometries, Inductive Learning

▶ "Algebraic View": Abstract computational system that gets to peek at the phonetics, but is largely independent
  ▶ Neurological Evidence, Acquisition Evidence, Extensive theoretical commonalities
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This has not been fruitful

- work has focused on the feature representations
- a lot of theoretical work is based on loose analogies to spoken language
  Handshape is "like" tone... etc.
- Representational issues still abound
  Senquentiality vs Simultaneity
  SLM 2006, Ch.14: "Is there a Syllable in Sign language"

A New Direction

- Adopt a Formal Language Theory Perspective
- Analyze the complexity of signed vs spoken patterns
- Compare them to limits on phonological complexity (Heinz 2016)
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Outline

1. Overview
2. Complexity
3. Strictly Local Functions
4. Sign Language Locality
5. Conclusion
The Structure of Signed Syllables
The Subregular Hypothesis

Phonology is **Subregular**: it fits best into the sub-classes of the regular languages.

This case is being pursued by

Jeff Heinz  Jane Chandlee  Adam Jardine  Thomas Graf

... and others
Phonological Mappings are Subregular

McNaughton & Papert 1971; Rogers & Pullum 2011; Rogers et al. 2012; Heinz 2016; Mohri 1997; Chandlee 2014
Input Strictly Local Mappings

Strictly Local (SL; Chandlee 2014)

- define a window of segments of length $k$ to map from input to output
  - $k = 2$
  - ‘np’ → ‘mp’
- Move through string from left to right.
- Rewrite segment $x$ as $y$ based on previous $n$ symbols in input string
- Mapping never considers both input and output.
Example: Word-Final Devoicing

**SL$_{2}$-Mapping:** -son $\rightarrow$ -voice / _$\times$

**Input String:** TOD

**ISL Output**

$\times$ T O D $\times$
Example: Word-Final Devoicing

**SL$_2$-Mapping:** -son $\rightarrow$ -voice / _\x

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$\times$ T O D $\times$

$\times$
Example: Word-Final Devoicing

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$\times$ T O D $\times$

$\times$ T
Example: Word-Final Devoicing

\textbf{SL}_2\text{-Mapping}: \text{-son} \rightarrow \text{-voice} / _\chi_ \\
\text{Input String: TOD} \\
\text{ISL Output} \\
\times T O D \times \\
\times T
Example: Word-Final Devoicing

**SL$_2$-Mapping:** -son $\rightarrow$ -voice / _$\neq$

**Input String:** TOD

**ISL Output**

$\times$ T O D $\times$

$\times$ T O
Example: Word-Final Devoicing

**SL$_2$-Mapping:** -son $\rightarrow$ -voice / $\_\times$

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**ISL Output**

$\times$ T O D $\times$

$\times$ T O
Example: Word-Final Devoicing

\textbf{SL}^{2}\textbf{-Mapping}: \text{-son} \rightarrow \text{-voice} / _\times_

\textbf{Input String:} TOD

\textbf{ISL Output}

\begin{itemize}
  \item \times \quad T \quad O \quad D \quad \times
  \item \times \quad T \quad O
\end{itemize}
Example: Word-Final Devoicing

**SL$_2$-Mapping**: -son $\rightarrow$ -voice / _\x

**Input String**: TOD

**ISL Output**

\[
\begin{array}{cccc}
\times & T & O & D & \times \\
\times & T & O & T & \\
\end{array}
\]
Strictly Local To Sign Language

What Kind of Processes are Strictly Local?

- Substitution
- Deletion
- Epenthesison
- ‘Bounded’ Metathesis

Strictly Local Processes in Sign Language

- Non-Local Metathesis
- Partial Reduplication
- Compound reduction/Blending
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Strictly Local Processes in Sign Language

- Non-Local Metathesis
- Partial Reduplication
- Compound reduction/Blending
Chandlee 2014: Spoken Metathesis and Reduplication are Strictly Local processes

### Partial reduplication

<table>
<thead>
<tr>
<th>Marshallese</th>
<th>English</th>
<th>Marshallese</th>
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</tr>
</thead>
<tbody>
<tr>
<td>ebbok</td>
<td>'to make full'</td>
<td>ebbok-bok</td>
<td>'puffy'</td>
</tr>
<tr>
<td>ebbok-bok</td>
<td>'puffy'</td>
<td>susulat</td>
<td>'will write'</td>
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### Non-Local Metathesis

- Metathesis = Delete x Copy
- 'Long Distance Metathesis'
  - Cuzco Quechua (Davidson 1977)
  - yuraq → ruyaq, 'white'
  - aBc → cBa
ASL Final Syllable Reduplication

FAINT (ASL)

OVERSLEEP

(ASL)

\[ \sigma \\
L \quad M \quad L \\
a \quad b \quad \\
\text{the compound} \\
\]

\[ \sigma \\
L \quad M \quad L \\
a \quad b \quad \\
\text{the reduplicant} \\
\]

\[ \sigma_1 \\
L \quad M \quad L \\
a \quad b \quad c \\
\text{the compound} \\
\]

\[ \sigma_2 \\
L \quad M \quad L \\
b \quad c \quad \\
\text{the reduplicant} \\
\]

\[ \sigma_1 \\
L \quad M \quad L \\
a \quad b \quad (M) \\
\]

\[ \sigma_2 \\
L \quad L \\
b \quad c \quad c \\
\]
ASL Final Syllable Reduplication

\( \sigma_1 \quad \sigma_2 \quad \sigma_2 \)

- \( L \quad M \quad L \quad M \quad L \)
- \( a \quad b \quad c \)
- the compound

- \( L \quad M \quad L \)
- \( b \quad c \)
- the reduplicant

Window Length: 4 segments
ISL\(_4\) Mapping: \( \emptyset \rightarrow \text{LML / LML\text{--\;\;}\text{x}} \)
Input String: LMLML

\( \times \quad L \quad M \quad L \quad M \quad L \quad \text{x} \)
ASL Final Syllable Reduplication

Window Length: 4 segments
ISL\textsubscript{4} Mapping: $\emptyset \rightarrow \text{LML} / \text{LML} \_\_ \_\_\_ \times$
Input String: LMLMLML

× L M L M L ×
ASL Final Syllable Reduplication

Window Length: 4 segments

ISL₄ Mapping: $\emptyset \rightarrow \text{LML / LML}_\text{-}^\text{×}$

Input String: LMLML

$\boxtimes$ L M L M L $\boxtimes$

L
ASL Final Syllable Reduplication

Window Length: 4 segments
ISL₄ Mapping: ∅ → LML / LML⁻⁻×
Input String: LMLML

× L M L M L ×
L
ASL Final Syllable Reduplication

Window Length: 4 segments

ISL₄ Mapping: $\emptyset \rightarrow \text{LML / LML}$

Input String: LMLML

$\otimes$ L M L M L
L M
ASL Final Syllable Reduplication

Window Length: 4 segments
ISL₄ Mapping: $\emptyset \rightarrow \text{LML / LML}_\_\_\_\_\_\_\times$
Input String: LMLML

$\times$ L M L M L $\times$
L M
ASL Final Syllable Reduplication

Window Length: 4 segments
ISL$_4$ Mapping: $\emptyset \rightarrow \text{LML / LML}_{--\times}$
Input String: LMLML

\[
\begin{array}{c}
\sigma_1 \\
L \quad M \quad L \\
a \\
\sigma_2 \\
L \quad M \quad L \\
b \\
\sigma_2 \\
L \quad M \quad L \\
c \\
\end{array}
\]

the compound
the reduplicant
ASL Final Syllable Reduplication

Window Length: 4 segments
ISL₄ Mapping: $\emptyset \rightarrow \text{LML / LML}_-$
Input String: LMLML

\[
\begin{array}{c}
\sigma_1 \\
L & M & L \\
a & b & c \\
\text{the compound}
\end{array}
\quad \begin{array}{c}
\sigma_2 \\
L & M & L \\
b & c \\
\text{the reduplicant}
\end{array}
\]

$\otimes$ L M L M L $\otimes$
L M L M
ASL Final Syllable Reduplication

Window Length: 4 segments
ISL₄ Mapping: ∅ → LML / LML
Input String: LMLML

× L M L M L
L M L M
ASL Final Syllable Reduplication

Window Length: 4 segments

ISL$_4$ Mapping: $\emptyset \rightarrow \text{LML / LML}$

Input String: LMLML

$\times$ L M L M L LML
### Metathesis and Reduplication

Chandlee 2014: Spoken Metathesis and Reduplication are Strictly Local processes

#### Partial reduplication

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  - aBc $\rightarrow$ cBa
Metathesis

a. FATHER  DEAF (ASL)
b. MOTHER  DEAF (ASL)
Metathesis

ISL4 Mapping: \[ aBc \rightarrow cBa \]

Window: 4 segments

Input String: \[ L_1ML_2L_3ML_2 \]
Metathesis

ISL4 Mapping: $aBc \rightarrow cBa$
Window: 4 segments
Input String: $L_1ML_2L_3ML_2$

$\times \quad L_1 \quad M \quad L_2 \quad L_3 \quad M \quad L_2 \quad \times$
Metathesis

ISL4 Mapping: \[ \text{aBc} \rightarrow \text{cBa} \]

Window: 4 segments

Input String: \( L_1 ML_2 L_3 ML_2 \)

\[ \times \quad L_1 \quad M \quad L_2 \quad L_3 \quad M \quad L_2 \quad \times \]

\[ \times \quad L_1 \]

\( L_1 \)
Metathesis

ISL4 Mapping:  \( \text{aBc} \rightarrow \text{cBa} \)

Window: 4 segments

Input String:  \( L_1ML_2L_3ML_2 \)

\[ \times \]

\[ L_1 \quad M \quad L_2 \quad L_3 \quad M \quad L_2 \quad \times \]

\[ L_1 \quad M \quad L_1 \quad M \]
Metathesis

ISL4 Mapping:  
Window:  
Input String:  

ɑbC → cBa  
4 segments  
$L_1ML_2L_3ML_2$  

$\times L_1 M L_2 L_3 M L_2 \times$
Metathesis

ISL4 Mapping: $aBc \rightarrow cBa$
Window: 4 segments
Input String: $L_1ML_2L_3ML_2$

$\times \quad L_1 \quad M \quad L_2 \quad L_3 \quad M \quad L_2 \quad \times$

$\times \quad L_1 \quad M \quad L_2$

$\times \quad L_1 \quad M$
Metathesis

ISL4 Mapping: \( aBc \rightarrow cBa \)

Window: 4 segments

Input String: \( L_1ML_2L_3ML_2 \)

\( \times L_1 M L_2 L_3 M L_2 \times \)
\( \times L_1 M L_2 \)
Metathesis

ISL4 Mapping: \textbf{aBc} \rightarrow \textbf{cBa}

Window: 4 segments

Input String: \textbf{L}_1\textbf{ML}_2\textbf{L}_3\textbf{ML}_2

\[
\begin{array}{cccc}
\otimes & L_1 & M & L_2 \\
L_1 & M & L_2 & L_3 \\
& L_2 & M & L_3
\end{array}
\]
Compound Reduction

a. MIND

b. DROP

c. FAINT (ASL)
Compound Reduction

a. MIND

b. STOP (suspend)

c. MIND^STOP = DAYDREAM
Compound Reduction

a. THINK

b. MARRY

c. BELIEVE
Compound Reduction

a. THINK

b. MARRY

c. BELIEVE

L1 [prox] M L2 [contact] L3 [medial] M L4 [contact] → L2 M L4 [contact] [head] [non-dominant hand] [head] [hand]
Compound Reduction

Window Size: 4

ISL4 Mapping: $\times L_1^1 M_1^1 L_2^1 L_3^2 M_2^2 L_4^2 \times L_2^2 M_2^2 L_4^2 \times$
Conclusion

Today’s Results

- Strict Locality Across Modalities for:
  - Bounded Metathesis
  - Partial Reduplication
  - Compound Reduction

- The Subregular Hypothesis seems to hold regardless of the phonetic system

- Some phonological processes are "algebraic", and some part of phonology is independent
Conclusion

Predictions

- Any (morpho)phonological process/structure in sign should have the same subregular complexity class as its spoken counterpart
- If not, or any part of Sign phonology is more than subregular, then either:
  - the subregular hierarchy is not expressive enough
  - the signed modality imposes a different complexity than the oral modality
  - the “algebraic” view is wrong
Conclusion

Future Directions

- Suprasegmental vs segmental dichotomy (Jardine 2015)
- Handshape Configuration
  - Eccarius OT Dissertation
- Typological similarities
- Why stop at phonology?

The aim is to see *complete nature* as different aspects of *one set* of phenomena.

- Richard Feynman, *Six Easy Pieces*
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The Structure of Signed Syllables

**Diagram:**
- **HC** (Head Contact)
- **L** (Left)
- **M**
- **R** (Right)

- **[head]**
- **[contact]**
- **[+ipsi]**
- **[+proximal]**

**Image:**
- **IDEA (ASL)**