DEVELOPING AN ARTICULATORY MODEL OF HANDSHAPE

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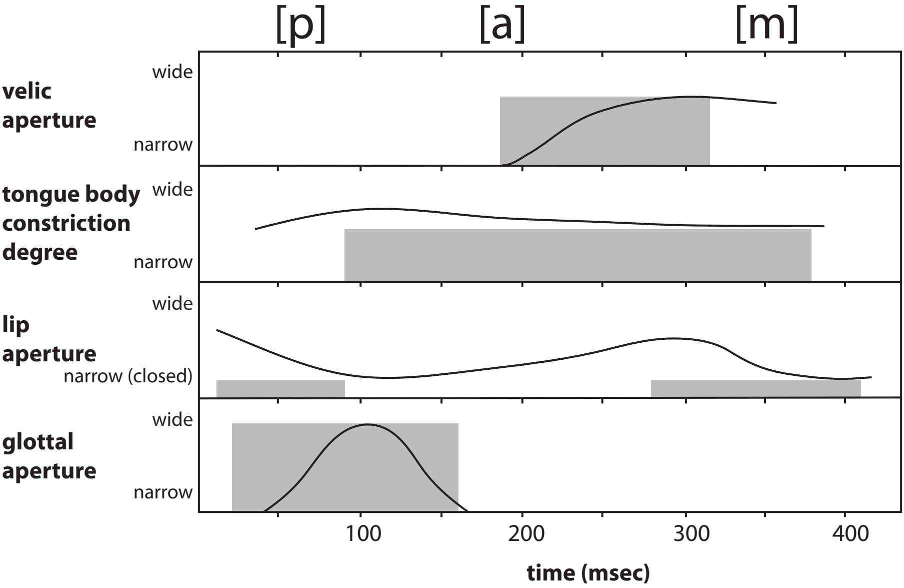
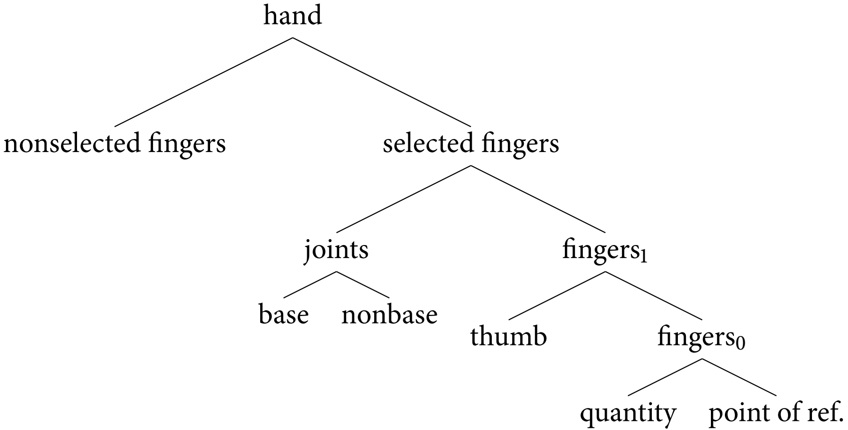
Goals of this talk

1. Translate models of spoken language articulatory phonology to handshape
2. Provide an explicit method of phonetic implementation for handshape
3. Use this model to make predictions about variation in handshape



adapted from (Browman and Goldstein, 1992, pp28)

Handshape portion from the Prosodic Model



(Brentari, 1998)

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- are described as the most salient fingers for a given handshape,
- are often (but not always!) extended, with other fingers (more) flexed,
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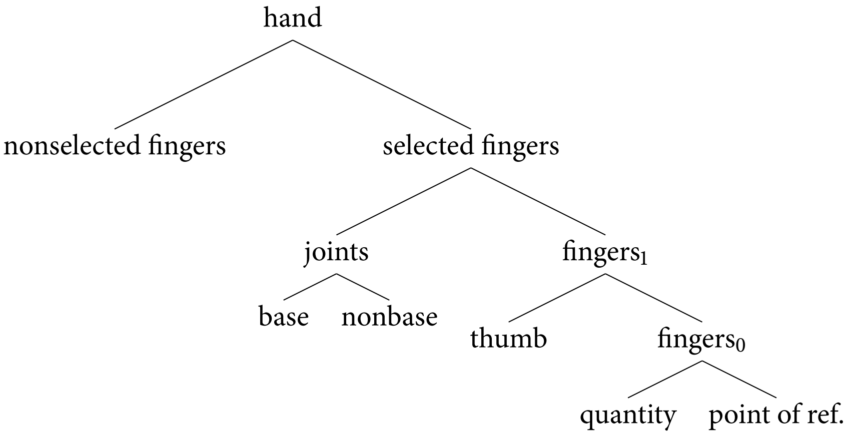
There is independent evidence for their existenc:e

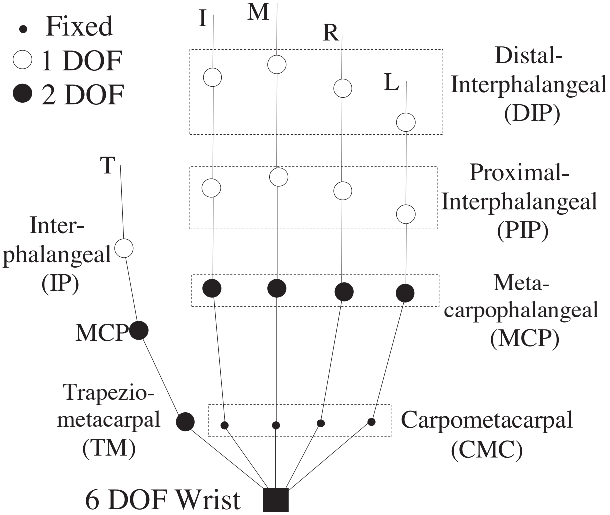
- restrictions on handshapes in signs,
- selected fingers contact the body,
- selected fingers are preserved in compounds.

Handshape portion from the Prosodic Model



(Brentari, 1998)

Degrees of freedom



Erol et al. (2005)

The articulatory model of handshape

group	joint	tract variable	values
selected fingers	MCP	SF-MCP	-15–90°
	PIP	SF-PIP	0–90°
	MCP	SF-ABDUCTION	[±ABDUCTED]

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nonselected fingers	all	nsf	[±FLEXED]

Johnson and Liddell phonetic representation

1. flexion specification for each joint (4–6 categories)
2. abduction between each pair of fingers (7 categories)
3. thumb CM rotation (3 categories)
4. thumb CM abduction (3 categories)

Johnson and Liddell (2011a,b); Liddell and Johnson (2011a,b)

General hypotheses

A. Because gestures are dynamic individual handshapes, the articulators that make up the hand will not be static, sequential elements, but rather individual articulator gestures, involving all parts of the hand (eg, digits, wrist), will overlap across several hand configurations.

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B. The hand configuration of a specific segment will vary in predictable ways based on the surrounding context.

Specific hypotheses

1. The nonselected (nonactive) fingers are more frequently the targets of coarticulatory pressure (vs. selected (active) fingers).

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2. The selected fingers are the sources of coarticulatory pressure.
3. Finger configuration that is due to (phonetic) coarticulatory pressure will differ from configuration due to phonological specification (ie, gradient in extension, time, etc. vs. categorical in nature).

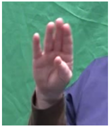
Why ASL fingerspelling?

Fingerspelling is a loanword system for borrowing written English words into ASL. It involves quick and sequential handshape changes, unlike signing. This results in an ideal data set to look at variation in handshape because there are

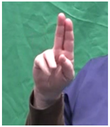
- a large number of individual tokens
- a huge variety of contexts
- most of the handshapes in ASL

B-U-I-L-D-I-N-G; half speed

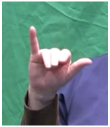
building.mp4



-B-



-U-



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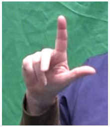
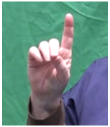
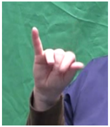


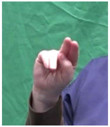
*-L-



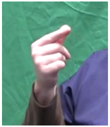
*-D-



-I-



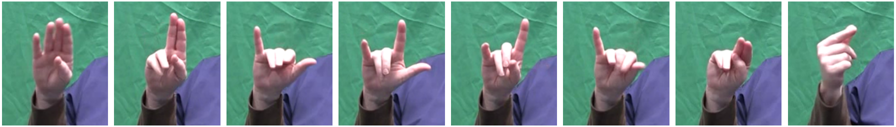
-N-



-G-

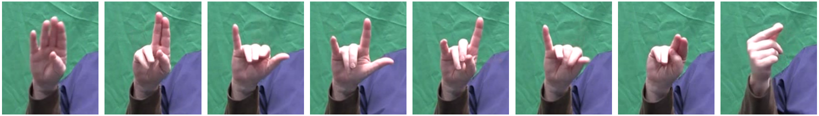
B-U-I-L-D-I-N-G; half speed

building.mp4

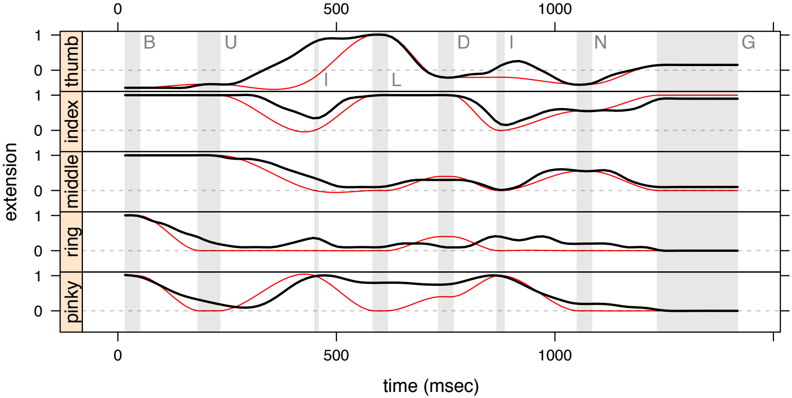


-B- -U- -I- -L- -D- -I- -N- -G-

Gestural score for B-U-I-L-D-I-N-G



-B- -U- -I- -L- -D- -I- -N- -G-



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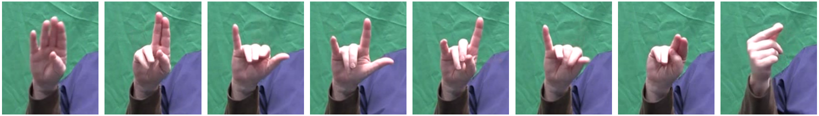

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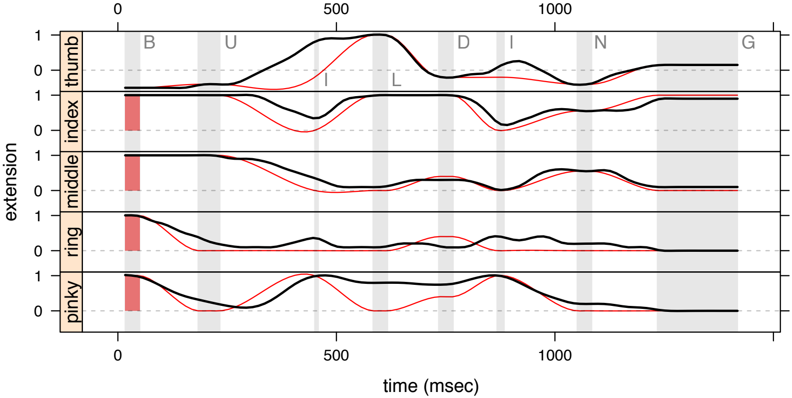

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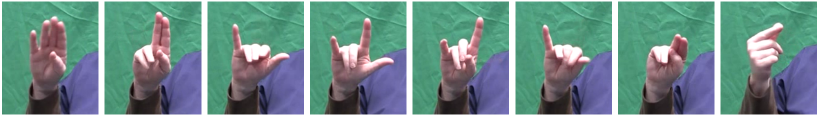
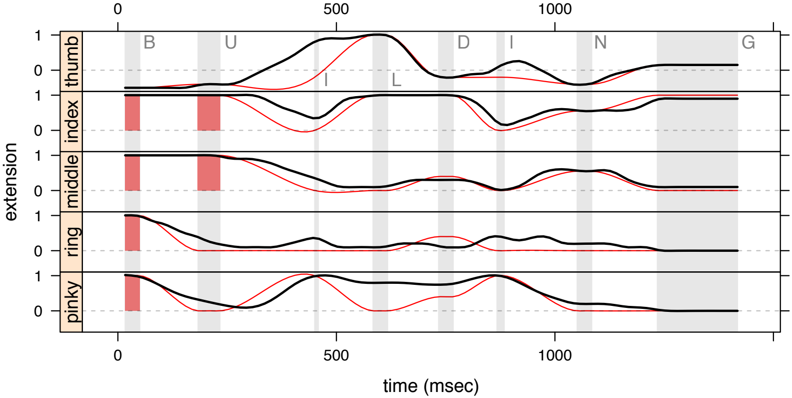


-B- -U- -I- -L- -D- -I- -N- -G-



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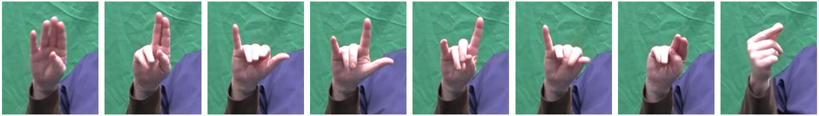

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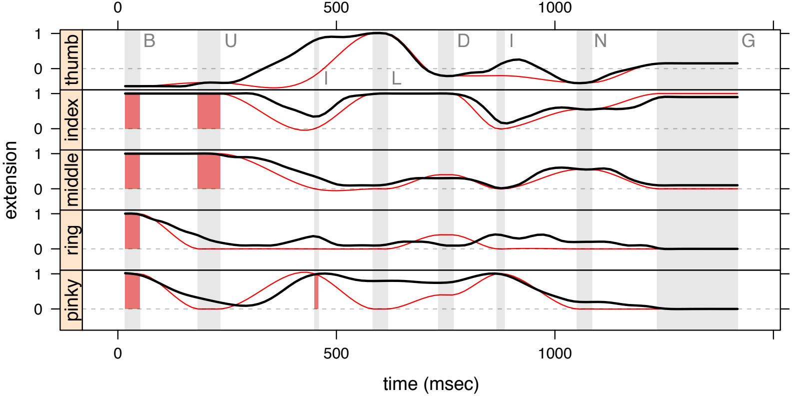

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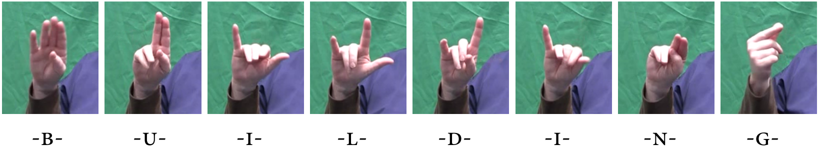

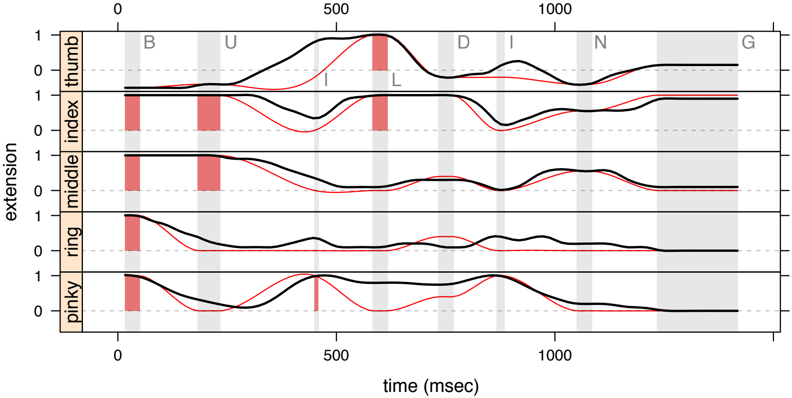

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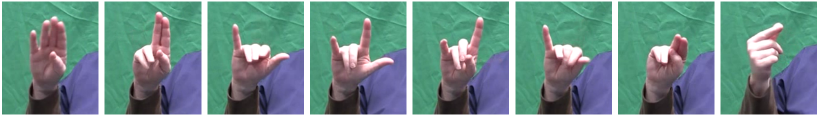
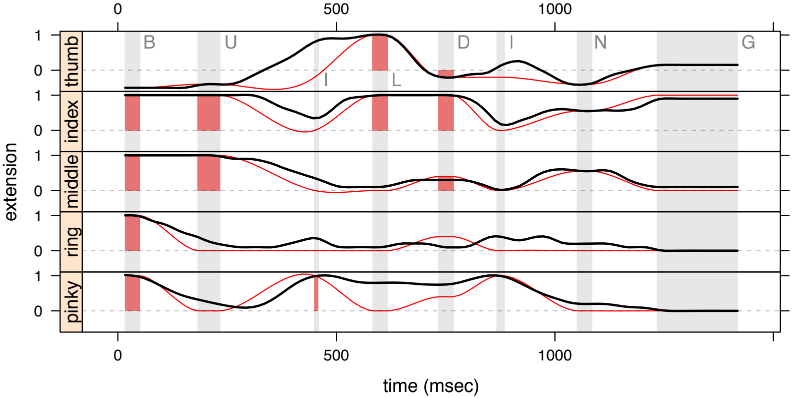


-B- -U- -I- -L- -D- -I- -N- -G-



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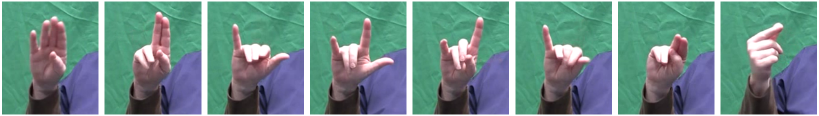

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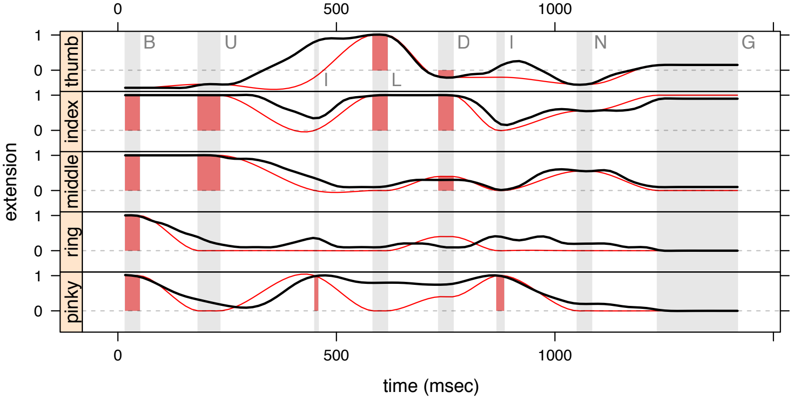

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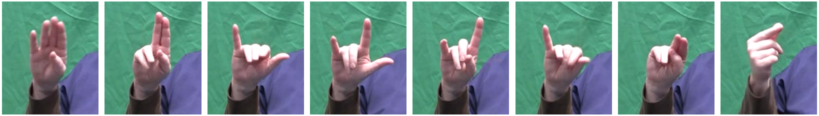

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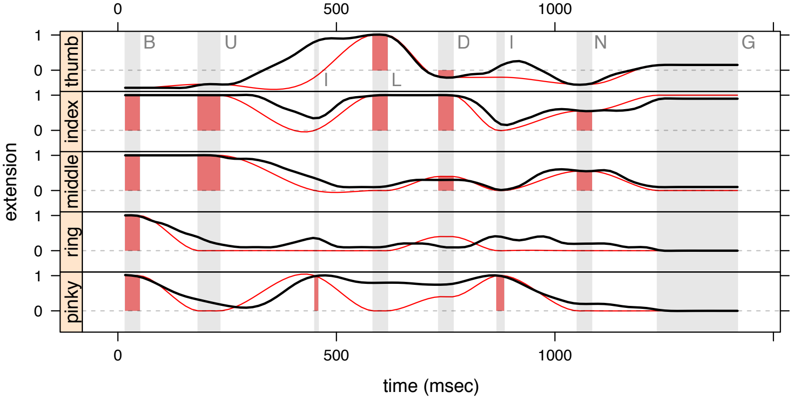

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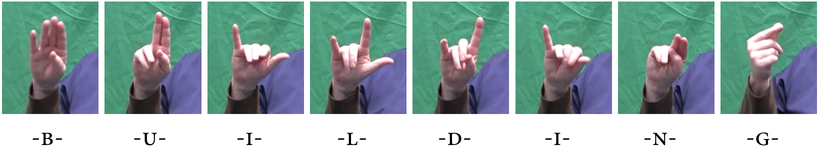
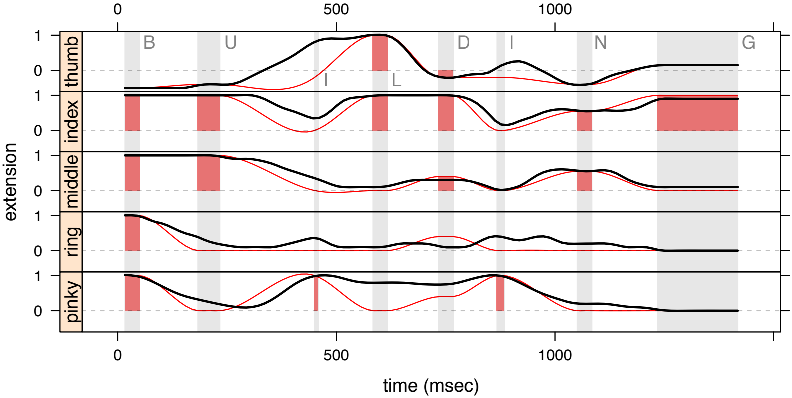




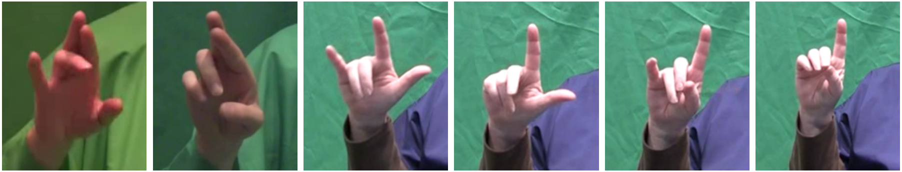
Data collection

- 4 native signers, 1 early leaner (4 coded so far) produced
- 600 words
    - 100 names
    - 100 nouns
    - 100 non-English words
    - 300 most frequent nouns from CELEX
- repeating each word twice
- being recorded by 2 or 3 video cameras
- recording at 60 FPS
- for a total of 14,169 apogees

Pinky extension

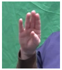
A still image of each apogee was annotated for pinky extension, defined as:

- The tip of the pinky was above the plane perpendicular to the palmar plane, at the base of the pinky finger (the MCP joint).
- The proximal interphalangeal joint (PIP) was more than half extended.



-R- [+ext] -R- [−ext] -L- [+ext] -L- [−ext] -D- [+ext] -D- [−ext]

What affects the -L- handshape?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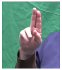
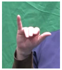
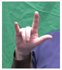
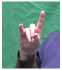
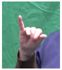
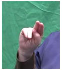

-U-

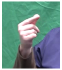

-I-

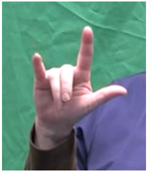

-L-


-D-


-I-


-N-


-G-



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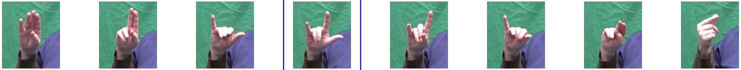
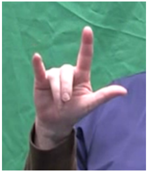


-B- -U- -I- -L- -D- -I- -N- -G-



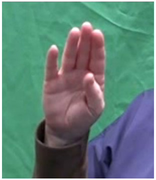
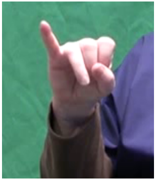
↑

apogee handshape

-B-, -C-, -F-, -I-, -J-, or -Y-;

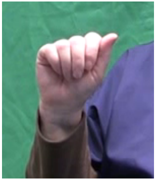
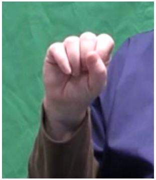
-A-, -S-, -E-, or -O-; other

apogee handshape groups

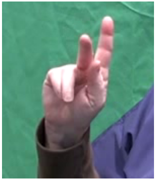
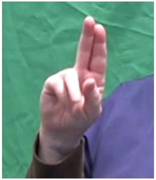
Extended (and selected) pinky:

-B-, -C-, -F-, -I-, -J-, or -Y-

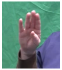
Flexed and selected pinky:

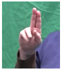
-A-, -S-, -E-, or -O-

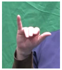



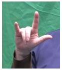
other

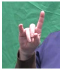
What affects the -L- handshape?

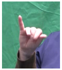

-B-

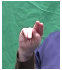

-U-

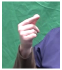

-I-


-L-

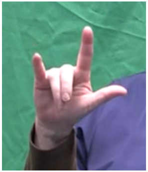

-D-


-I-


-N-


-G-

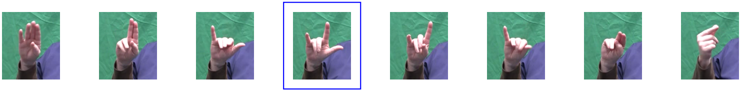
word type
name; noun;
non-English
↙



↑

apogee handshape
-B-, -C-, -F-, -I-, -J-, or -Y-;
-A-, -S-, -E-, or -O-; other

What affects the -L- handshape?



-B- -U- -I- -L- -D- -I- -N- -G-

local transition time

zscore of log(time)

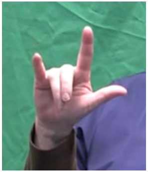
↓

word type

name; noun;

non-English

↙



↑

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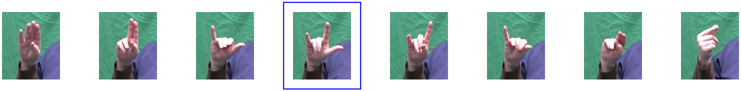


-B- -U- -I- -L- -D- -I- -N- -G-

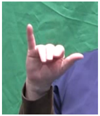
local transition time

zscore of log(time)

word type

name; noun;

non-English



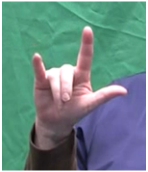
previous handshape

-B-, -C-, or -F-;

-I-, -J-, or -Y-;

other;

word boundary



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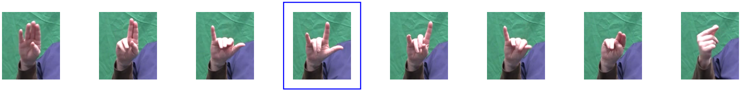
What affects the -L- handshape?



-B- -U- -I- -L- -D- -I- -N- -G-

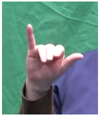
local transition time

zscore of log(time)

word type

name; noun;

non-English



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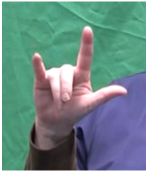
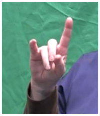




following handshape

-B-, -C-, or -F-;

-I-, -J-, or -Y-;

other;

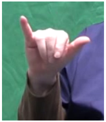
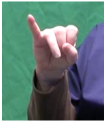
word boundary

apogee handshape

-B-, -C-, -F-, -I-, -J-, or -Y-;

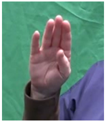
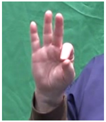
-A-, -S-, -E-, or -O-; other

previous/following handshape groups

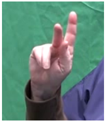
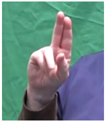
Extended pinky (alone):

-I-, -J-, or -Y-

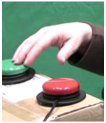
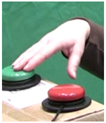



Extended pinky (with other fingers):

-B-, -C-, or -F-

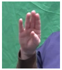



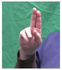
other

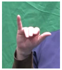



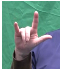
word boundary

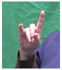
What affects the -L- handshape?

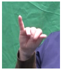

-B-

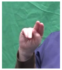

-U-

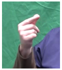

-I-


-L-


-D-


-I-


-N-

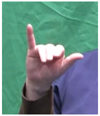

-G-

interaction →

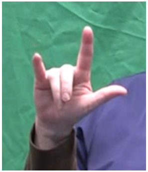
local transition time
zscore of log(time)

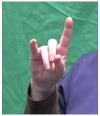
← *interaction*

word type
name; noun;
non-English



previous handshape
-B-, -C-, or -F-;
-I-, -J-, or -Y-;
other;
word boundary





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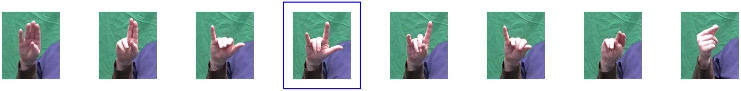
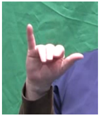


-B- -U- -I- -L- -D- -I- -N- -G-

local transition time
zscore of log(time)

interaction → ← *interaction*

word type
name; noun;
non-English



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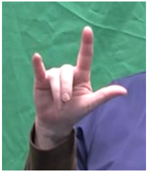

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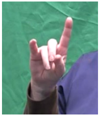

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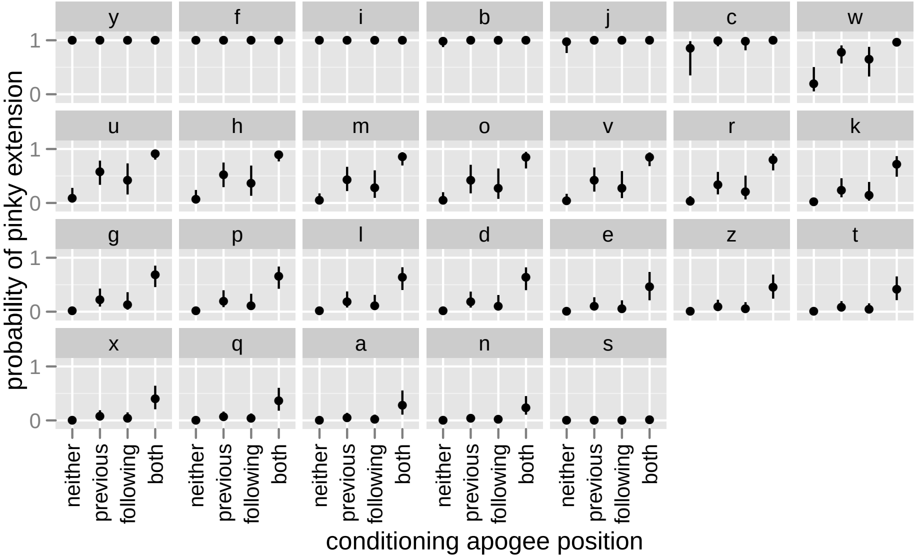
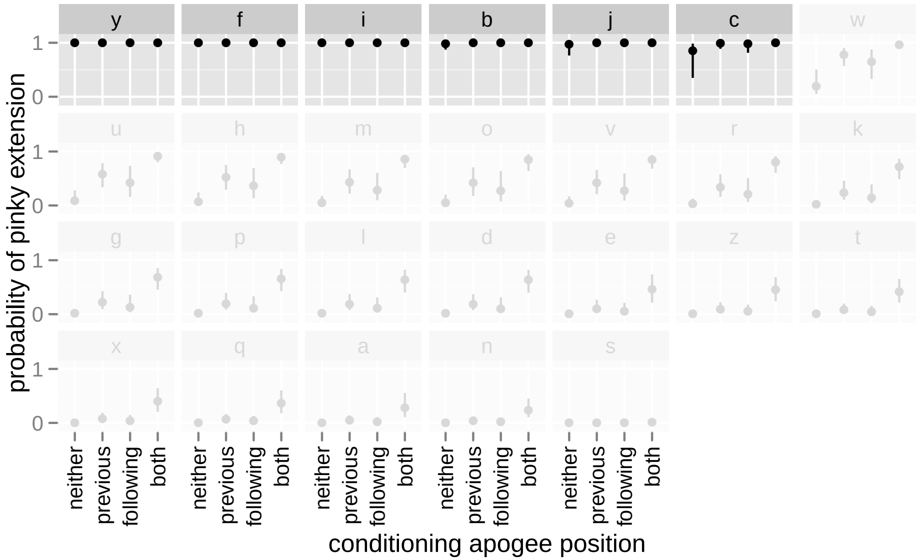
word boundary

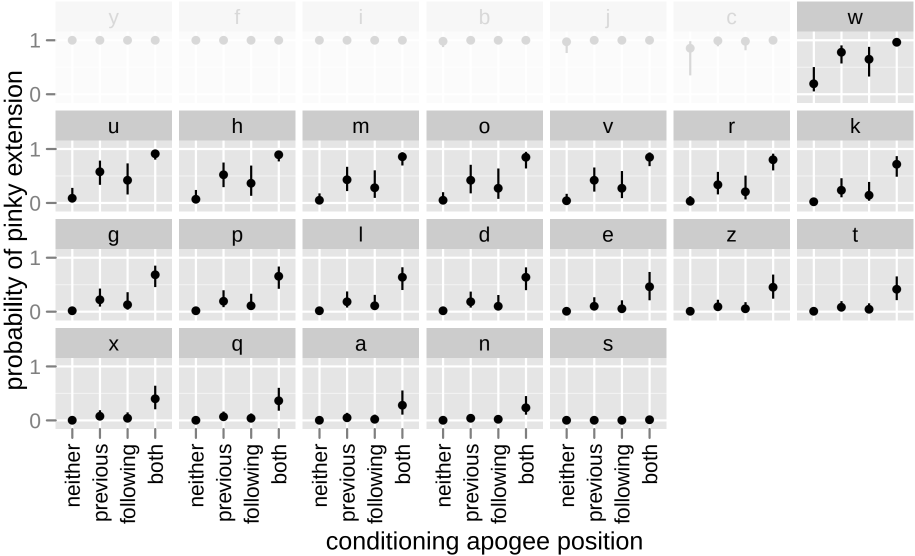
Model predictions around -I-, -J-, or -Y-



Model predictions around -I-, -J-, or -Y-



Model predictions around -I-, -J-, or -Y-



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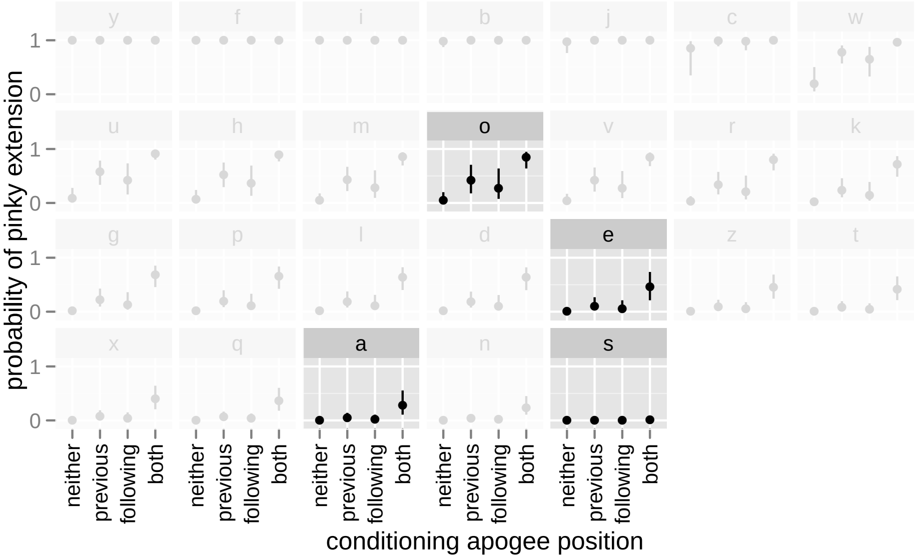
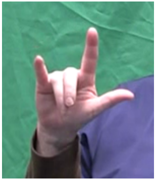
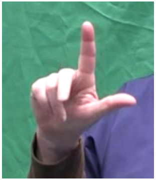
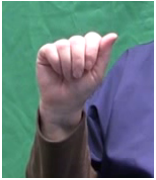
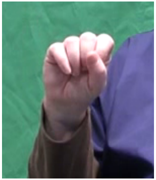


What's special about -A-, -S-, -E-, and -O-

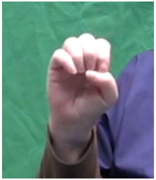
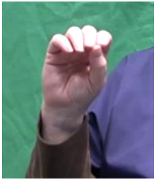
Flexed and nonselected pinky:

-L- with and without pinky extension

Flexed and selected pinky:

-A- and -S- have nearly no pinky extension

Flexed and selected pinky:

-E- and -O- both are close to the edge of our coding scheme for pinky extension.

Conclusions

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   - 3.2 The selected fingers are the sources of coarticulatory pressure.
   - 3.3 Finger configuration that is due to (phonetic) coarticulatory pressure will differ from configuration due to phonological specification (ie, gradient in extension, time, etc. vs. categorical in nature).

I must also acknowledge the contributions of many who contributed in ways big and small:

Fingerspelling data
Andy Gabel, Rita Mowl, Drucilla Ronchen, and Robin Shay

Main advisors
Diane Brentari, Jason Riggle, and Karen Livescu

Other researchers
Susan Rizzo, Greg Shakhnarovich, Raquel Urtasun, Rachel Hwang, Katie Henry, Julia Goldsmith-Pinkham, and Linda Liu.

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NSF Doctoral Dissertation Research Improvement Grant Coarticulation and the phonetics of fingerspelling BCS 1251807 and the Rella I Cohn fund for graduate student research

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