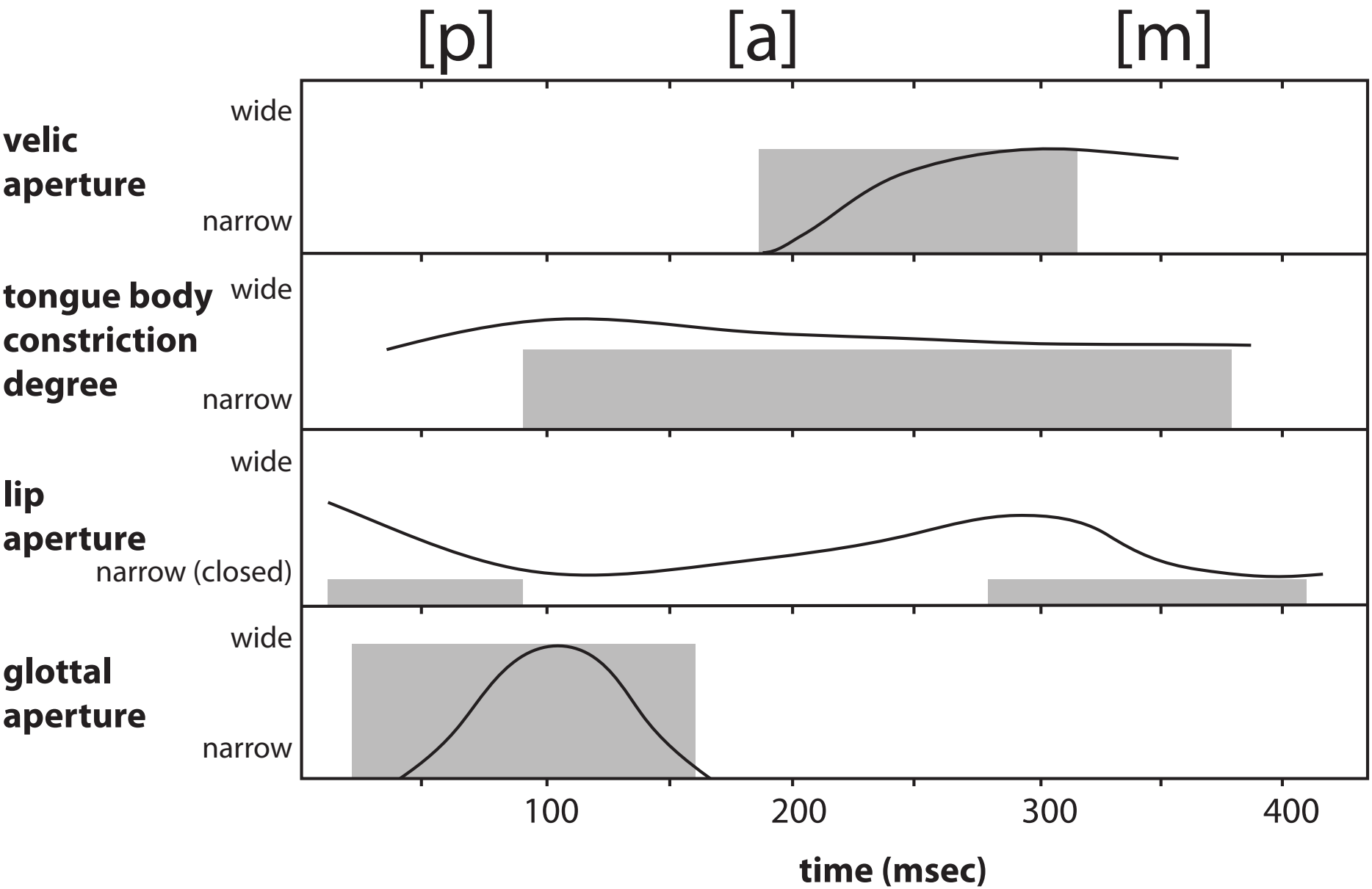
WHAT HANDSHAPE TELLS US ABOUT ACTIVE VERSUS INACTIVE ARTICULATORS

Jonathan Keane

University of Chicago

Goals of this talk

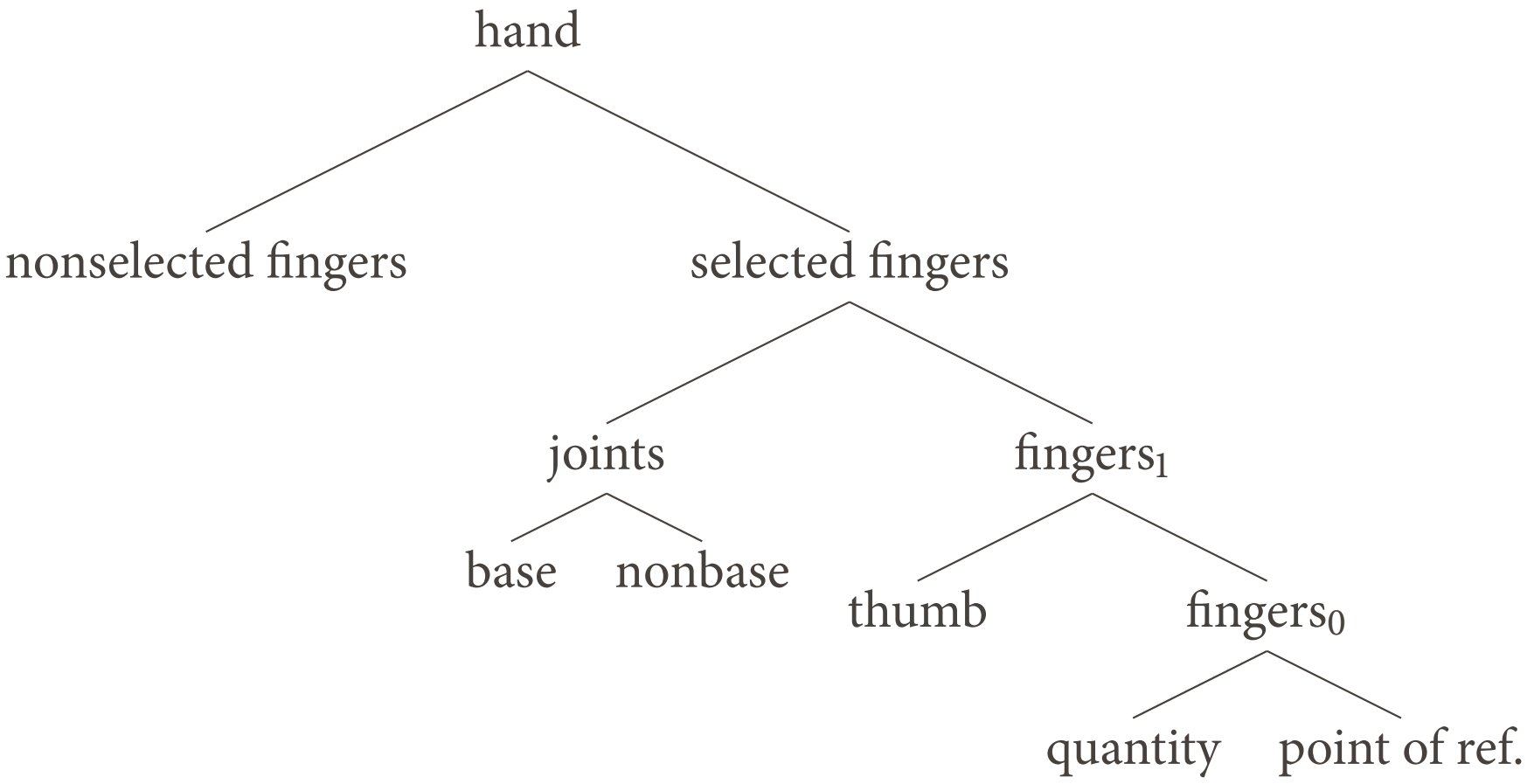
1. Translate models of spoken language articulatory phonology to handshape
2. Provide an explicit method of phonetic implementation for handshape
3. Use this model to make predictions about variation in handshape



adapted from (Browman and Goldstein, 1992, pp28)

Sign language phonology

Handshape portion from the Prosodic Model



(Brentari, 1998)

Selected fingers

- are described as the most salient fingers for a given handshape,
- are often (but not always!) extended, with other fingers (more) flexed,
- are used by many models of sign language phonology.

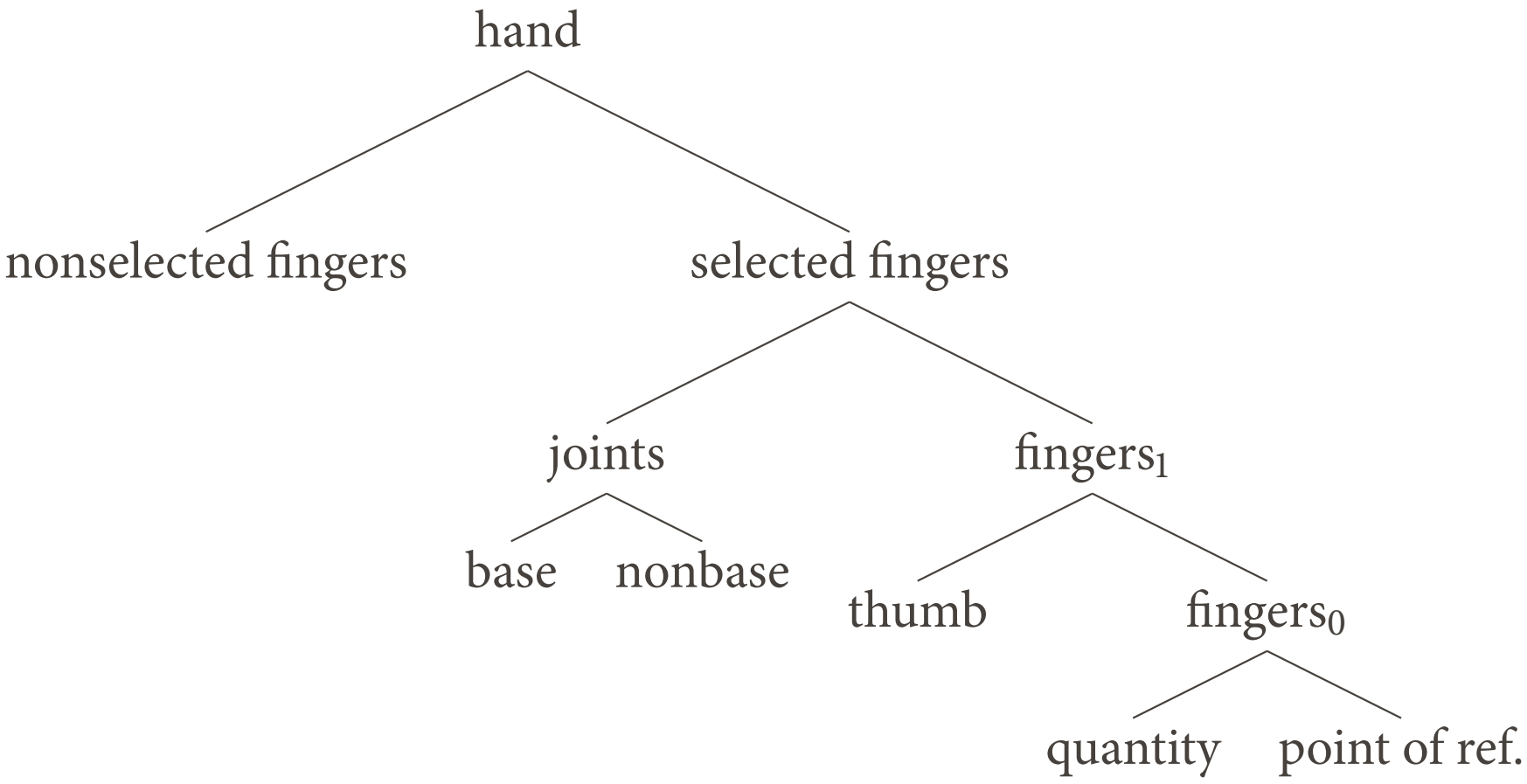
Selected fingers

- are described as the most salient fingers for a given handshape,
- are often (but not always!) extended, with other fingers (more) flexed,
- are used by many models of sign language phonology.

There is independent evidence for their existence:

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

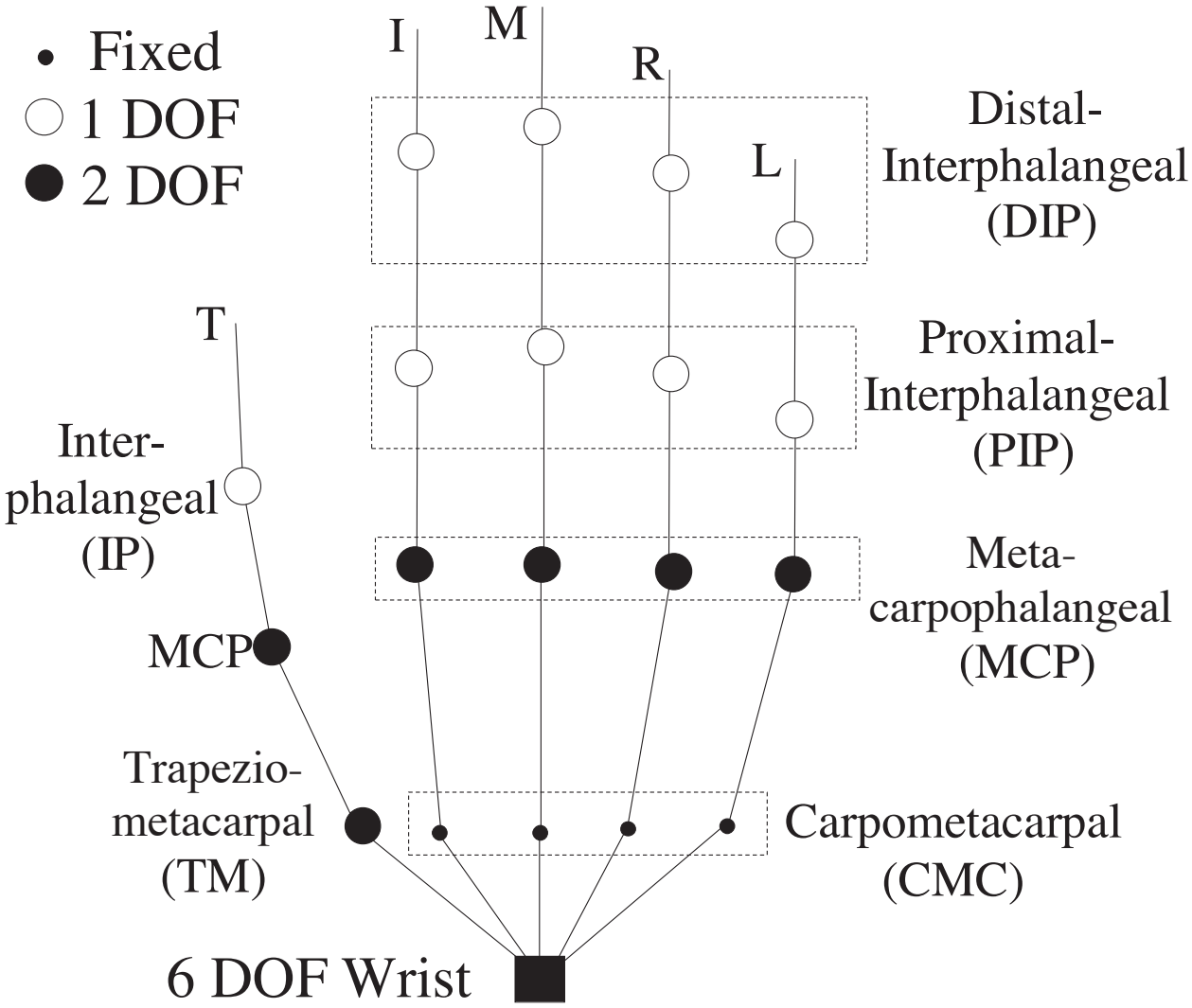
Handshape portion from the Prosodic Model



(Brentari, 1998)

Handshape tract variables

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]

Broadly compatible with phonological models Sandler (1989); Brentari (1998) among others; as well as phonetic models like Johnson and Liddell (2011a,b); Liddell and Johnson (2011a,b).

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]
secondary selected fingers	MCP	SSF-MCP	-15–90°
	PIP	SSF-PIP	0–90°

Broadly compatible with phonological models Sandler (1989); Brentari (1998) among others; as well as phonetic models like Johnson and Liddell (2011a,b); Liddell and Johnson (2011a,b).

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]
secondary selected fingers	MCP	SSF-MCP	-15–90°
	PIP	SSF-PIP	0–90°
thumb opposition	CM	CM-OPPOSITION	-45–90°
thumb abduction	CM	CM-ABDUCTION	0–90°

Broadly compatible with phonological models Sandler (1989); Brentari (1998) among others; as well as phonetic models like Johnson and Liddell (2011a,b); Liddell and Johnson (2011a,b).

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]
secondary selected fingers	MCP	SSF-MCP	-15–90°
	PIP	SSF-PIP	0–90°
thumb opposition	CM	CM-OPPOSITION	-45–90°
thumb abduction	CM	CM-ABDUCTION	0–90°
nonselected fingers	all	NSF	[±FLEXED]

Broadly compatible with phonological models Sandler (1989); Brentari (1998) among others; as well as phonetic models like Johnson and Liddell (2011a,b); Liddell and Johnson (2011a,b).

Predictions

General hypotheses

1. Because gestures are dynamic, signing does not consist of static, sequential handshapes, but rather articulator gestures which blend into each other.

General hypotheses

1. Because gestures are dynamic, signing does not consist of static, sequential handshapes, but rather articulator gestures which blend into each other.

2. 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).

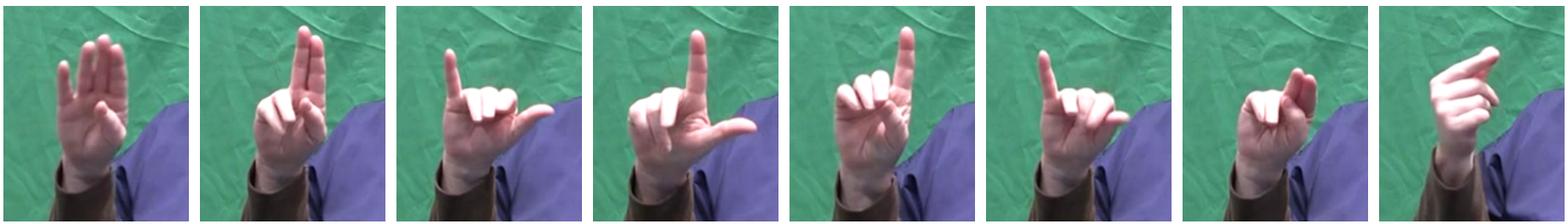
Specific hypotheses

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

2. The selected fingers are the sources of coarticulatory pressure.

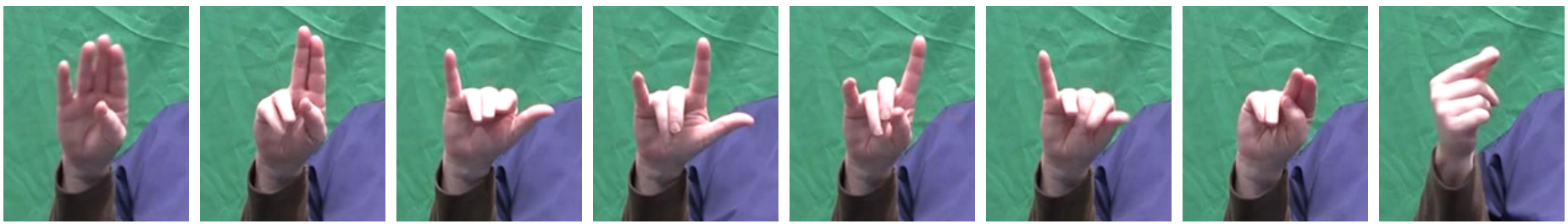
Case study: B-U-I-L-D-I-N-G

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



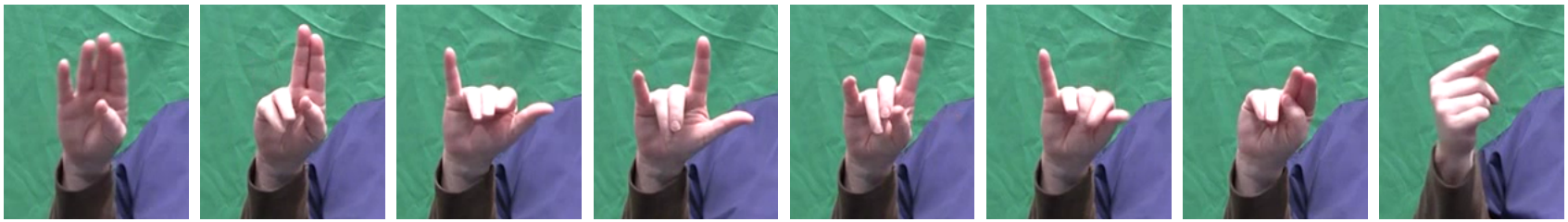
-B- -U- -I- *-L- *-D- -I- -N- -G-

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

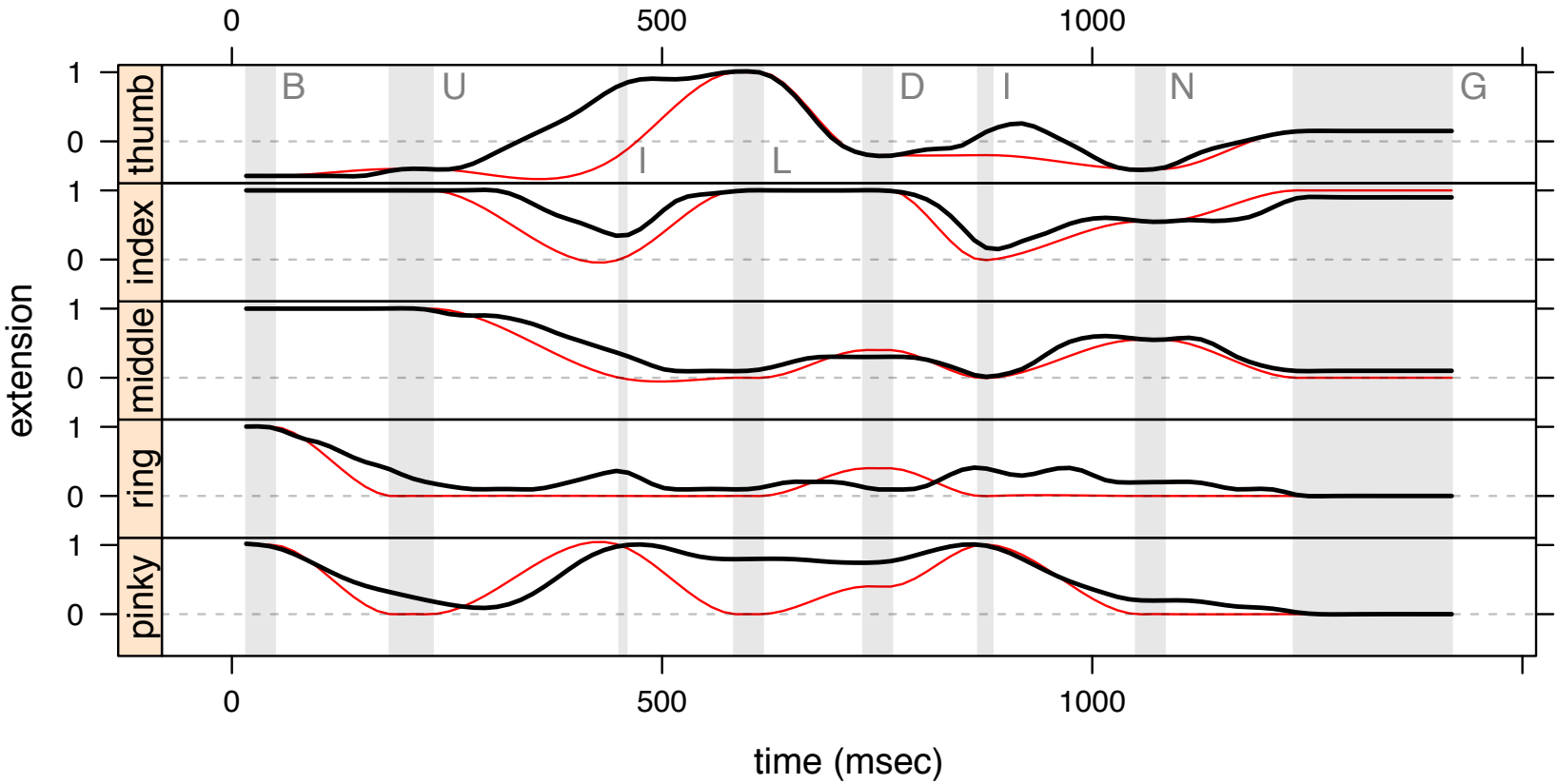


-B- -U- -I- -L- -D- -I- -N- -G-

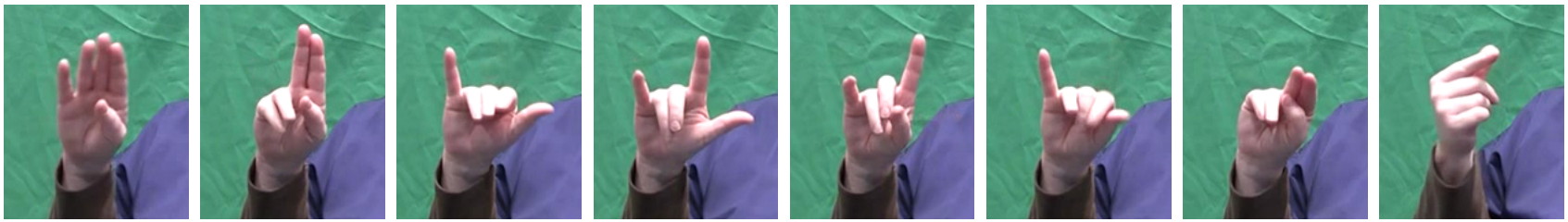
Gestural score for B-U-I-L-D-I-N-G



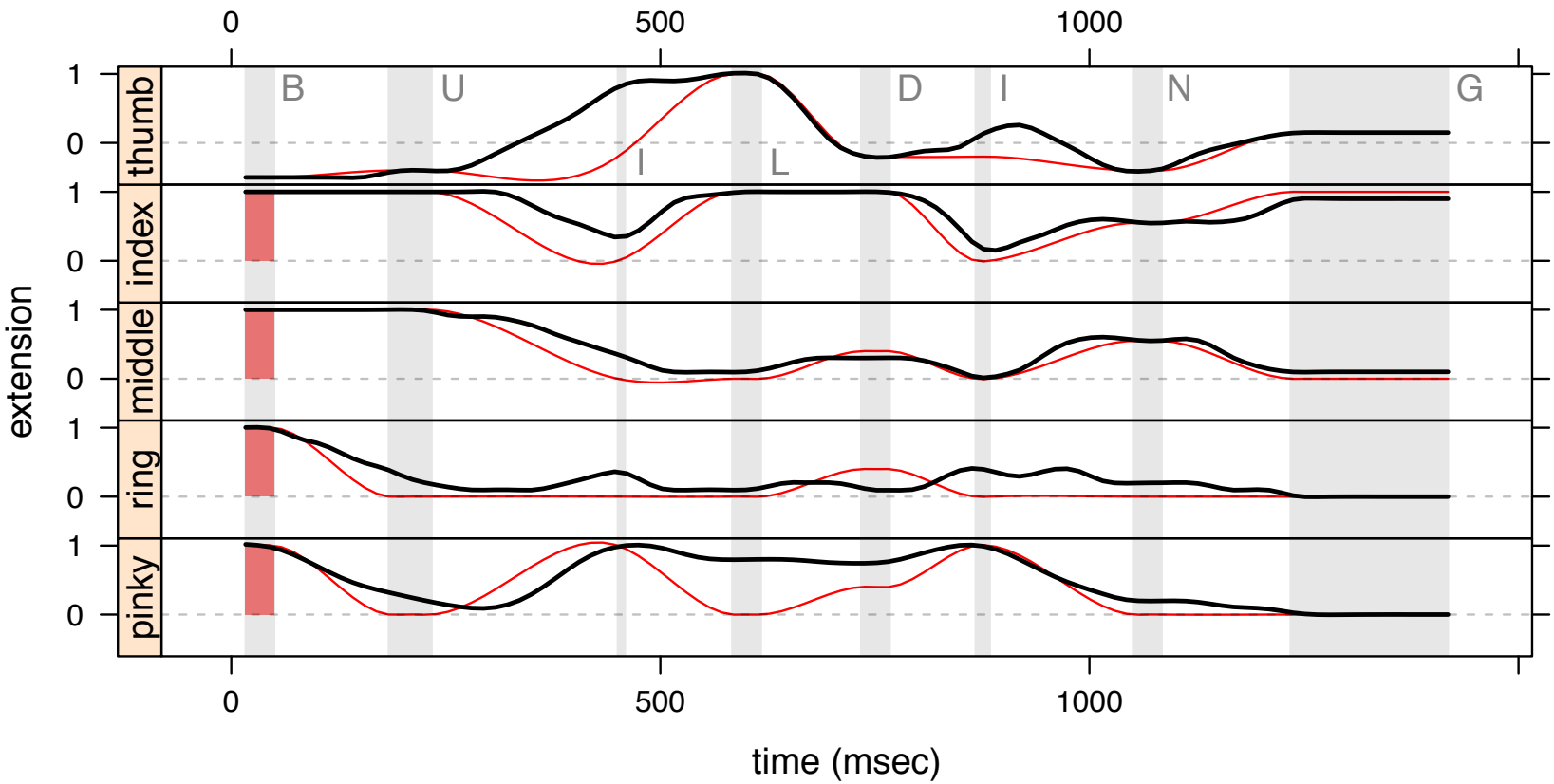
-B- -U- -I- -L- -D- -I- -N- -G-



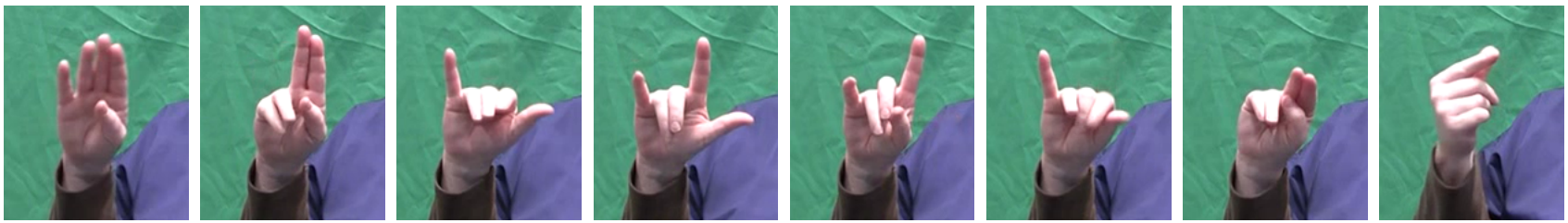
Gestural score for B-U-I-L-D-I-N-G



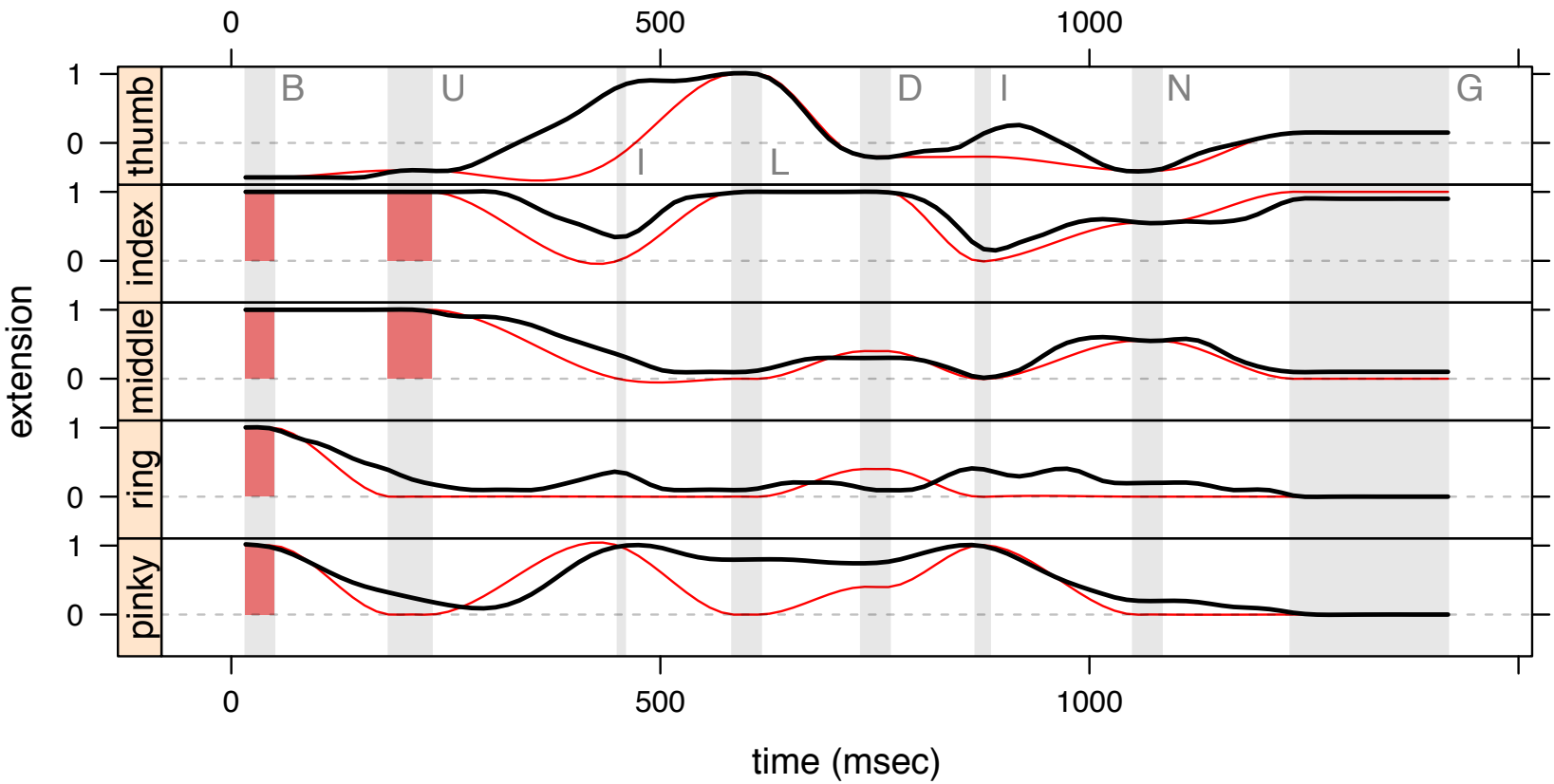
-B- -U- -I- -L- -D- -I- -N- -G-



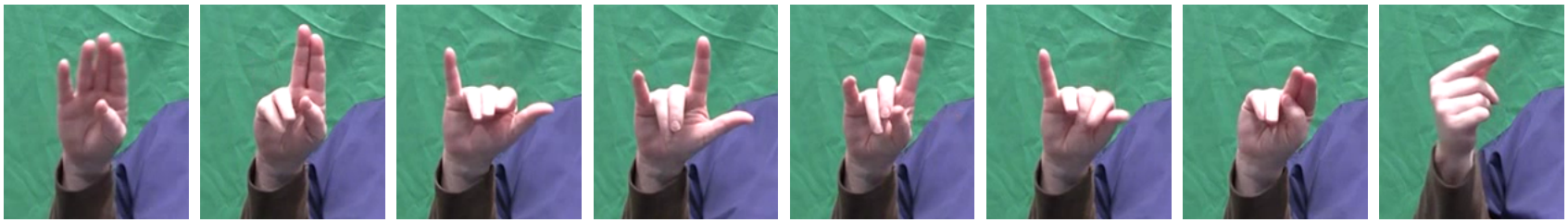
Gestural score for B-U-I-L-D-I-N-G



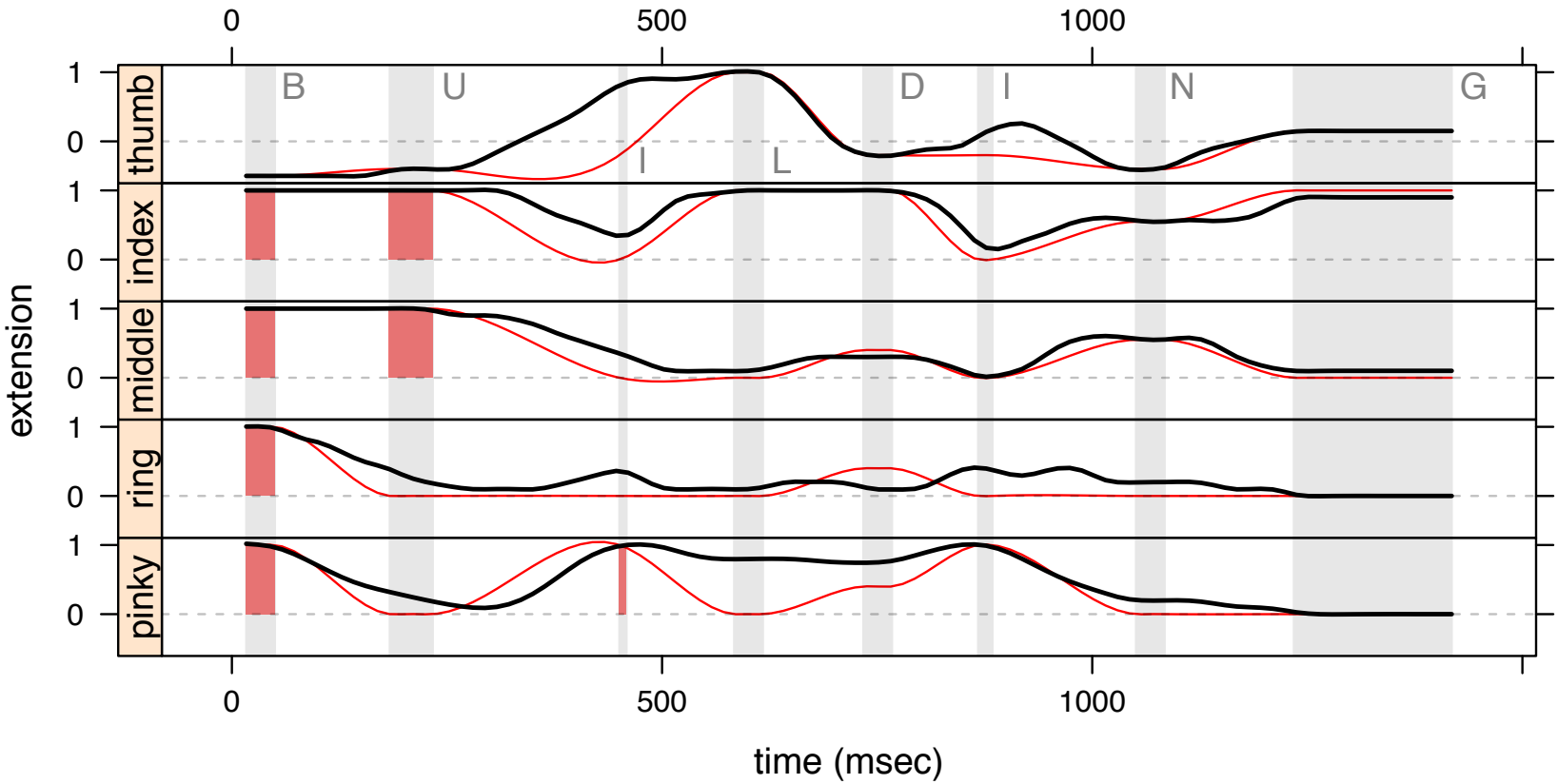
-B- -U- -I- -L- -D- -I- -N- -G-



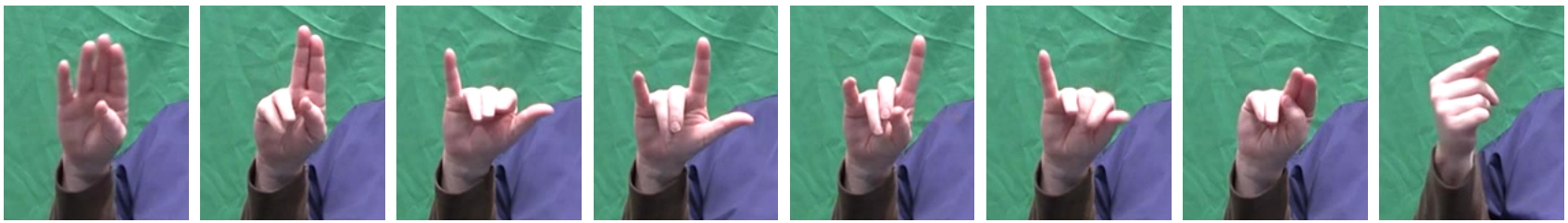
Gestural score for B-U-I-L-D-I-N-G



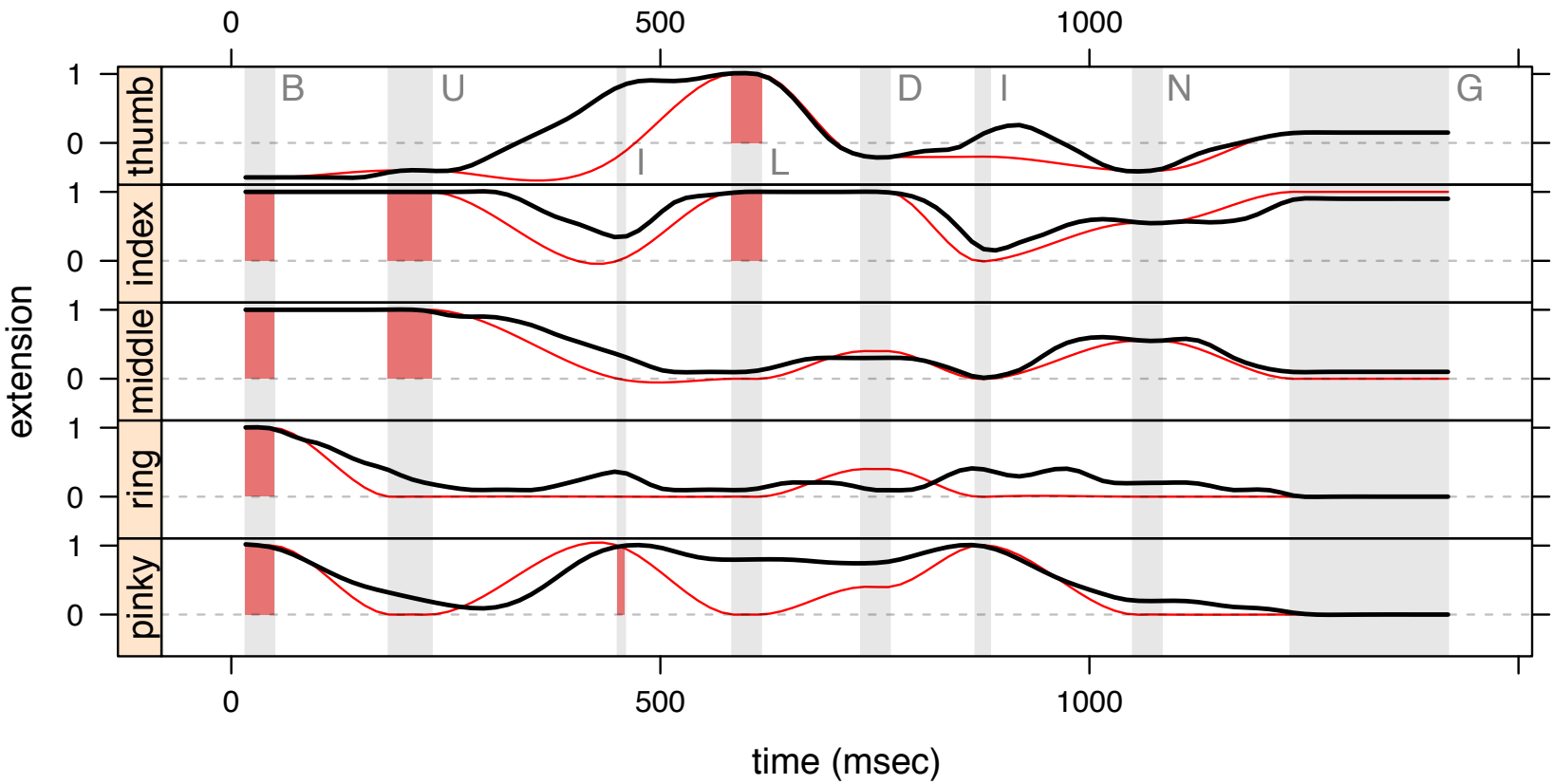
-B- -U- -I- -L- -D- -I- -N- -G-



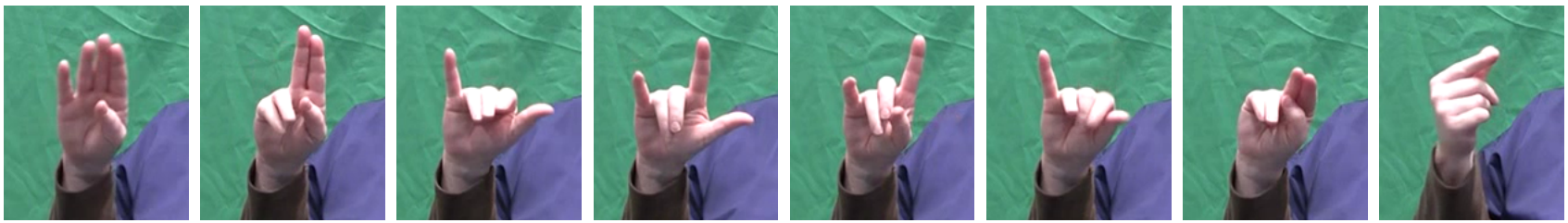
Gestural score for B-U-I-L-D-I-N-G



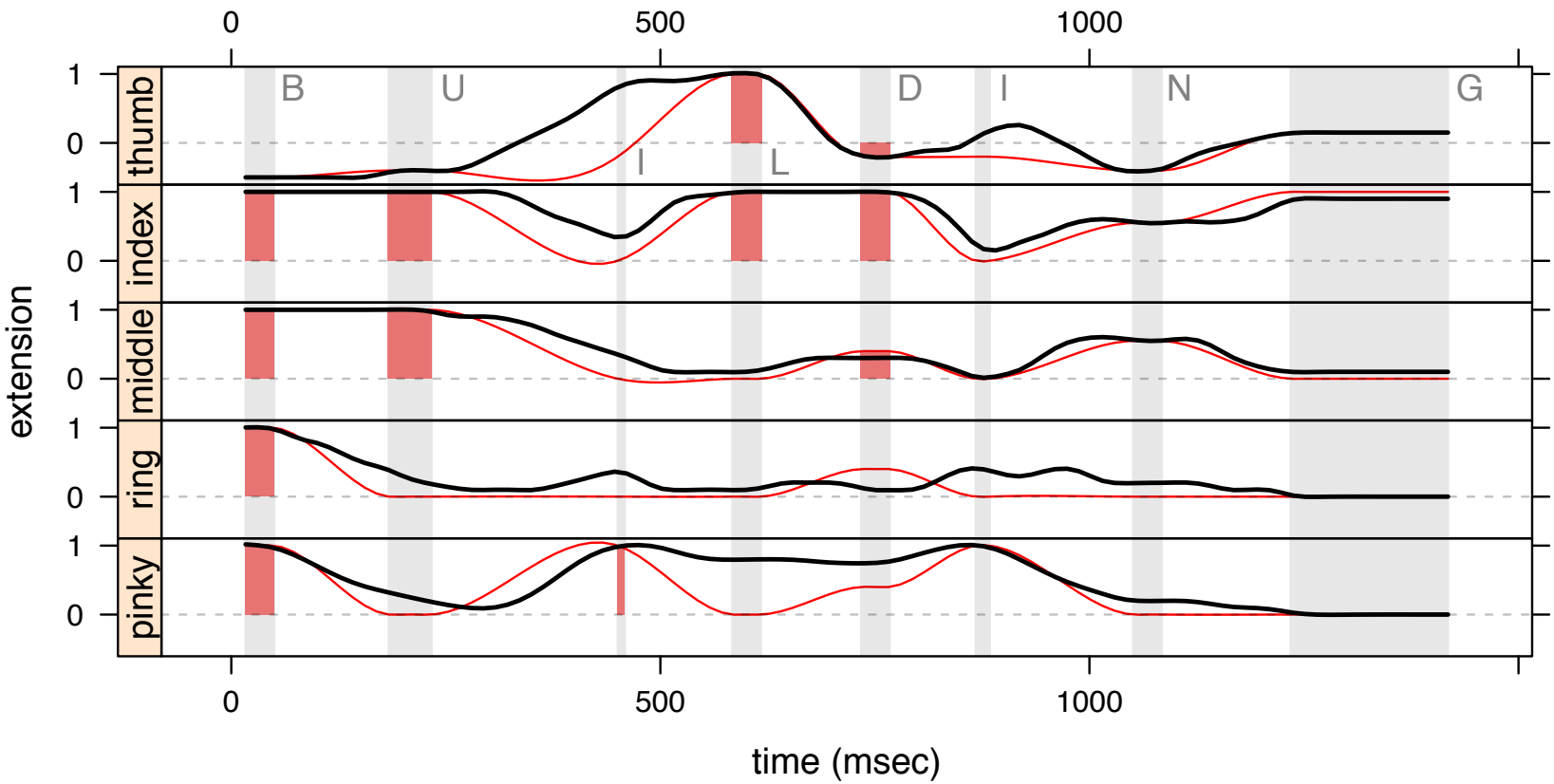
-B- -U- -I- -L- -D- -I- -N- -G-



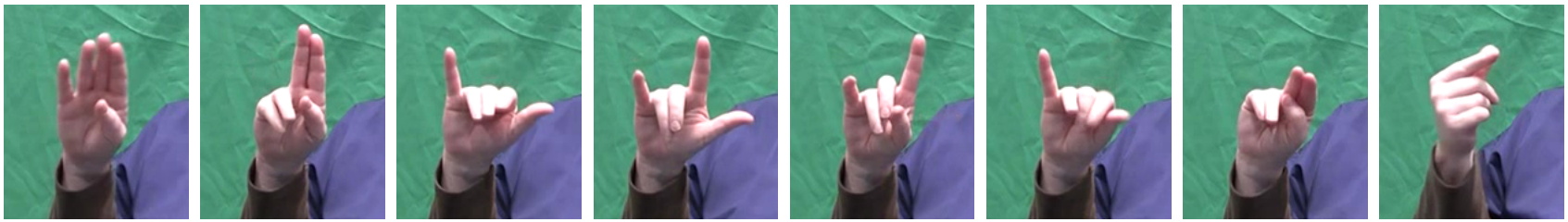
Gestural score for B-U-I-L-D-I-N-G



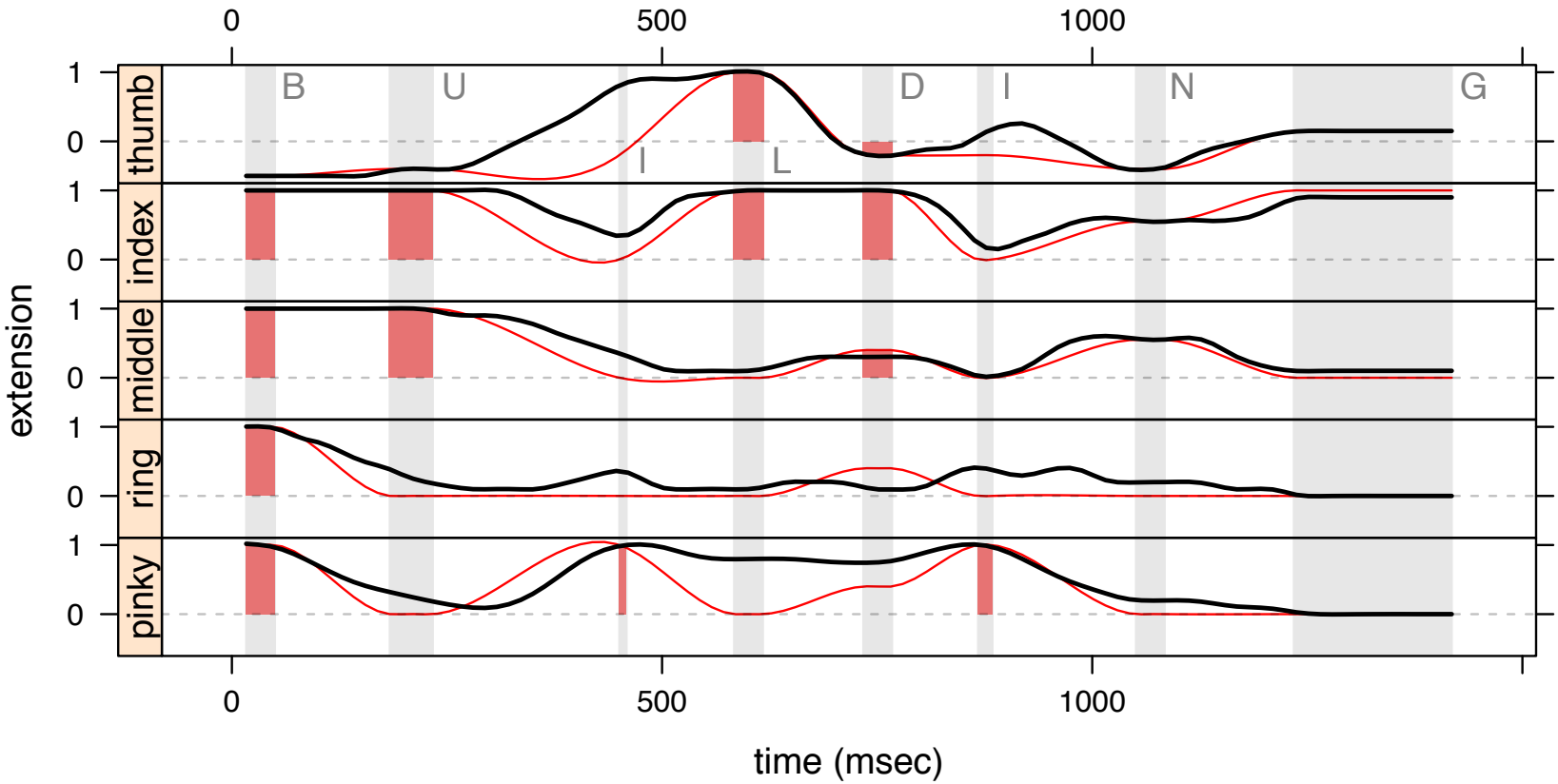
-B- -U- -I- -L- -D- -I- -N- -G-



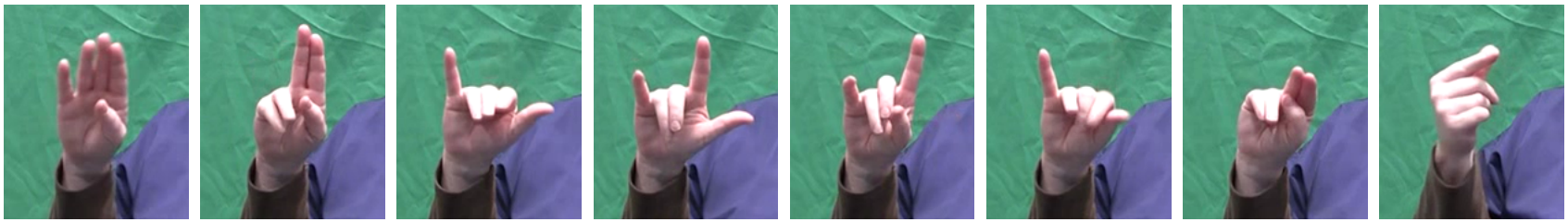
Gestural score for B-U-I-L-D-I-N-G



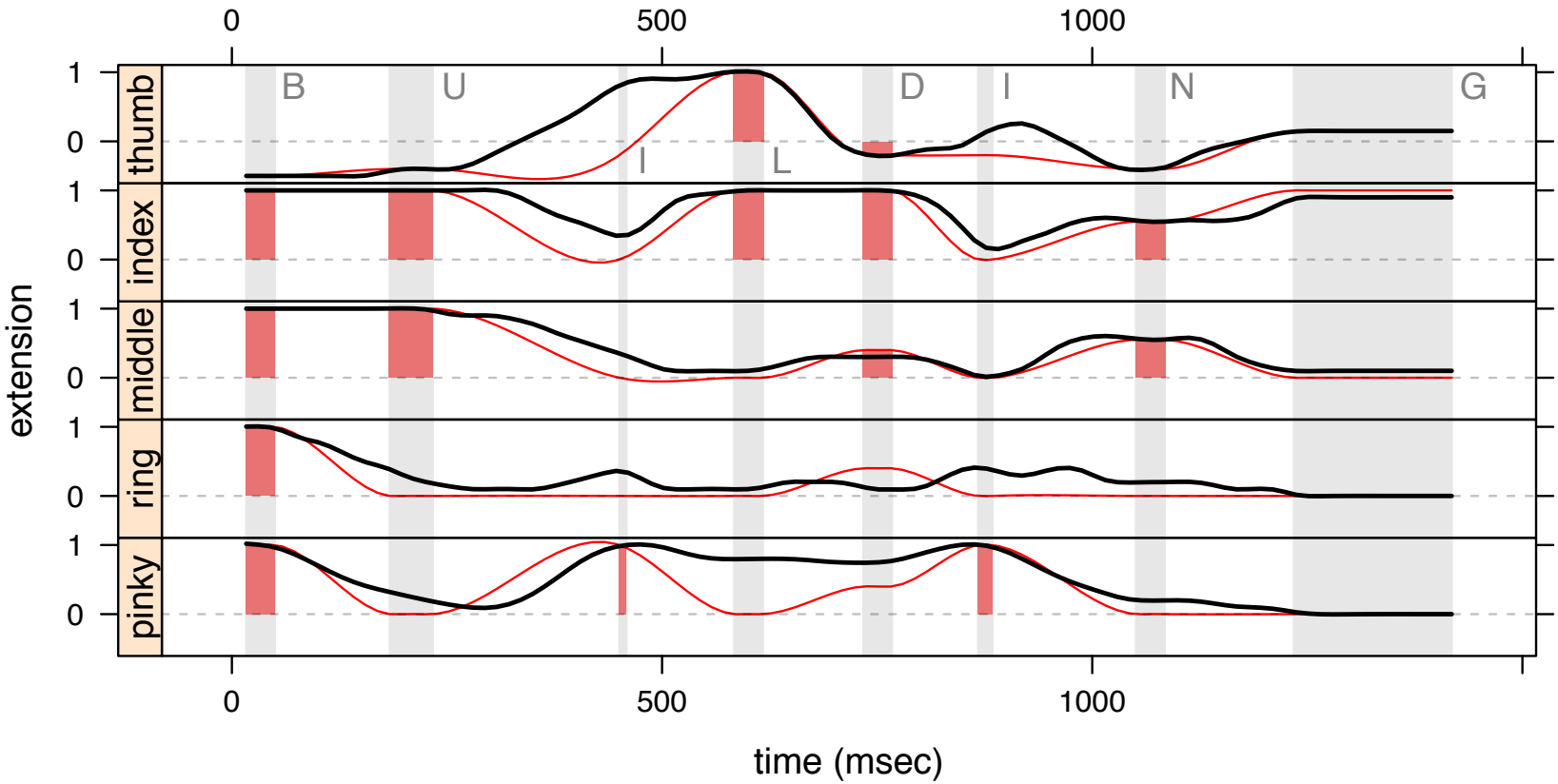
-B- -U- -I- -L- -D- -I- -N- -G-



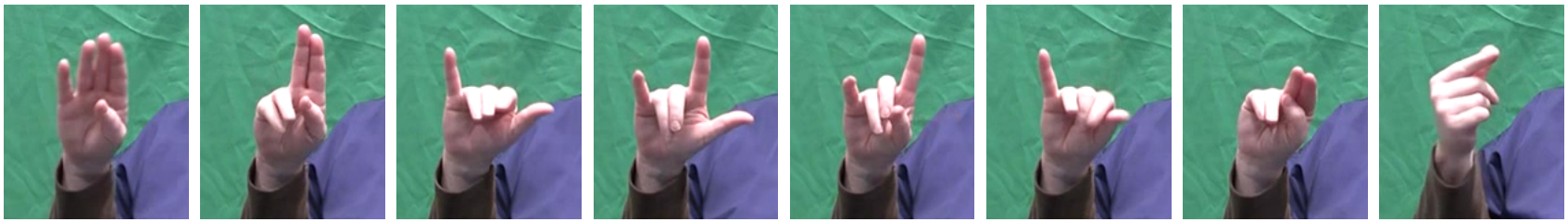
Gestural score for B-U-I-L-D-I-N-G



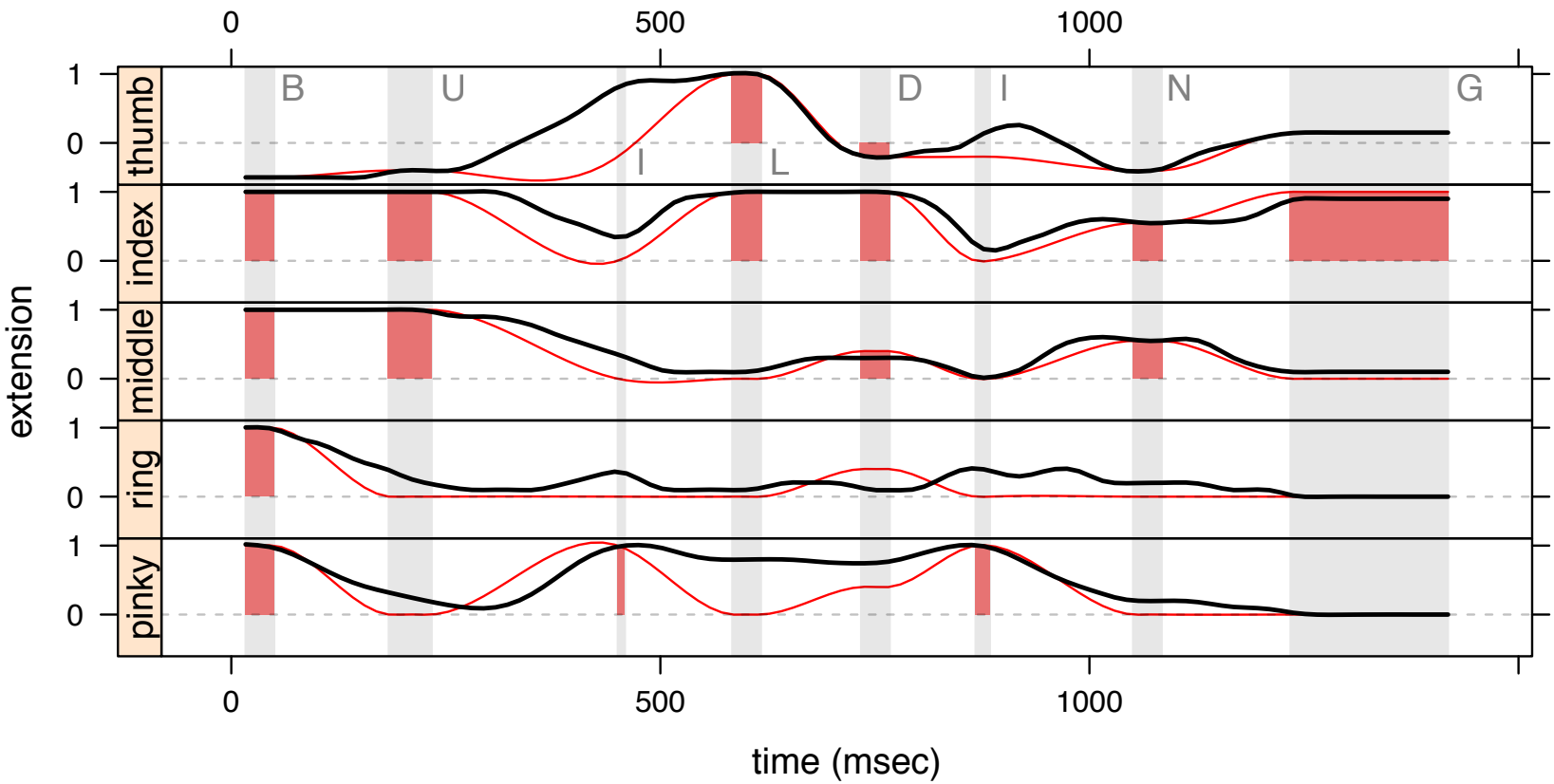
-B- -U- -I- -L- -D- -I- -N- -G-



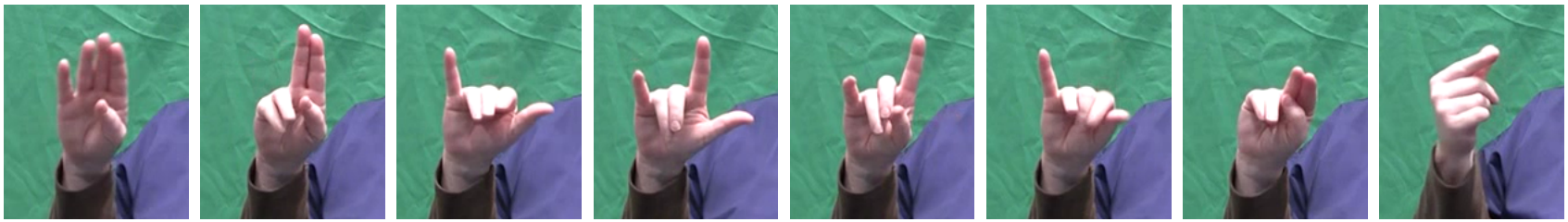
Gestural score for B-U-I-L-D-I-N-G



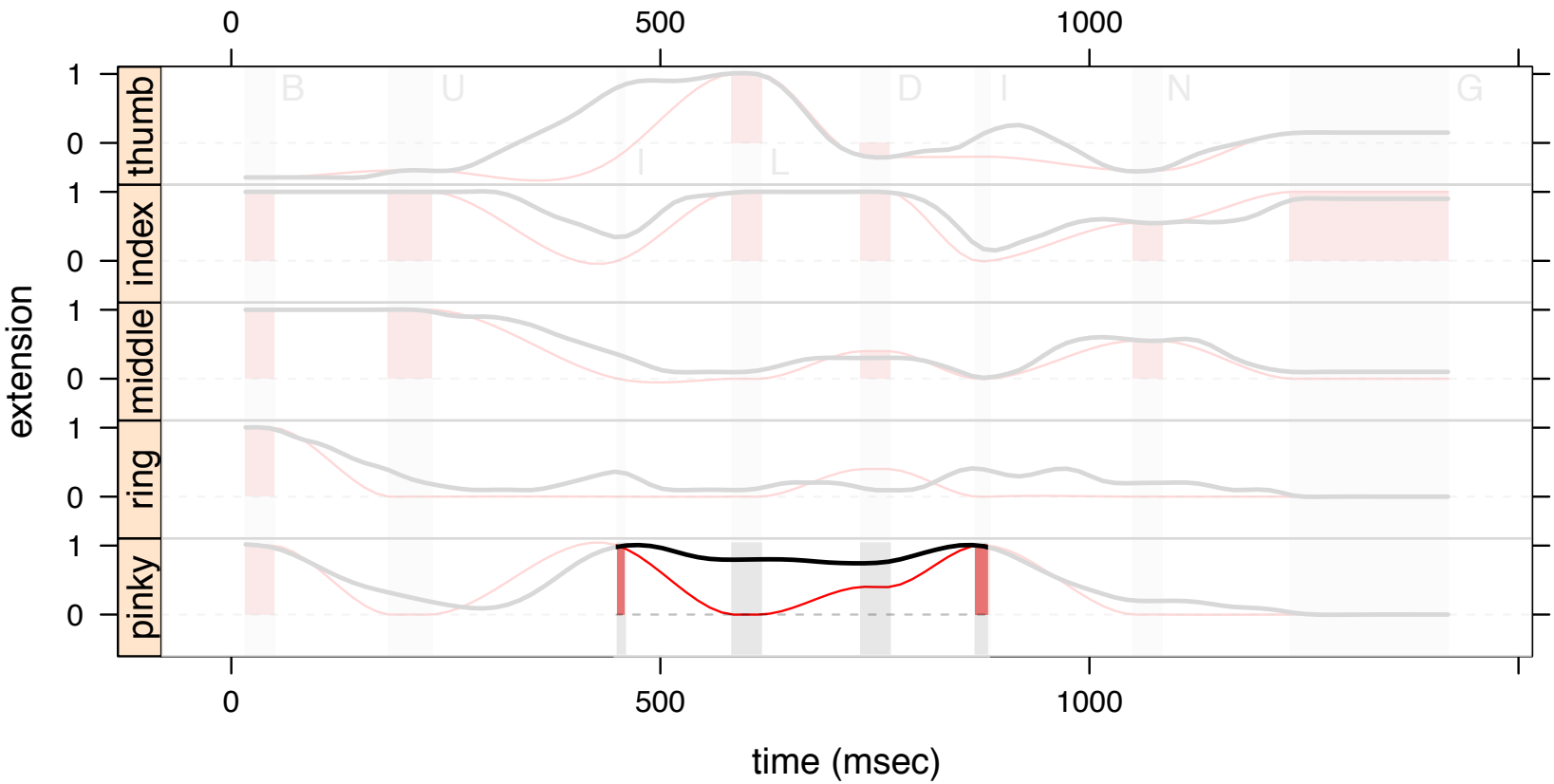
-B- -U- -I- -L- -D- -I- -N- -G-



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



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



Pinky extension coarticulation

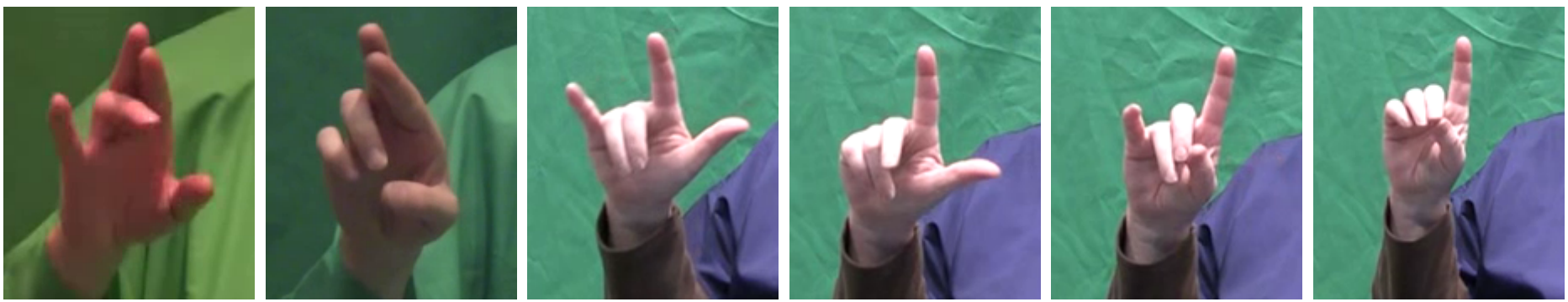
Data collection

- 4 native signers, 1 early learner (4 coded so far) produced
- 600 words
- repeating each word twice
- being recorded by 2 or 3 video cameras
- recording at 60 FPS
- for a total of 21,453 letters

Pinky extension

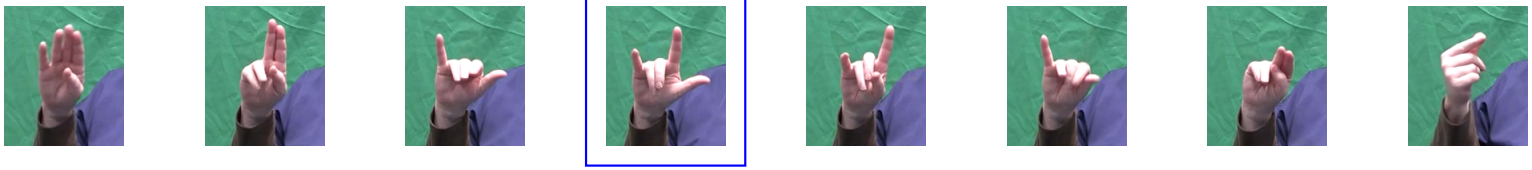
A still image of each letter was annotated for pinky extension, defined as:

- 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.

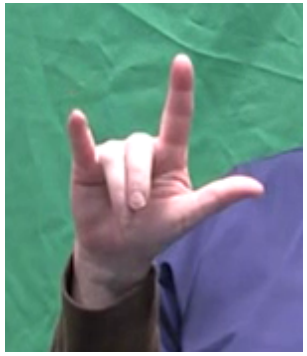


-R- [+ext] -R- [−ext] -L- [+ext] -L- [−ext] -D- [+ext] -D- [−ext]

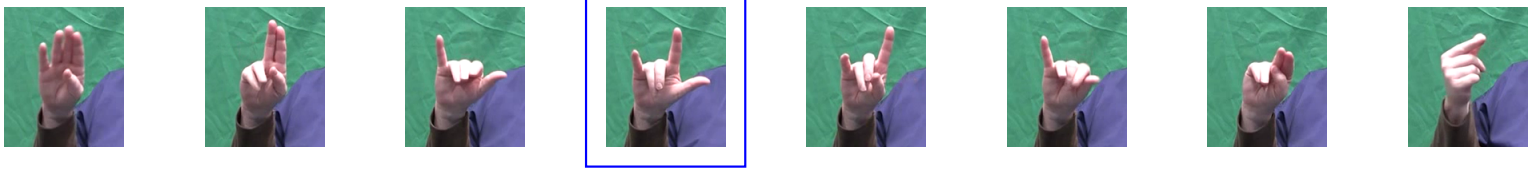
What affects the -L- handshape?



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



What affects the -L- handshape?



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

↑

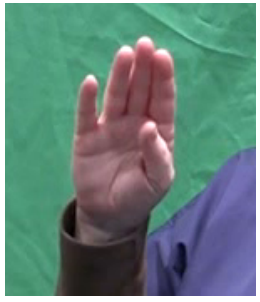
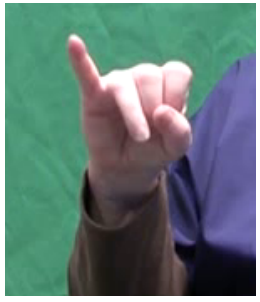
current handshape

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

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

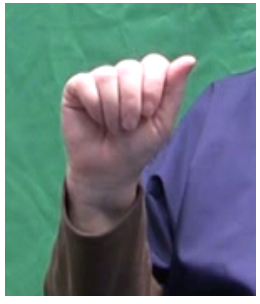
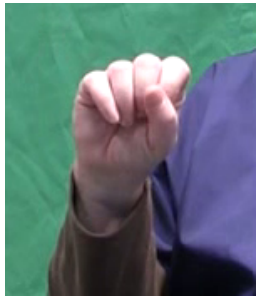
What affects the -L- handshape?

current handshape groups

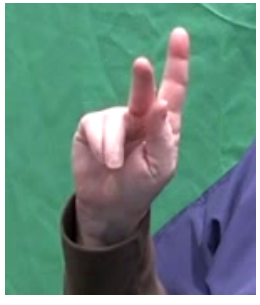
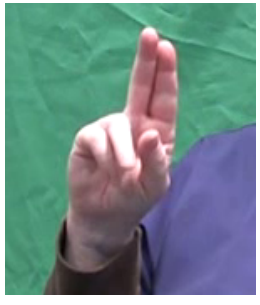
Extended (and selected) pinky:

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

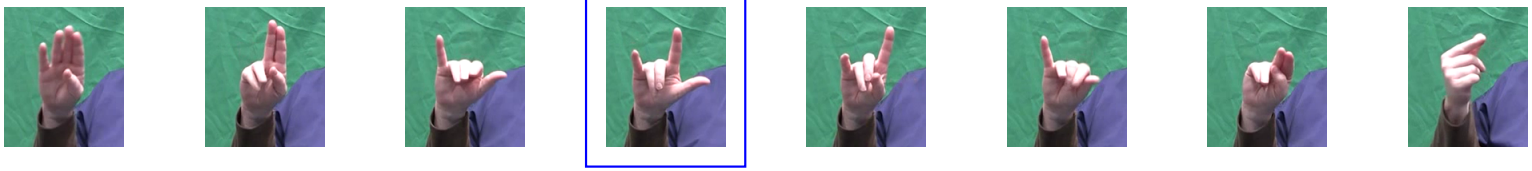
Flexed and selected pinky:

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

other

What affects the -L- handshape?

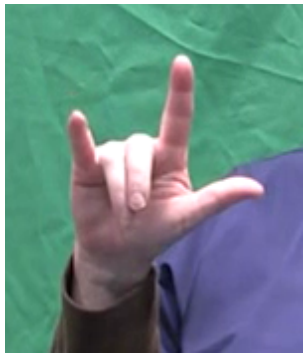


-B- -U- -I- -L- -D- -I- -N- -G-

word type

name; noun;

non-English

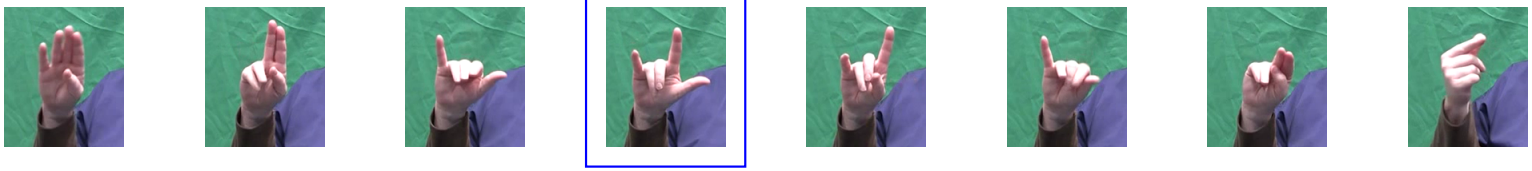


current handshape

-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;

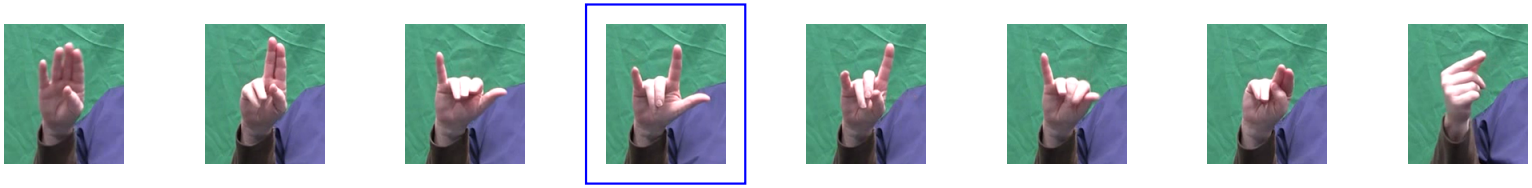
non-English

current 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-

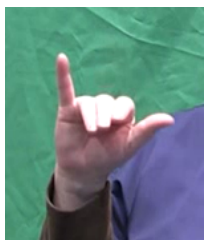
local transition time

zscore of log(time)

word type

name; noun;

non-English



previous handshape

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

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

other;

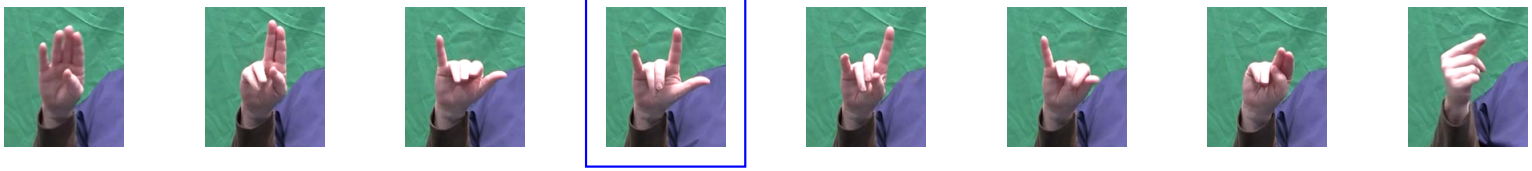
word boundary

current 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-

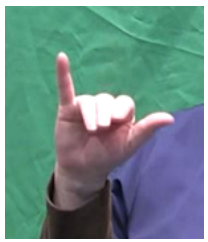
local transition time

zscore of log(time)

word type

name; noun;

non-English



previous handshape

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

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

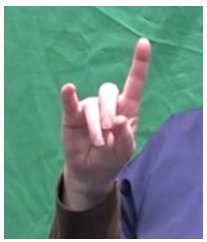
other;

word boundary

current handshape

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

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



following handshape

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

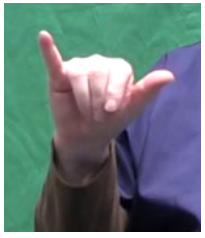
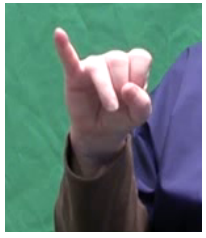
-I-, -J-, or -Y-;

other;

word boundary

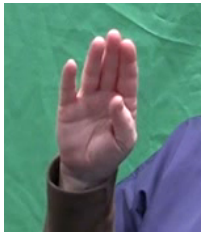
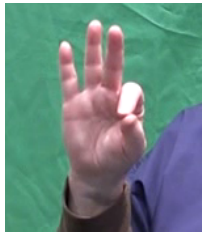
What affects the -L- handshape?

previous/following handshape groups

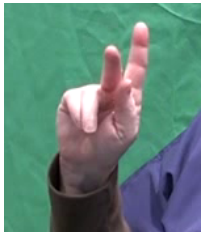
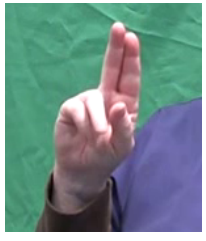
Extended pinky (alone):

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

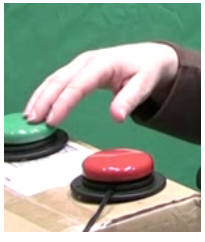
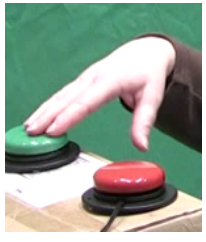



Extended pinky (with other fingers):

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

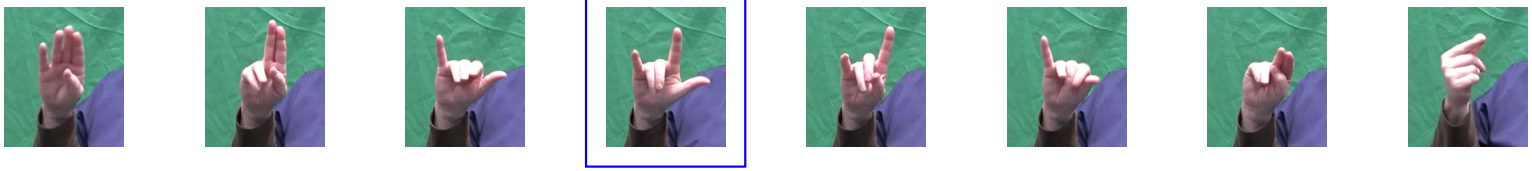



other

word boundary

What affects the -L- handshape?



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

local transition time

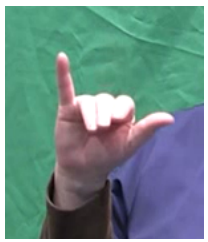
zscore of log(time)

interaction → *interaction* ←

word type

name; noun;

non-English



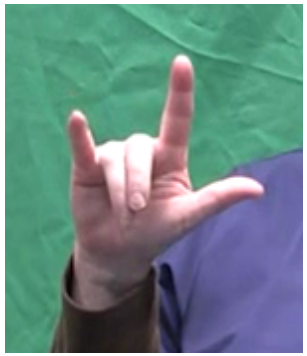
previous handshape

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

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

other;

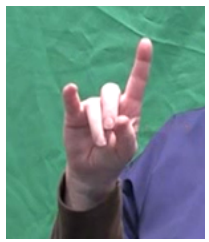
word boundary



current handshape

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

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



following handshape

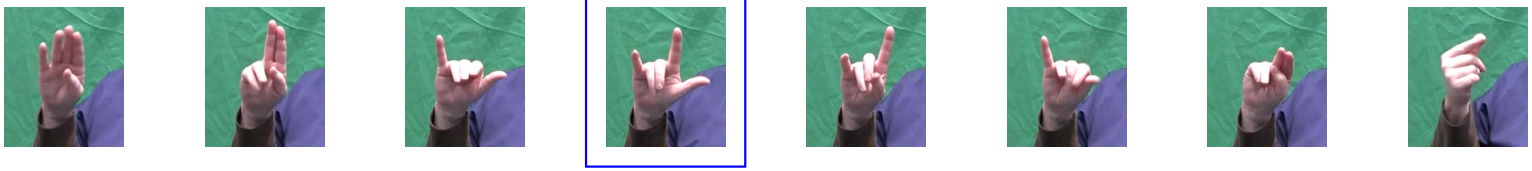
-B-, -C-, or -F-;

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

other;

word boundary

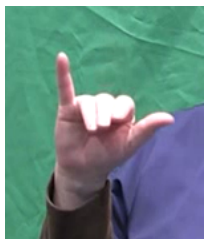
What affects the -L- handshape?



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

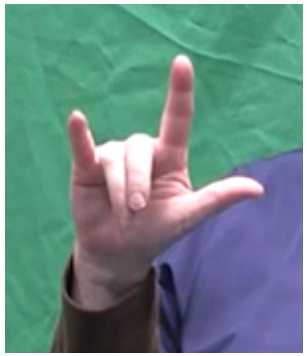
interaction → local transition time
zscore of log(time)
← *interaction*

word type
name; noun;
non-English



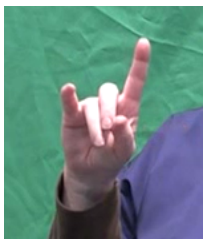
previous handshape

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



current handshape

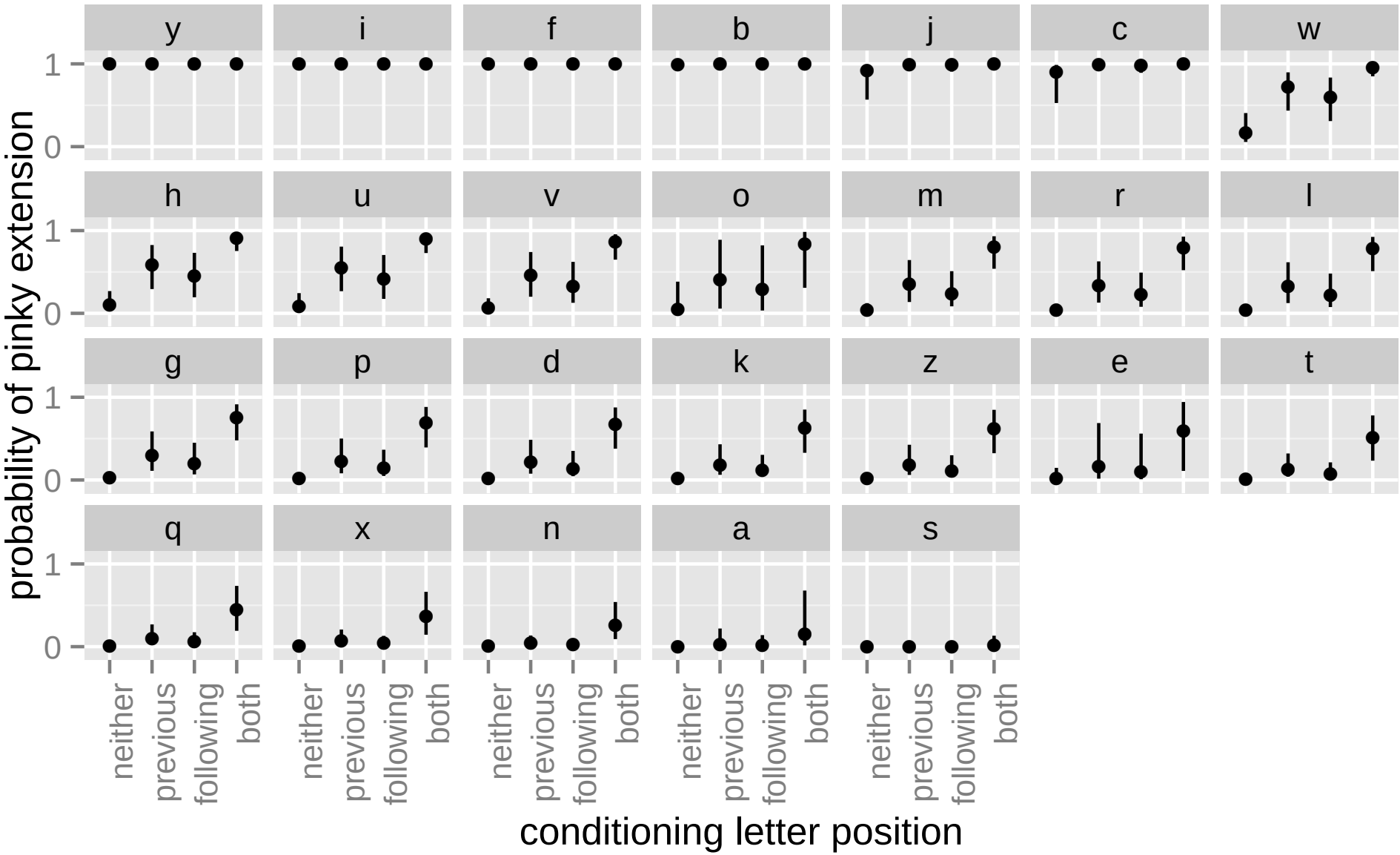
-B-, -C-, -F-, -I-, -J-, or -Y-;
-A-, -S-, -E-, or -O-; other



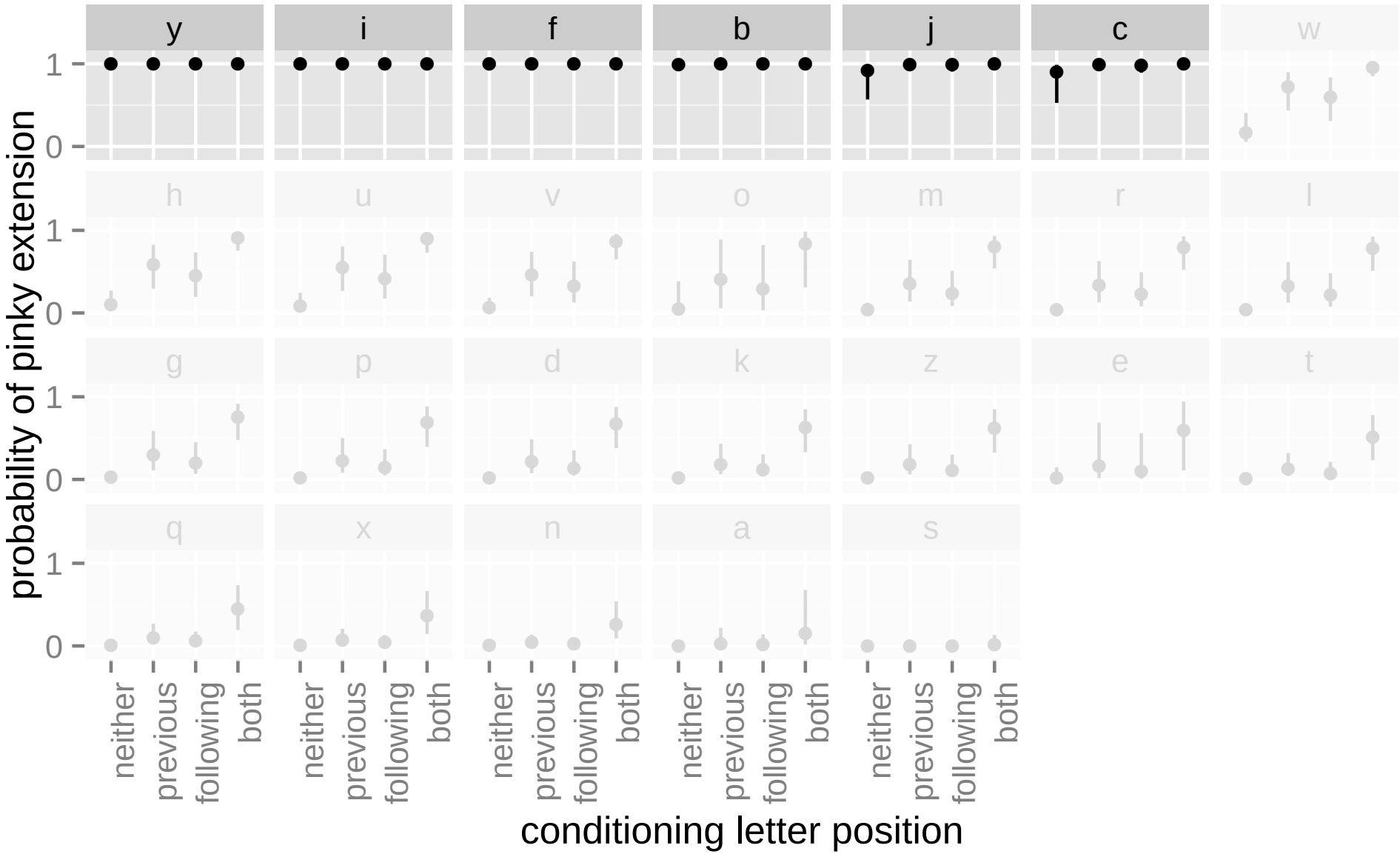
following handshape

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

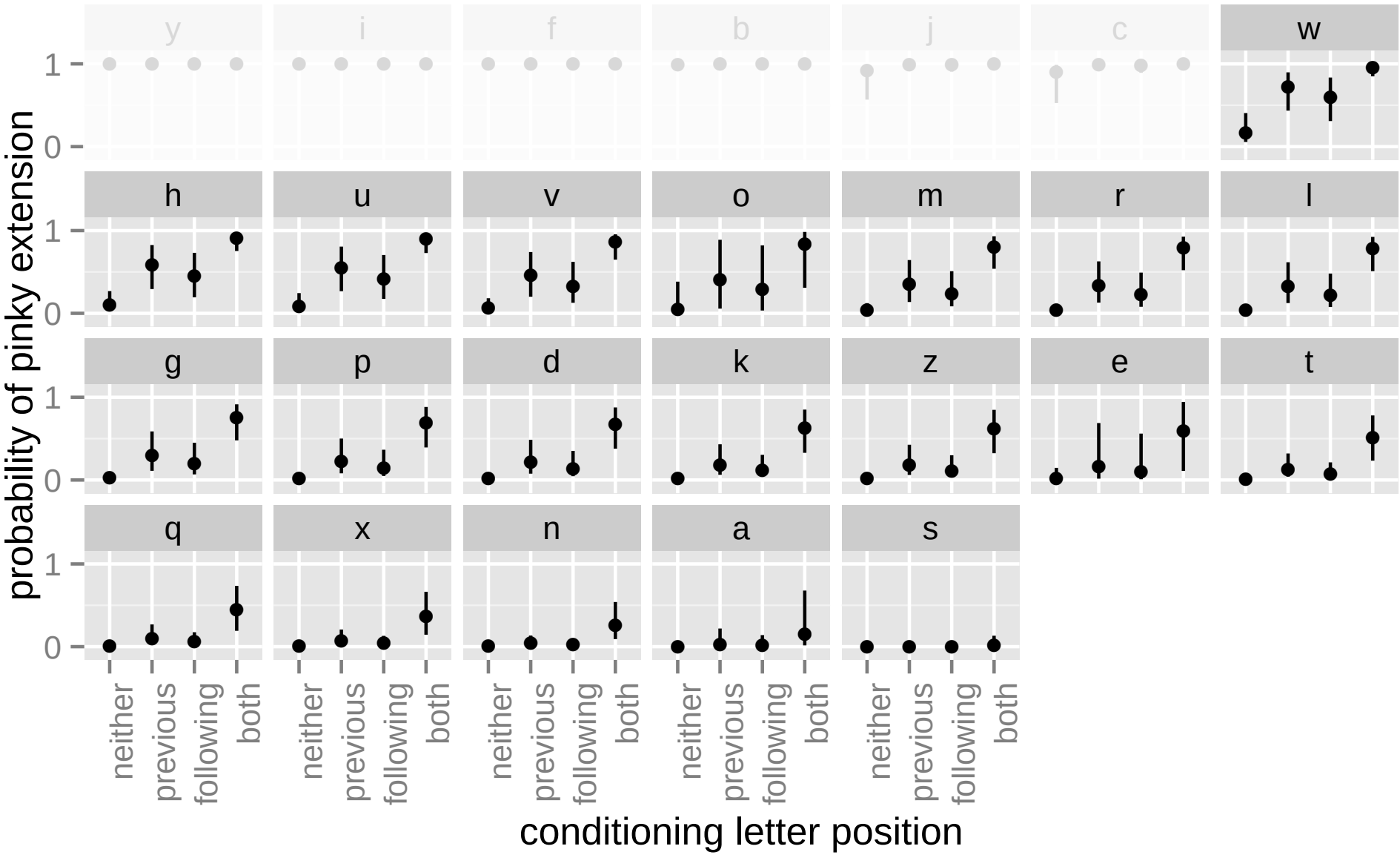
Model predictions around -I-, -J-, or -Y-



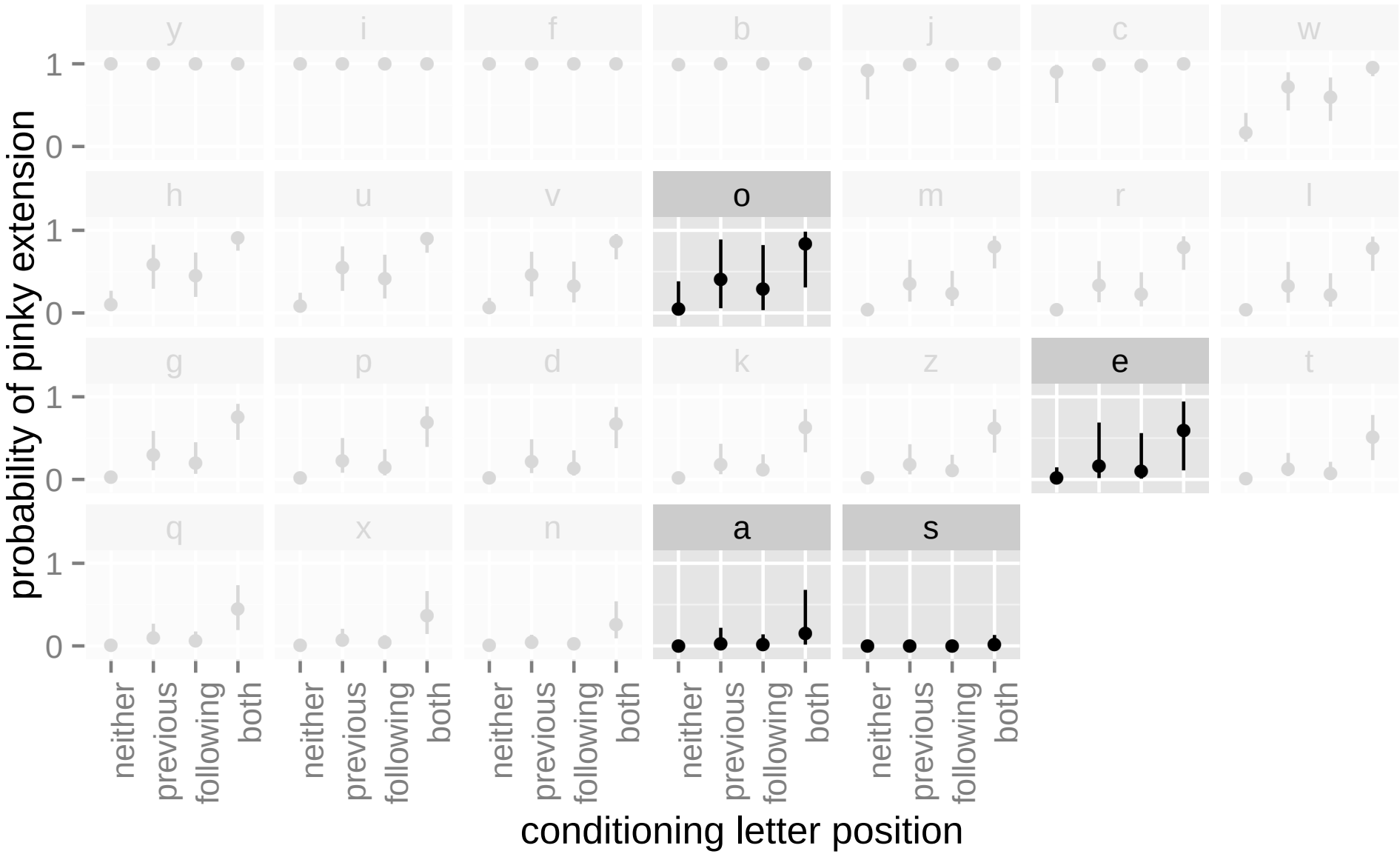
Model predictions around -I-, -J-, or -Y-



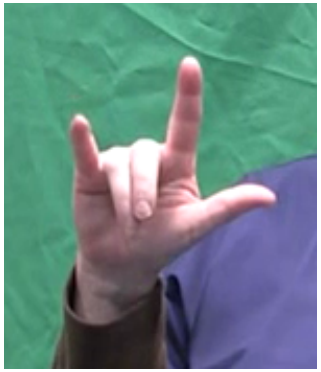
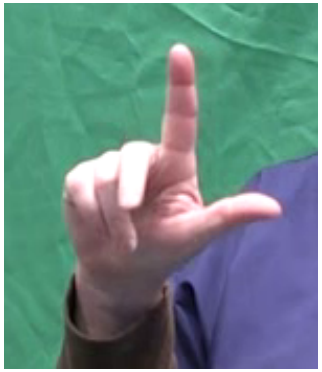
Model predictions around -I-, -J-, or -Y-



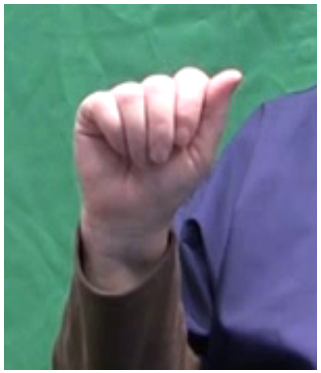
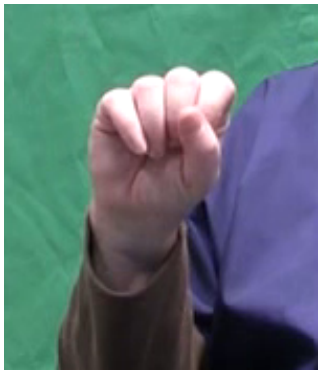
Model predictions around -I-, -J-, or -Y-



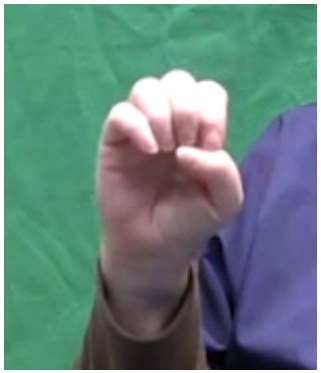
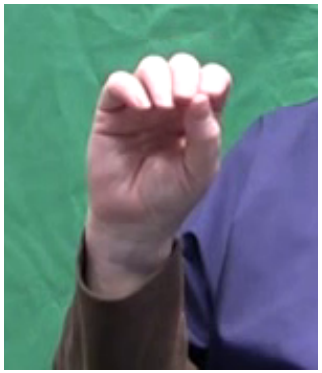
What's special about -A-, -S-, -E-, and -O-?

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

1. Articulatory models of speech production are generalizable to sign languages.

Conclusions

1. Articulatory models of speech production are generalizable to sign languages.
2. The articulatory model of handshape provides a link between phonological specifications and phonetic implementation.

Conclusions

1. Articulatory models of speech production are generalizable to sign languages.
2. The articulatory model of handshape provides a link between phonological specifications and phonetic implementation.
3. These models make specific predictions about contextual variation that are supported by data from ASL fingerspelling.

Conclusions

1. Articulatory models of speech production are generalizable to sign languages.
2. The articulatory model of handshape provides a link between phonological specifications and phonetic implementation.
3. These models make specific predictions about contextual variation that are supported by data from ASL fingerspelling.
   - 3.1 The nonselected (nonactive) fingers are more frequently the targets of coarticulatory pressure (vs. selected (active) fingers).

Conclusions

1. Articulatory models of speech production are generalizable to sign languages.
2. The articulatory model of handshape provides a link between phonological specifications and phonetic implementation.
3. These models make specific predictions about contextual variation that are supported by data from ASL fingerspelling.
   - 3.1 The nonselected (nonactive) fingers are more frequently the targets of coarticulatory pressure (vs. selected (active) fingers).
   - 3.2 The selected fingers are the sources of coarticulatory pressure.

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, Rachel Hwang, Katie Henry, Julia Goldsmith-Pinkham, and Linda Liu

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

References I

Brentari, Diane. 1998. A prosodic model of sign language phonology. The MIT Press.

Browman, Catherine P, and Louis Goldstein. 1992. Articulatory phonology: An overview. Tech. rep., Haskins Laboratories.

Erol, Ali, George Bebis, Mircea Nicolescu, Richard D Boyle, and Xander Twombly. 2005. A review on vision-based full dof hand motion estimation. Computer vision and pattern recognition-workshops, 2005. CVPR workshops. IEEE computer society conference, 75–75. IEEE.

Johnson, Robert E, and Scott K Liddell. 2011a. Toward a phonetic representation of hand configuration: The thumb. Sign Language Studies 12.316–333.

Johnson, Robert E, and Scott K Liddell. 2011b. Toward a phonetic representation of signs: Sequentiality and contrast. Sign Language Studies 11.241–274.

Liddell, Scott K, and Robert E Johnson. 2011a. A segmental framework for representing signs phonetically. Sign Language Studies 11.408–463.

References II

Liddell, Scott K, and Robert E Johnson. 2011b. Toward a phonetic representation of hand configuration: The fingers. Sign Language Studies 12.5–45.

Sandler, Wendy. 1989. Phonological representation of the sign: Linearity and nonlinearity in american sign language. Foris Pubs USA.