

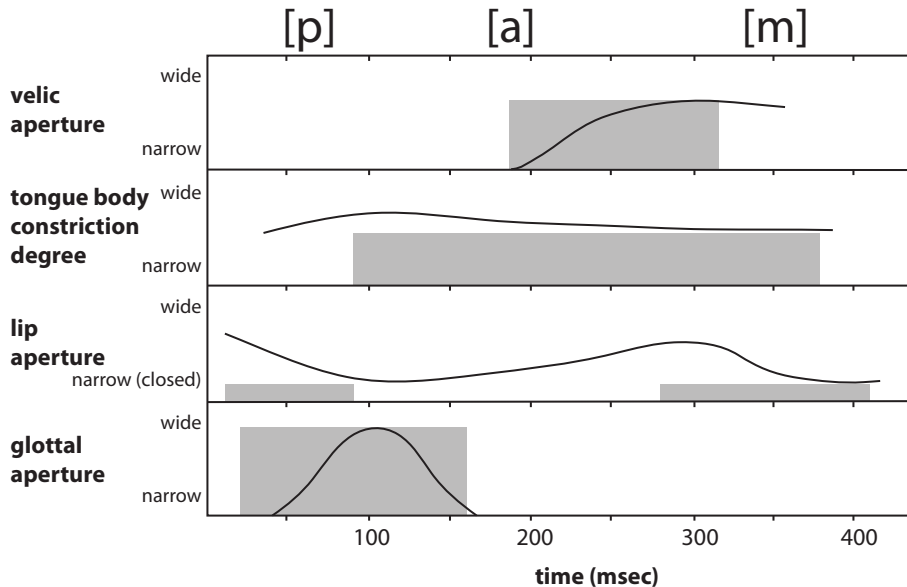
TOWARDS AN ARTICULATORY MODEL OF HANDSHAPE

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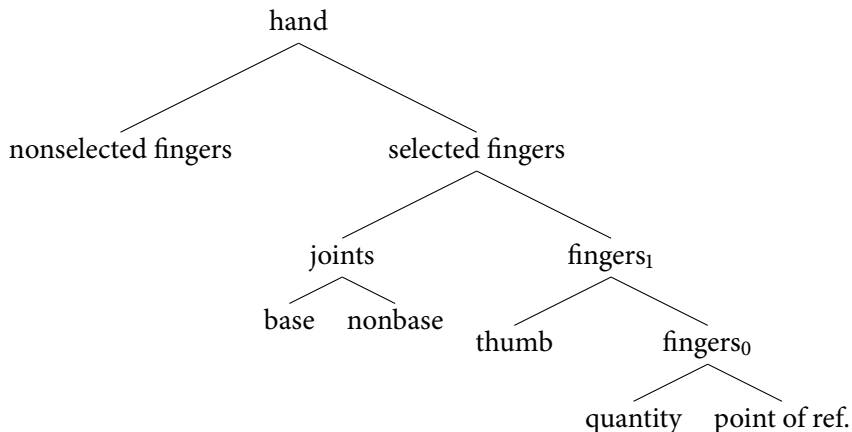
Goals of this talk

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)

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.

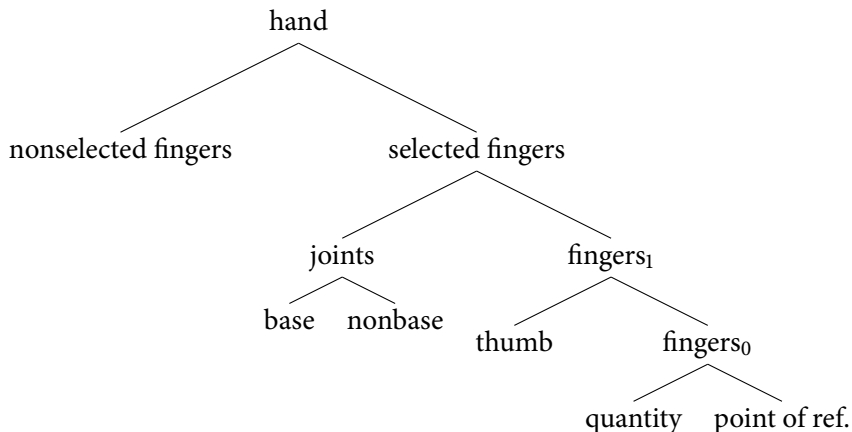
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There is independent evidence for their existence:

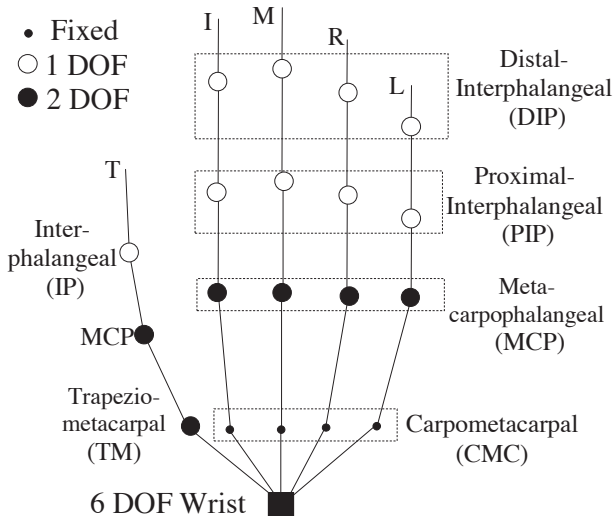
- ▶ restrictions on handshapes in signs,
- ▶ selected fingers contact the body,
- ▶ selected fingers are preserved in compounds.

Handshape portion from the Prosodic Model



(Brentari, 1998)

Degrees of freedom



The articulatory model of handshape

group	joint	tract variable	values
selected fingers	MCP	SF-MCP	$-15-90^{\circ}$
	PIP	SF-PIP	$0-90^{\circ}$
	MCP	SF-ABDUCTION	$[\pm\text{ABDUCTED}]$

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

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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°

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thumb opposition	CM	CM-OPPOSITION	-45-90°
thumb abduction	CM	CM-ABDUCTION	0-90°

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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).

General hypotheses

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

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

Specific hypotheses

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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
- ▶ involves most of the handshapes in ASL

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-

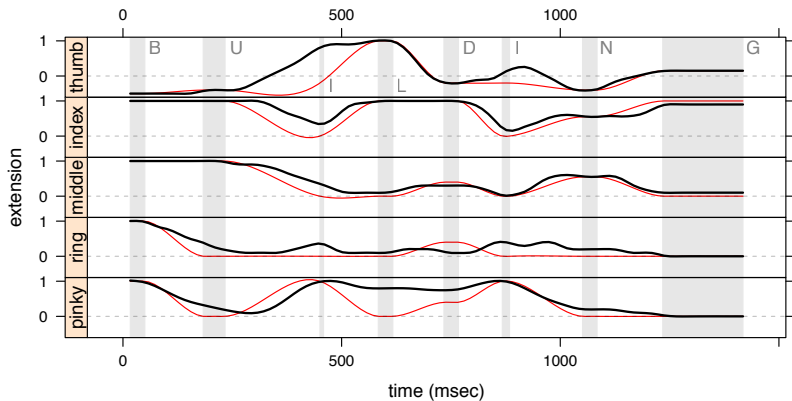


-G-

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-

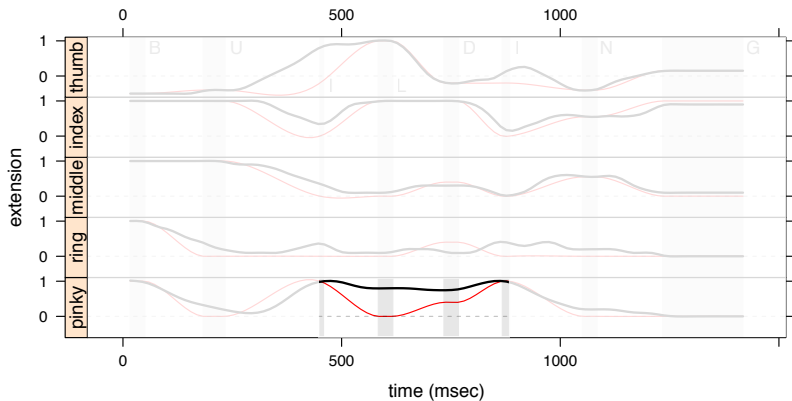
-L-

-D-

-I-

-N-

-G-



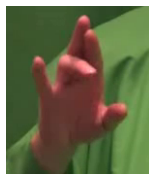
Data collection

- ▶ 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 14,169 apogees

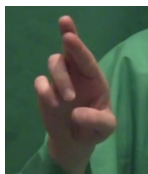
Pinky extension

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.



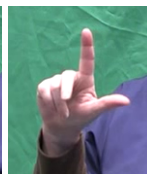
-R- [+ext]



-R- [-ext]



-L- [+ext]



-L- [-ext]



-D- [+ext]



-D- [-ext]

What affects the -L- handshape?



-B-



-U-



-I-



-L-



-D-



-I-



-N-



-G-



What affects the -L- handshape?



-B-



-U-



-I-



-L-



-D-



-I-



-N-



-G-

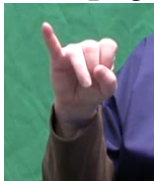


apogee handshape

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

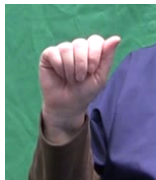
-A-, -S-, -E-, or -O-; other

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- handshake?



-B-



-U-



-I-



-L-



-D-



-I-



-N-



-G-



apogee handshake

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

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

word type
name; noun;
non-English



What affects the -L- handshape?



-B-



-U-



-I-



-L-



-D-



-I-



-N-



-G-

local transition time
zscore of $\log(\text{time})$



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)



previous 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

word type
name; noun;
non-English

What affects the -L- handshape?



-B-



-U-



-I-



-L-



-D-



-I-



-N-



-G-

local transition time
zscore of $\log(\text{time})$



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

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word boundary



apogee handshape

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

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

word type
name; noun;
non-English



following handshape

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

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

other;

word boundary

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- handshake?



-B-

-U-

-I-

-L-

-D-

-I-

-N-

-G-

local transition time
zscore of log(time)

*interaction**interaction*

previous handshake

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

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

other;

word boundary

word type
name; noun;
non-English



following handshake

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

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

other;

word boundary



apogee handshake

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

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

What affects the -L- handshake?



-B-

-U-

-I-

-L-

-D-

-I-

-N-

-G-

local transition time
zscore of log(time)

interaction

interaction



previous handshake

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

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

other;

word boundary



apogee handshake

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

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

word type
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non-English



following handshake

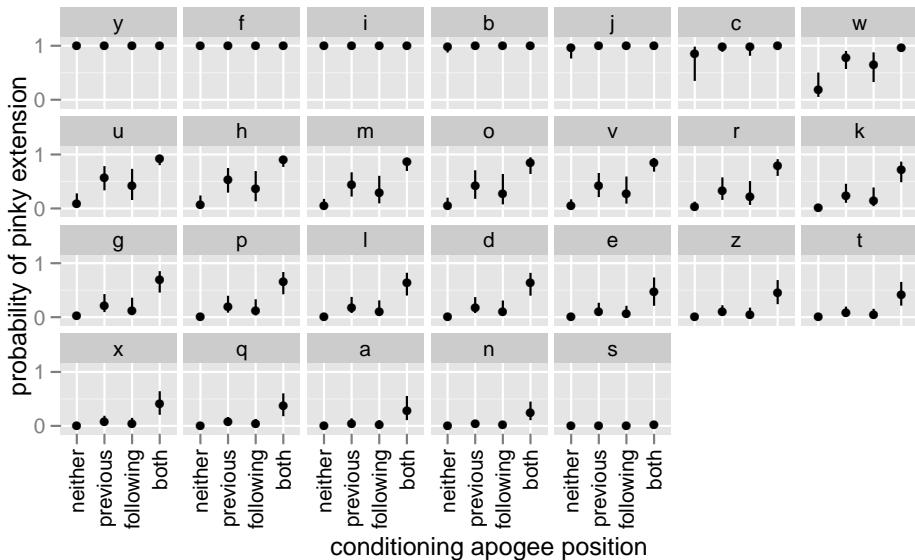
-B-, -C-, or -F-;

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

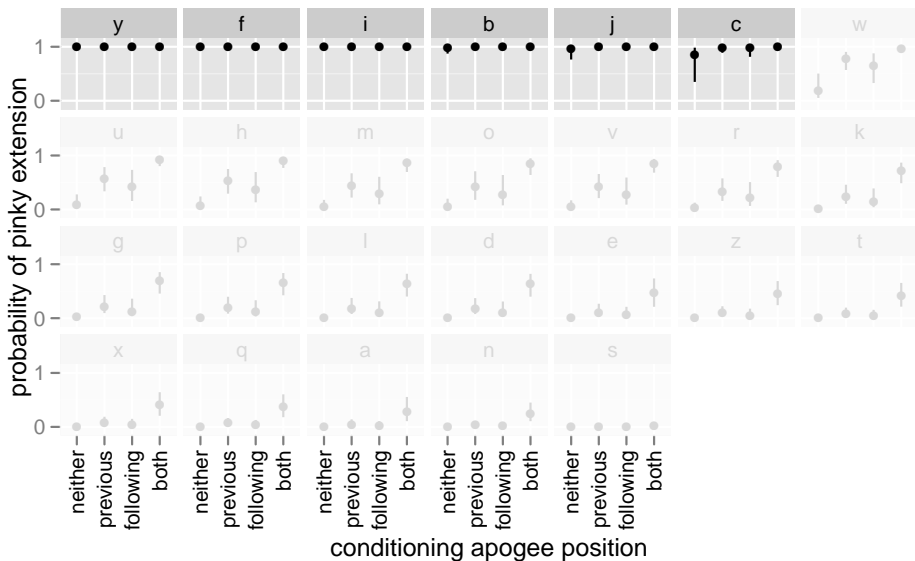
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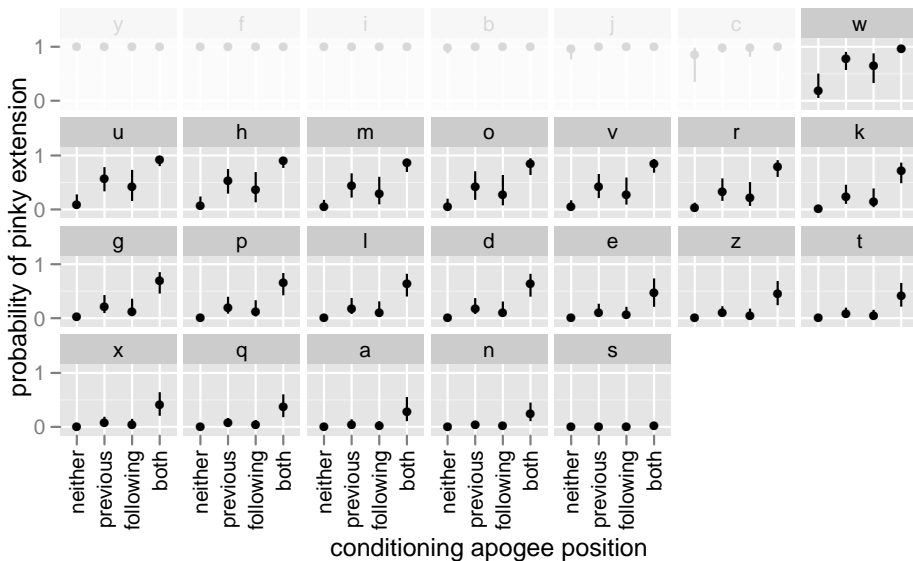
Model predictions around -I-, -J-, or -Y-



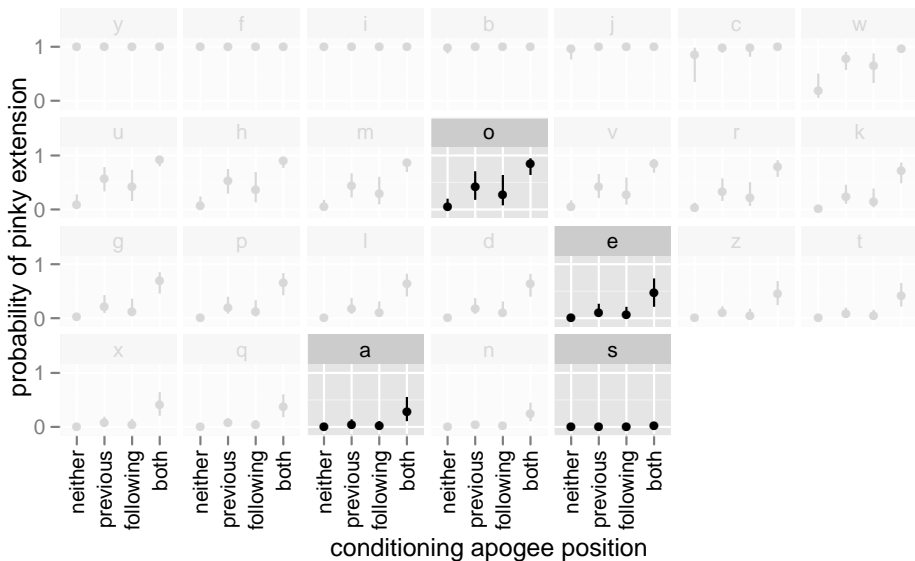
Model predictions around -I-, -J-, or -Y-



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

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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.

Support

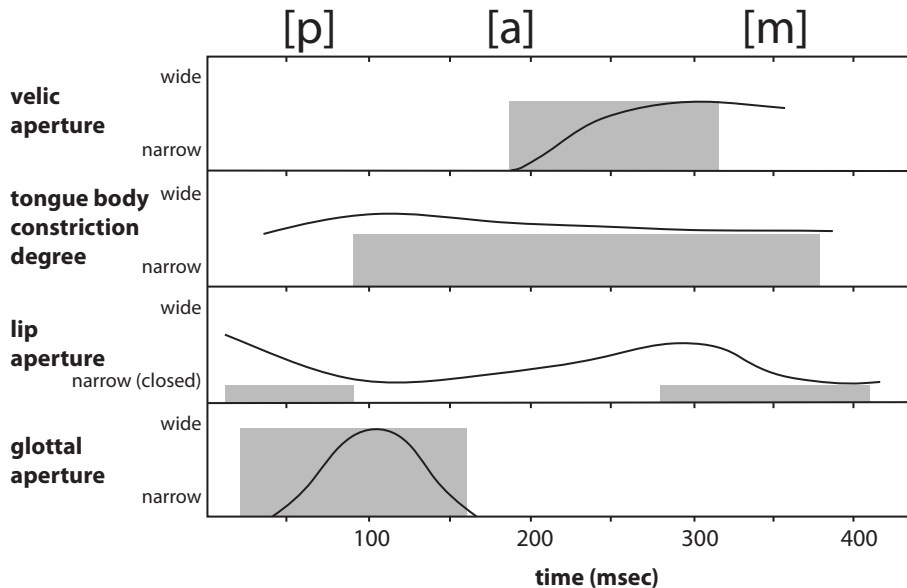
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Gestural score for B-U-I-L-D-I-N-G



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