HANDSHAPE ASSIMILATION IN ASL FINGERSPELLING

ULNAR DIGIT FLEXION AND SELECTED FINGERS

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Broad Questions

How do handshapes in fingerspelling, and ASL broadly, vary, and what causes this variation?

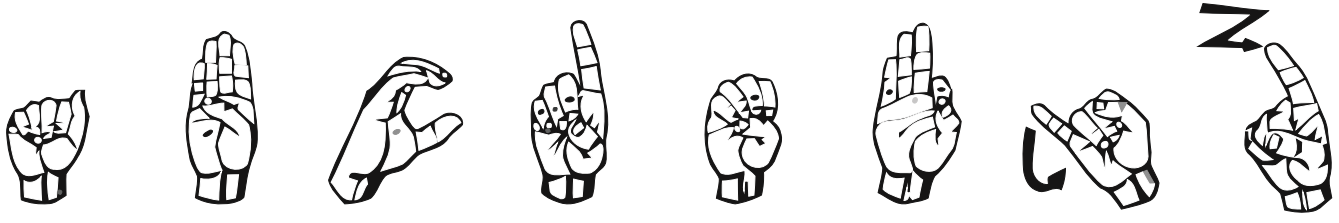
- environment?
- signer?
- phonological properties?

Objectives of this research

- Analyze a large corpus of fingerspelling data using a variety of manual, automated, and statistical techniques.
- Quantify and investigate the sources of variation within fingerspelling.
- Develop an articulatory model of handshape.

A basic description of fingerspelling

- Fingerspelling is a type of loanword system that makes up anywhere from 12–35% of ASL discourse (Padden, 1991; Padden and Gunsauls, 2003).
- Simplistically, fingerspelling is a set of static (except for -J- and -Z-) handshape-orientation combinations strung together sequentially, where each maps to one letter in an English word.
- Many note that this description is not quite accurate (Wilcox (1992); Akamatsu (1982) &c.).



What fingerspelling looks like; full speed

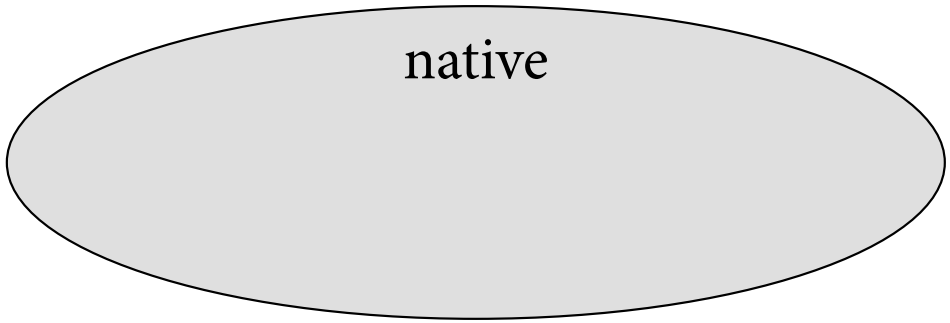
Fingerspelling in ASL borrowings

There has been some work on the process of borrowing from *neutral* fingerspelling to core lexical items. Battison (1978) looked at 40 loan signs, noting changes to handshape, among other phonological parameters.

Phonological paramaters for signed languages

- Handshape
- Location
- Movement
- Orientation
- Non-manuals

Structure of the ASL lexicon



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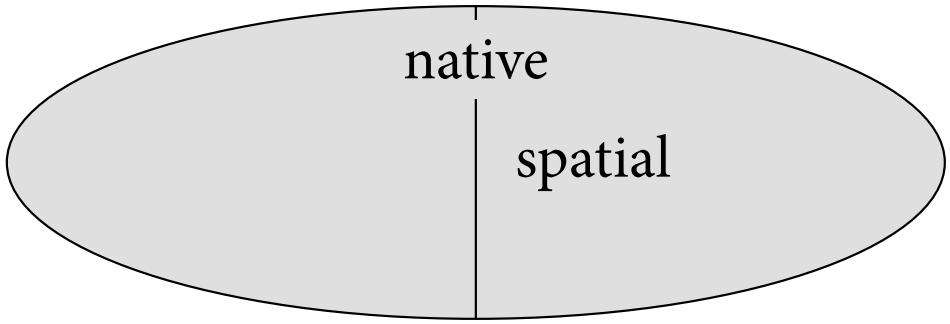

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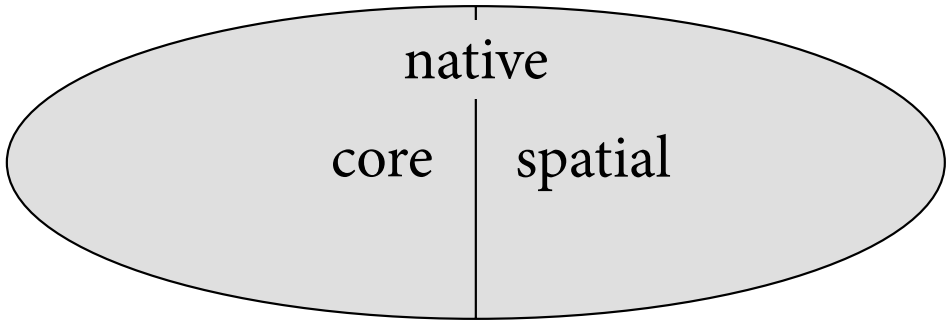

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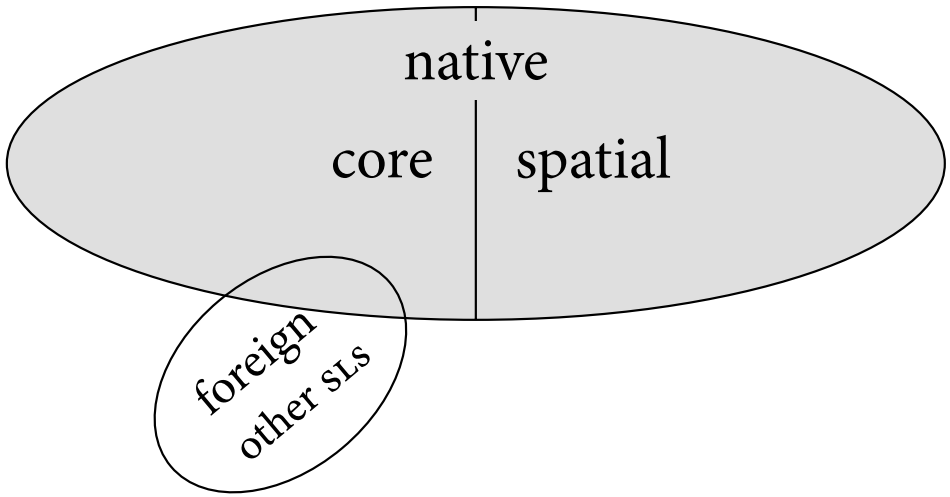

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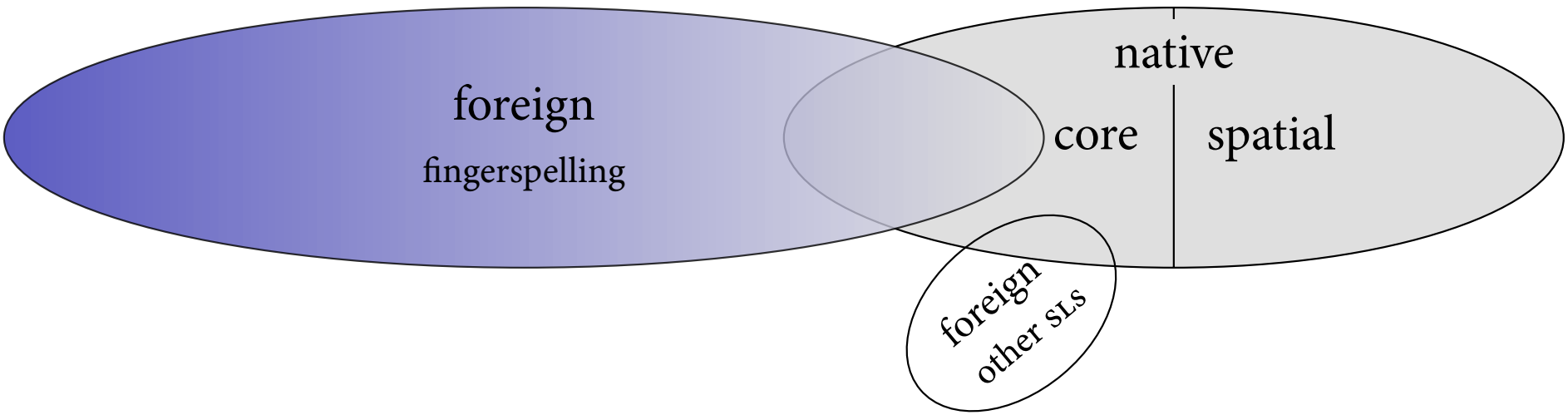

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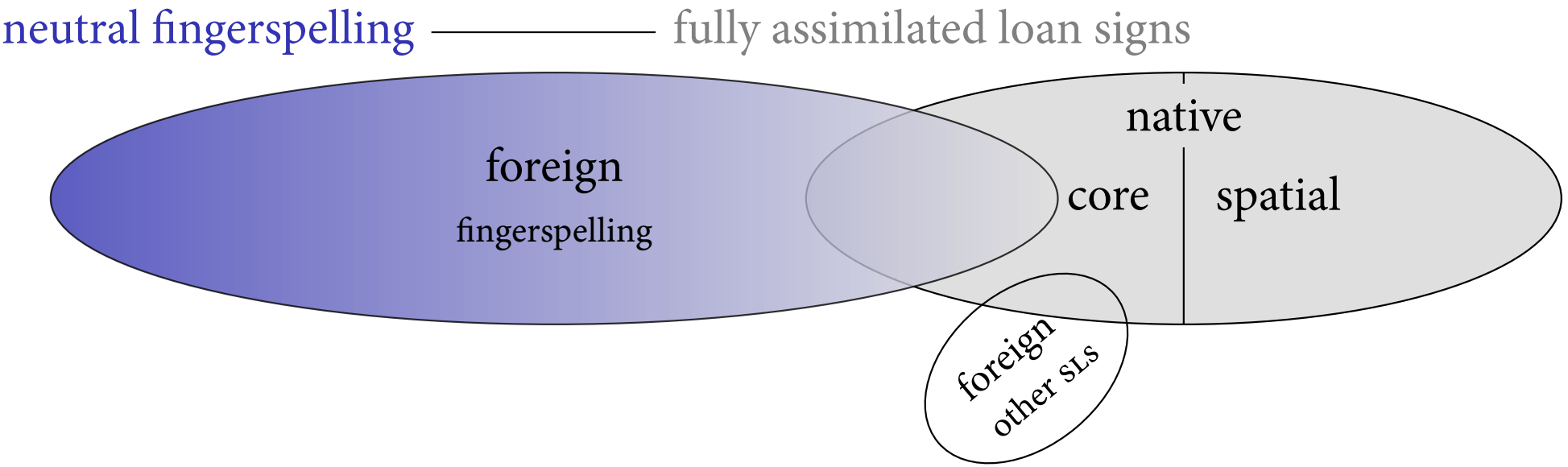

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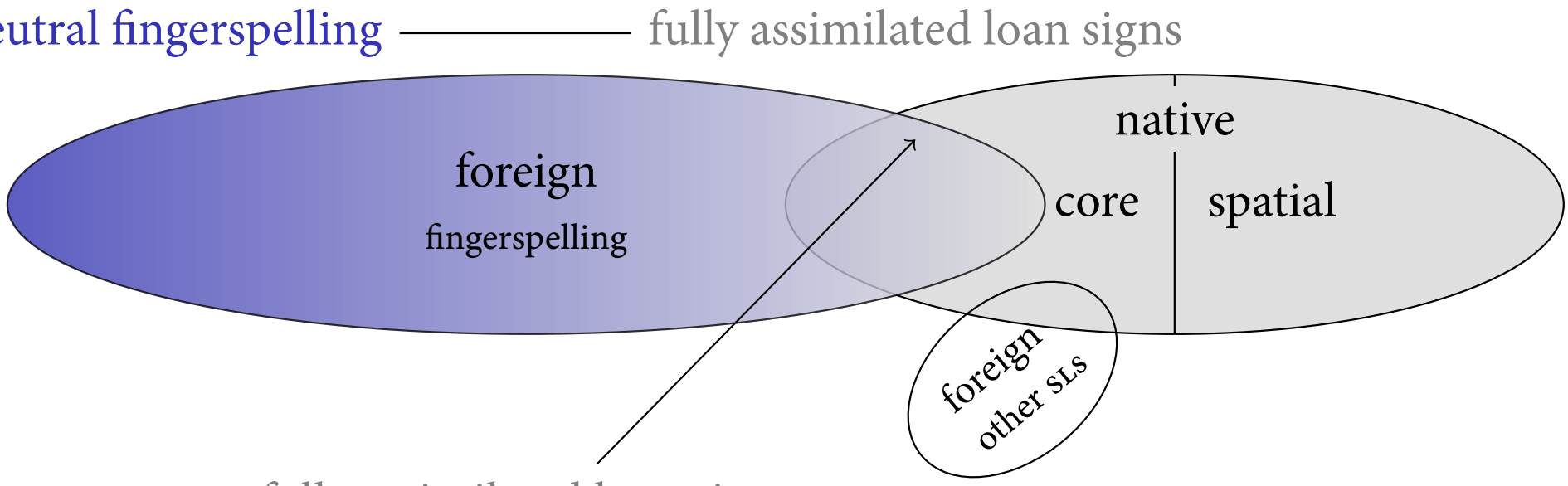

fully assimilated loan signs

eg NO

adapted from Brentari and Padden (2001); Battison (1978)

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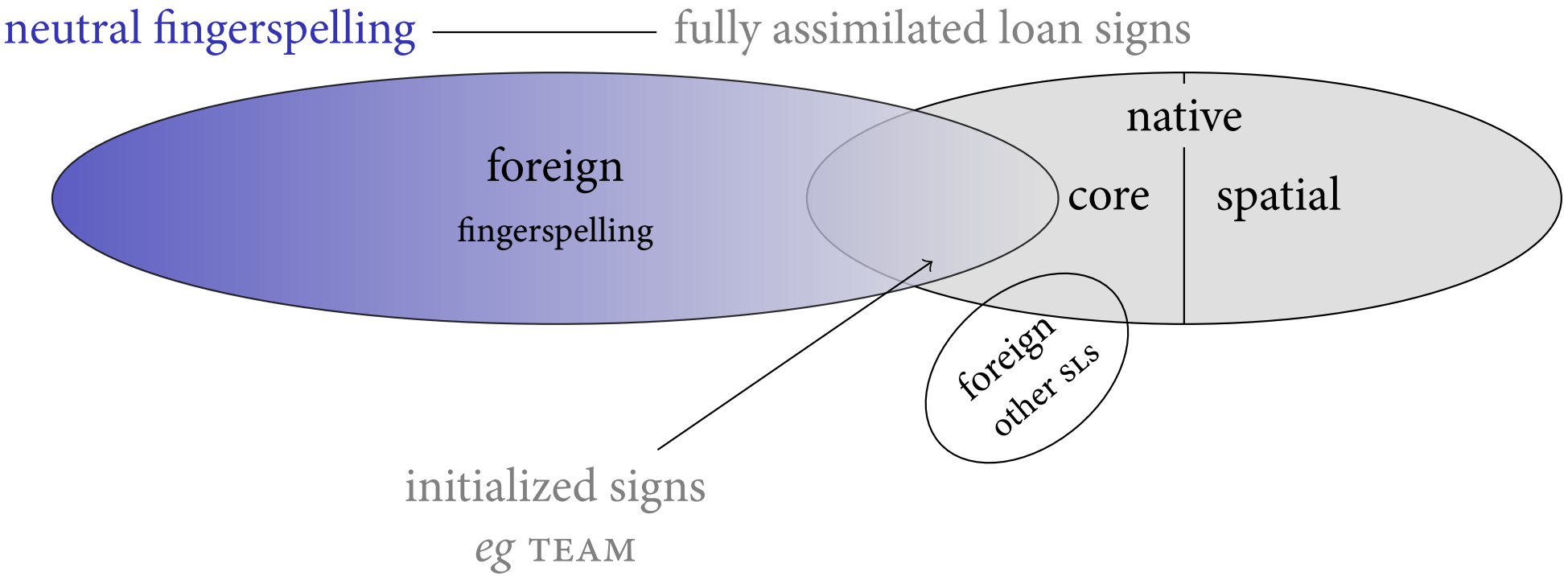

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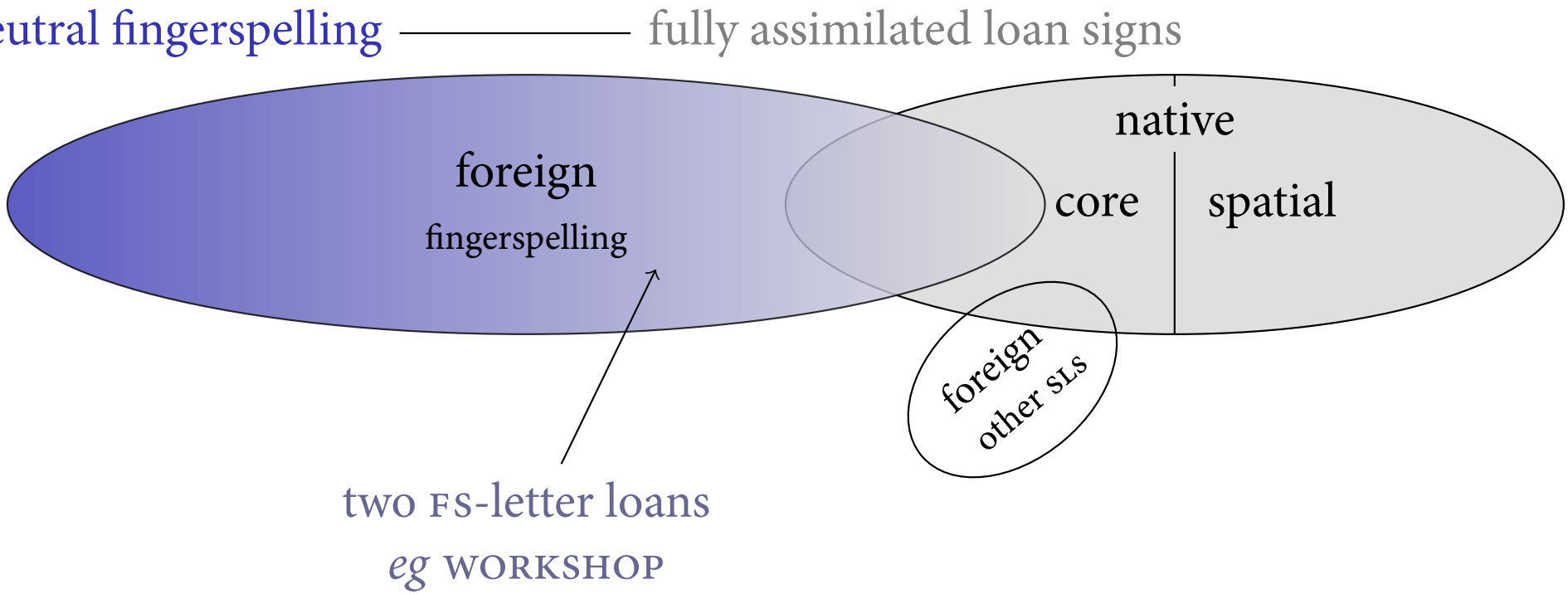

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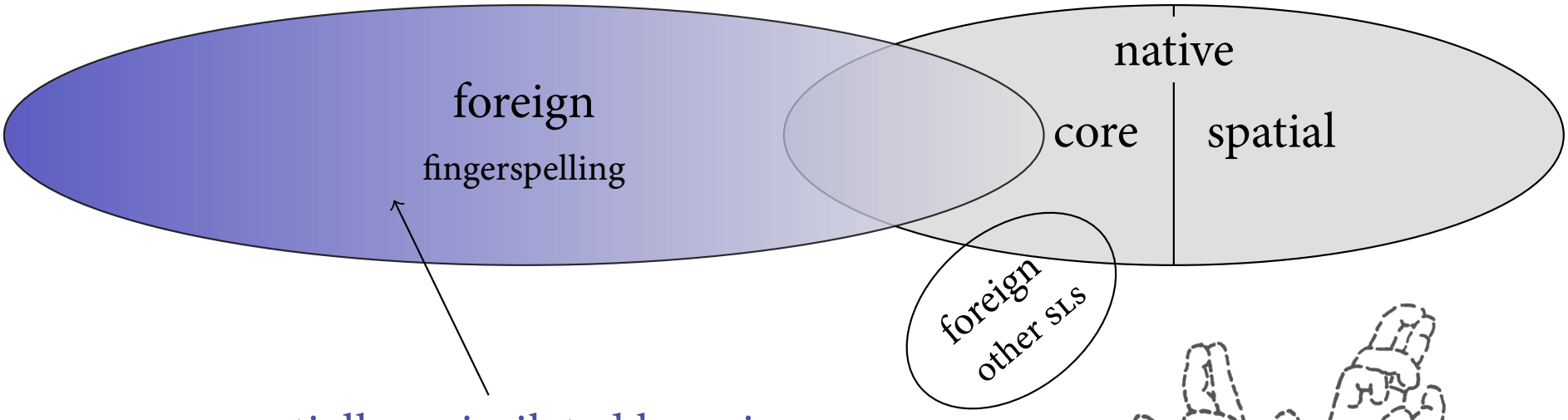
Structure of the ASL lexicon

neutral fingerspelling ——— fully assimilated loan signs



partially assimilated loansigns

eg #EARLY

adapted from Brentari and Padden (2001); Battison (1978)

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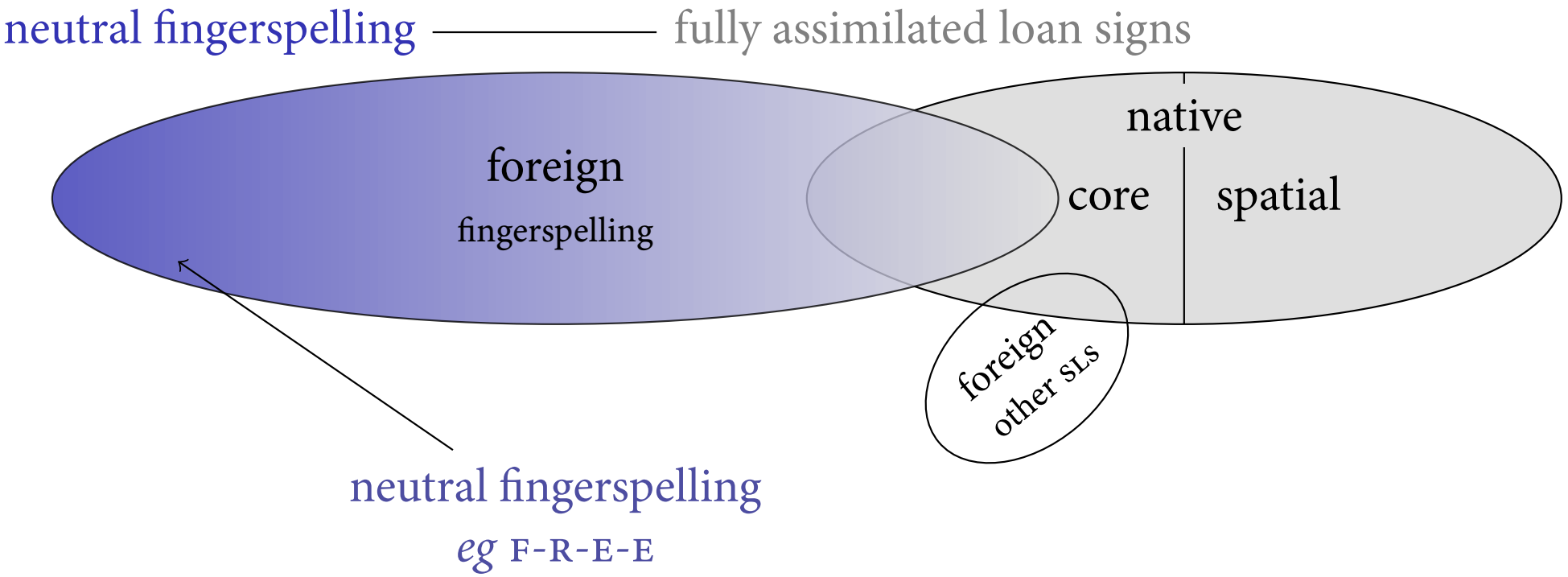

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Why neutral fingerspelling?

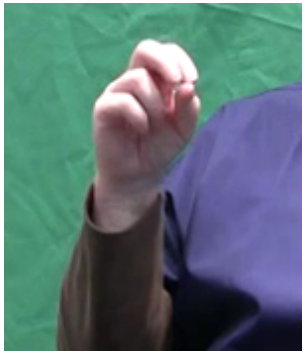
Fingerspelling involves quick and sequential handshape changes, unlike signing.

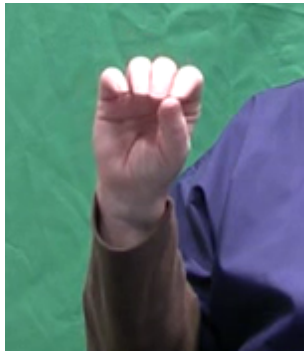
Which results in an ideal data set to look at variation in handshape because there are

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

Ulnar flexion

We defined ulnar flexion variants as apogees where either the proximal interphalangeal or the metacarpophalangeal joint was more flexed in ulnar digits than radial digits.


-O- [+flex]


-O- [−flex]

-E- [+flex]

-E- [−flex]

-D- [+flex]

-D- [−flex]

Apogees from A-U-T-H-O-R-I-T-Y, C-O-U-P-L-E, I-N-T-E-R-E-S-T, D-E-C-I-S-I-O-N, G-R-O-U-N-D, and D-A-Y-S,

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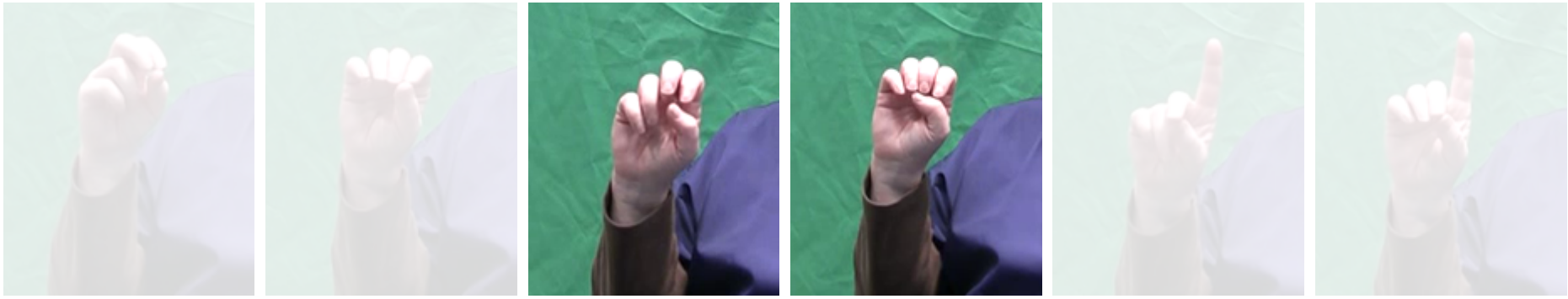

-O- [+flex] -O- [−flex] -E- [+flex] -E- [−flex] -D- [+flex] -D- [−flex]

Apogees from A-U-T-H-O-R-I-T-Y, C-O-U-P-L-E, I-N-T-E-R-E-S-T, D-E-C-I-S-I-O-N, G-R-O-U-N-D, and D-A-Y-S,

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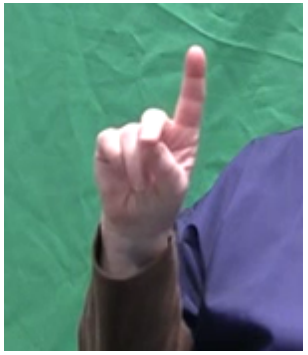
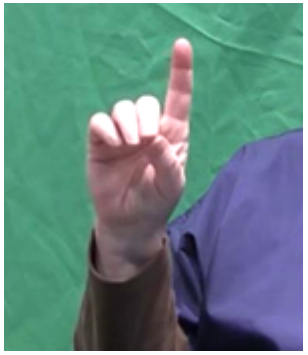
-O- [+flex]

-O- [−flex]

-E- [+flex]

-E- [−flex]


-D- [+flex]


-D- [−flex]

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Recording specifications

- 4 native signers, 1 early leaner (2 (native) coded so far) produced
- 300 words
  - 100 names
  - 100 nouns
  - 100 non-English words
- repeating each word twice
- being recorded by 2 or 3 video cameras
- recording at 60 FPS
- for a total of 8,115 apogees

Apogee detection

We used a combination of human coders, algorithmic averaging, forced alignment, and verification to code timing data.

Apogees

- are the point where the hand reached a target handshape and orientation, or
- the point of minimum instantaneous velocity of all of the articulators, but
- crucially are not defined as the canonical form.

(Keane et al., 2011)

Feature annotation

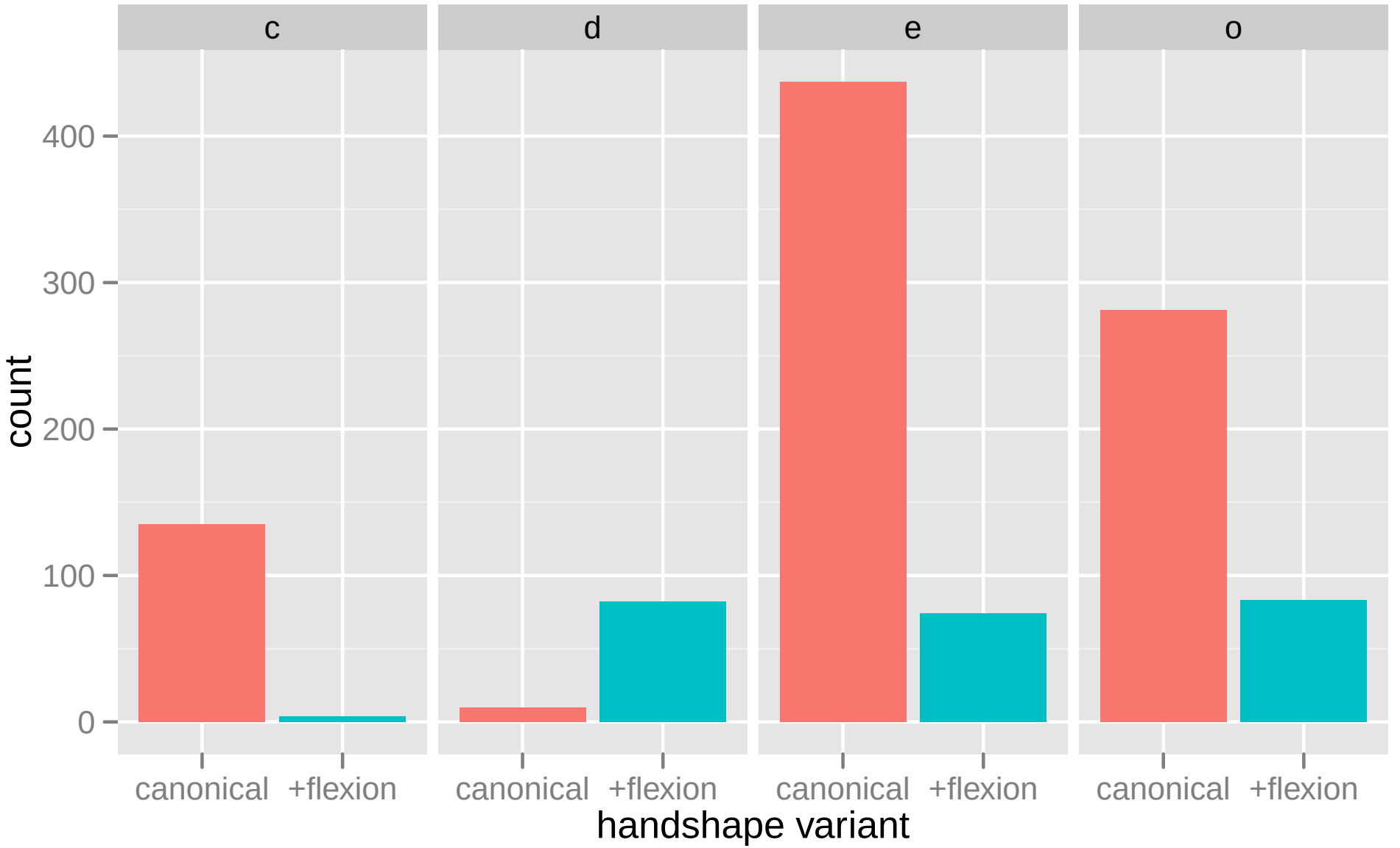
Feature annotation

- We extracted still images from each apogee that has been coded.
- We human coded features of hand configuration:
  - all -C-, -D-, -E-, and -O- apogees for ulnar flexion.
- There are 4,741 word medial apogees annotated.

Two goals

- A simple task with only a minimal amount of training necessary
- A metric that would apply regardless of how canonical a given handshape was

Handshape variation



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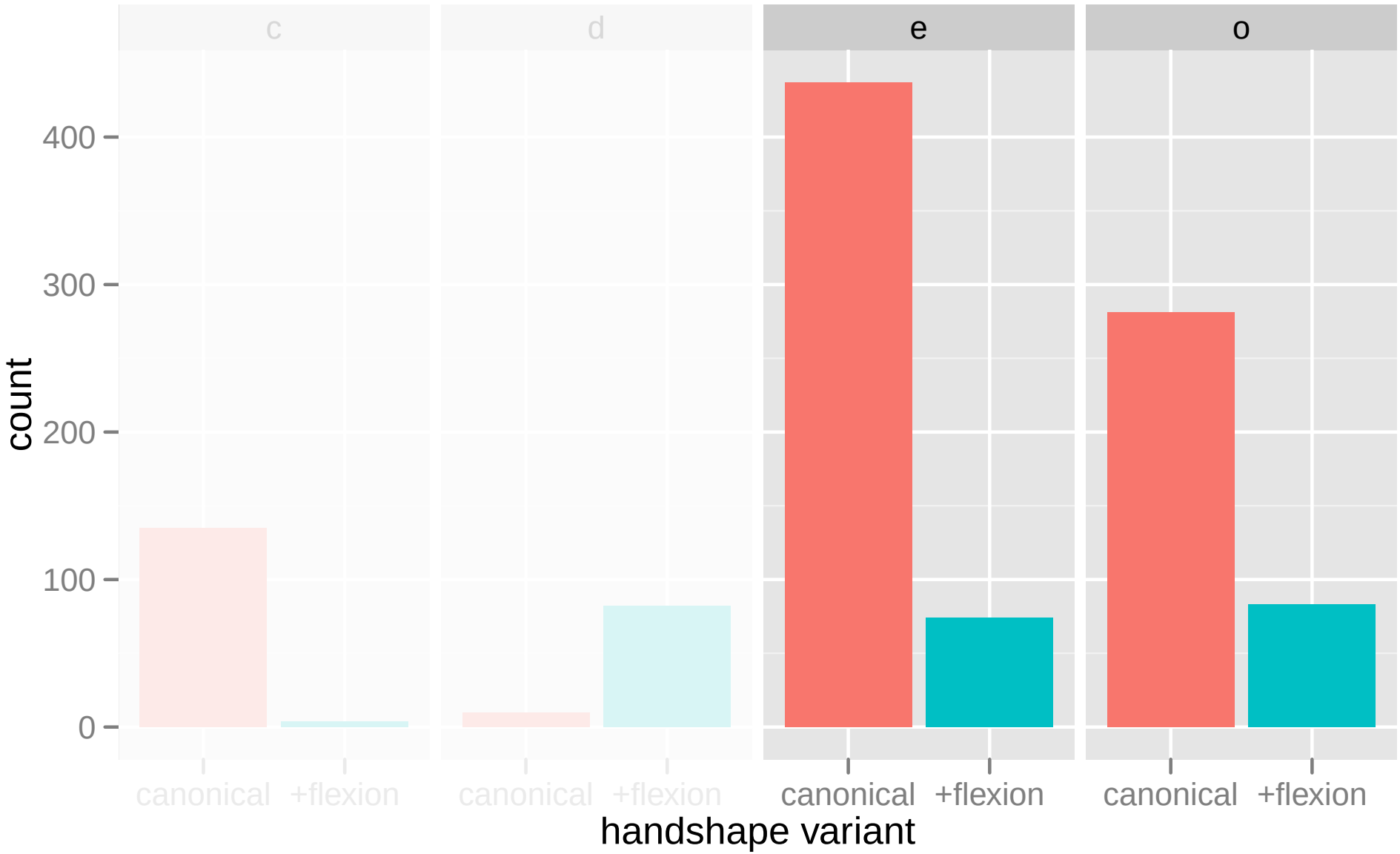

What features encourage ulnar digit flexion?

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.

one finger	two fingers	three fingers
-G-, -L-, -Q-, -T-, -X-, and -Z-	-H-, -K-, -N-, -P-, -R-, -U-, and -V-	-M-, -W-, and -D-

all fingers	others (ulnar)
-A-, -B-, -C-, -E-, -O-, and -S-	-F-, -I-, -J-, and -Y-

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radial: [−flex] (>extension)
ulnar: [+flex]

all fingers	others (ulnar)
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all fingers	others (ulnar)	
-A-, -B-, -C-, -E-, -O-, and -S-	-F-, -I-, -J-, and -Y-	all: [±flex] or radial: [+flex] ulnar: [−flex]

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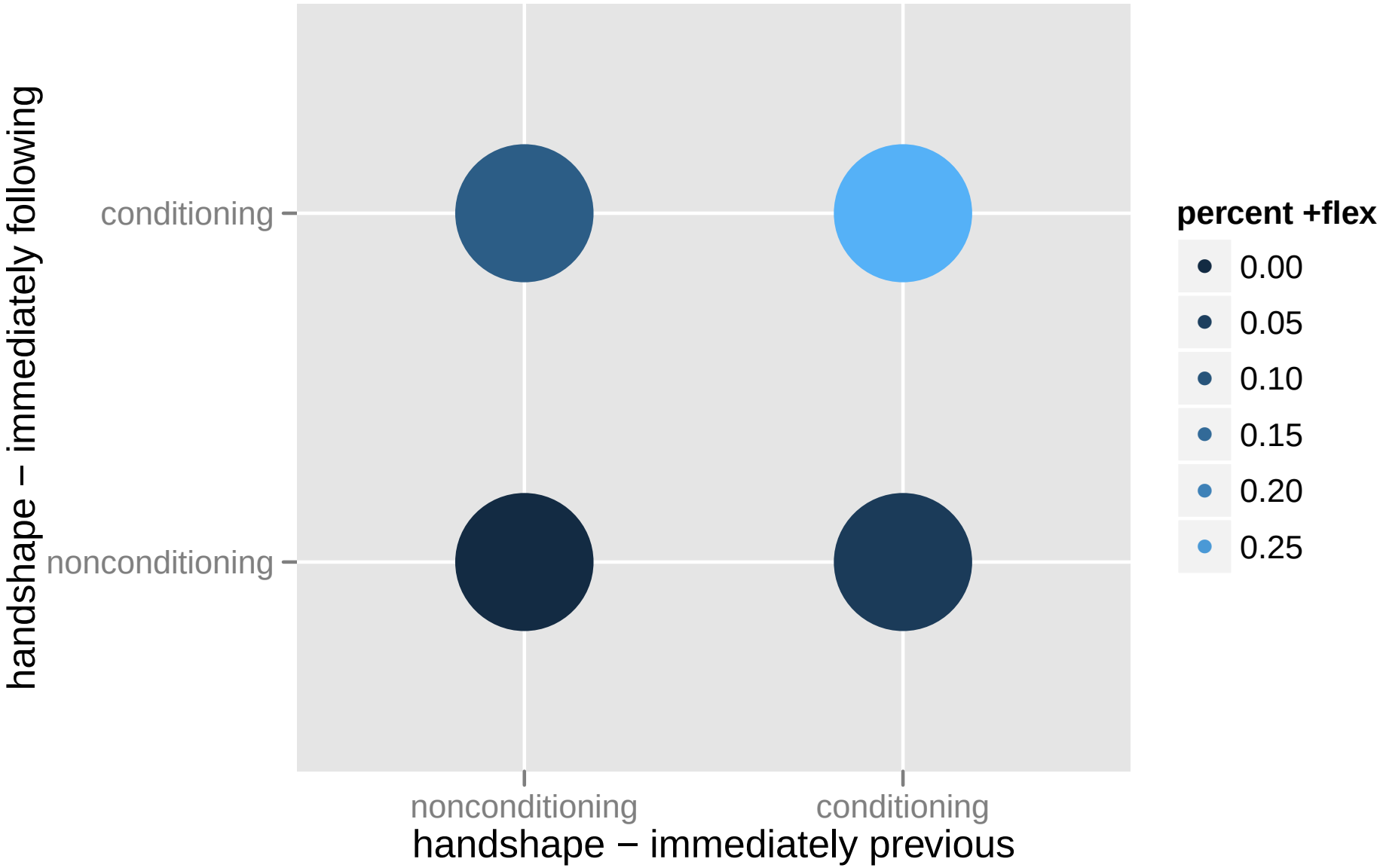
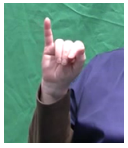
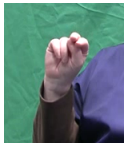
one finger	two fingers	three fingers	
-G-, -L-, -Q-, -T-, -X-, and -Z-	-H-, -K-, -N-, -P-, -R-, -U-, and -V-	-M-, -W-, and -D-	conditioning
all fingers	**others (ulnar)**		
-A-, -B-, -C-, -E-, -O-, and -S-	-F-, -I-, -J-, and -Y-		non-conditioning

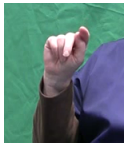
Flexion based on surrounding handshapes

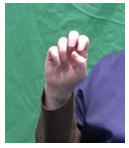


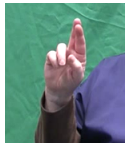
What effects the -E- handshape?

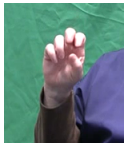

-I-

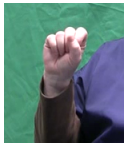

-N-

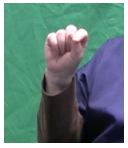

-T-

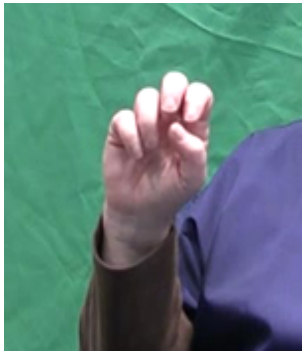

-E-


-R-


-E-


-S-


-T-



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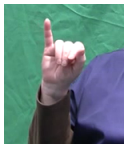
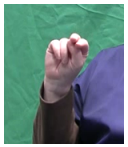
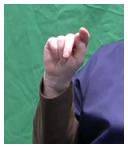
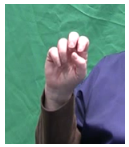

-I-


-N-


-T-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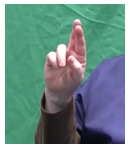
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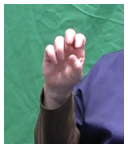
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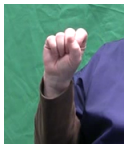
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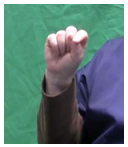
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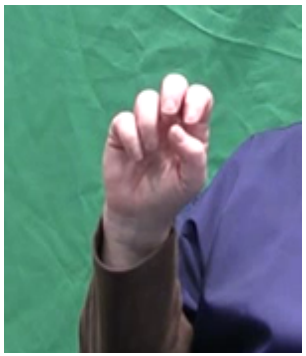


apogee handshape

What effects the -E- handshape?

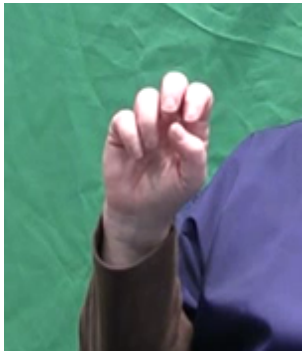
-I- -N- -T- -E- -R- -E- -S- -T-

word type

name, noun, foreign

signer

s1, s2



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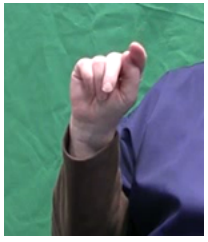
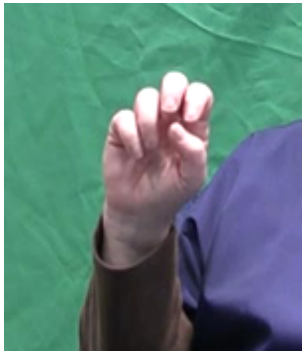


previous handshape ⟶



apogee handshape

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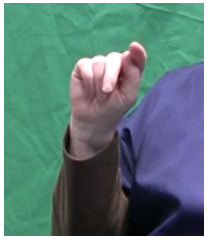
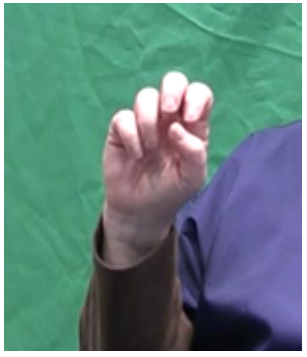
signer

s1, s2



previous handshape

previous transition time



apogee handshape

What effects the -E- handshape?

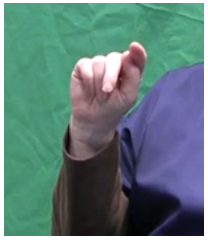
-I- -N- -T- -E- -R- -E- -S- -T-

word type

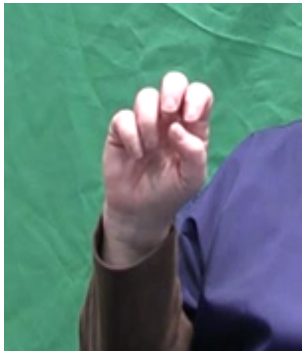
name, noun, foreign

signer

s1, s2



previous handshape



following handshape

previous transition time

apogee handshape

What effects the -E- handshape?

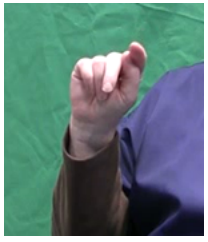
-I- -N- -T- -E- -R- -E- -S- -T-

word type

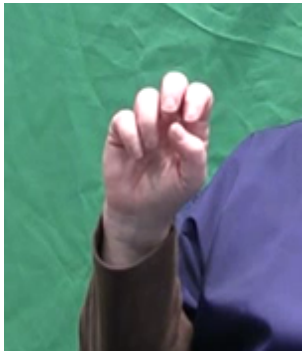
name, noun, foreign

signer

s1, s2



previous handshape



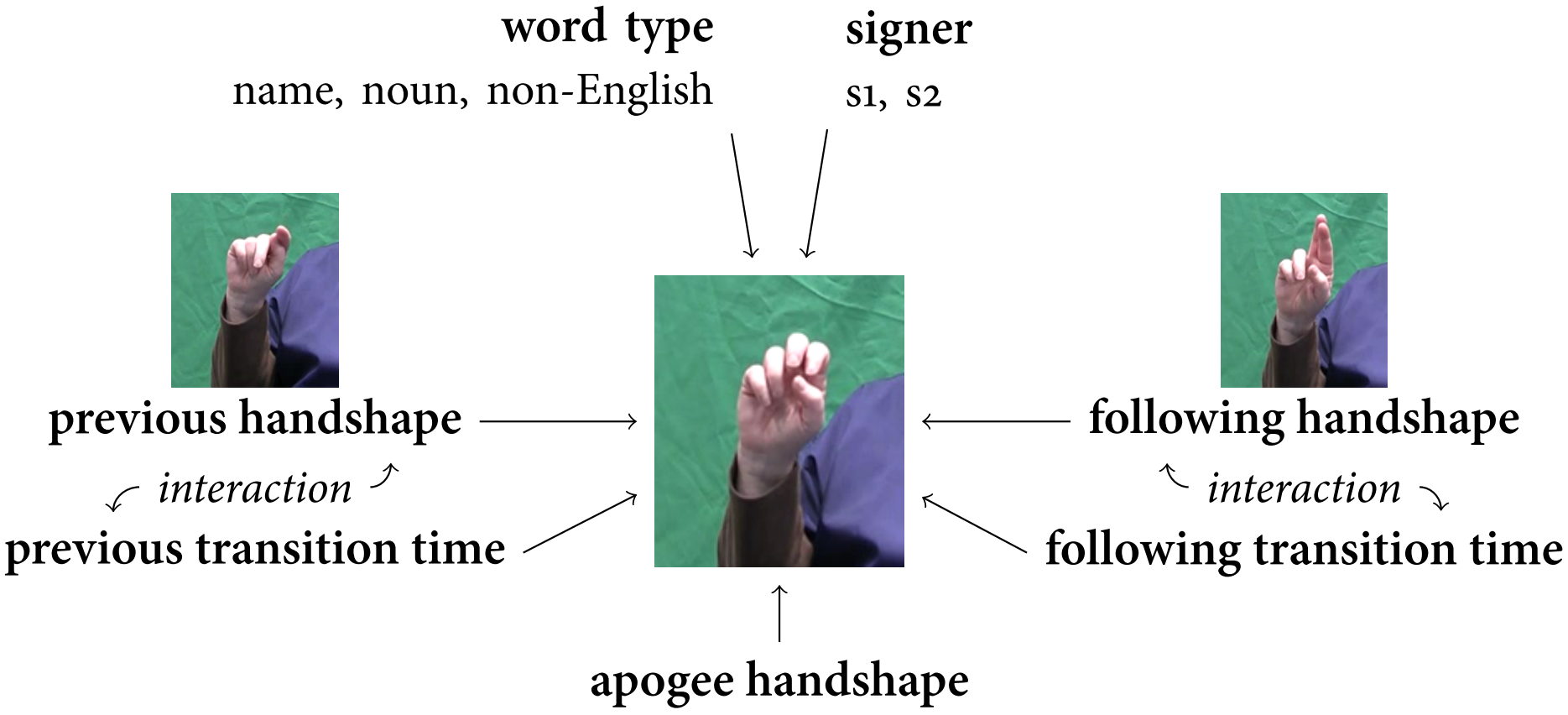
following handshape

previous transition time

following transition time

apogee handshape

Significant effects for ulnar flexion

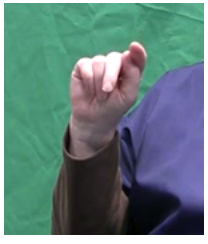


(Keane et al., 2012)

Significant effects for ulnar flexion

word type
name, noun, non-English

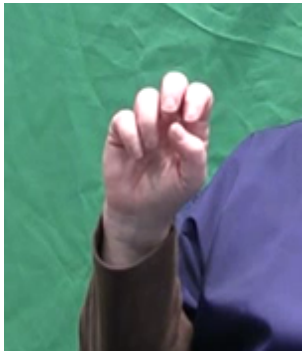
signer
s1, s2



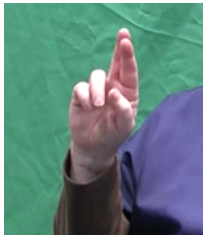
previous handshape

interaction

previous transition time



apogee handshape



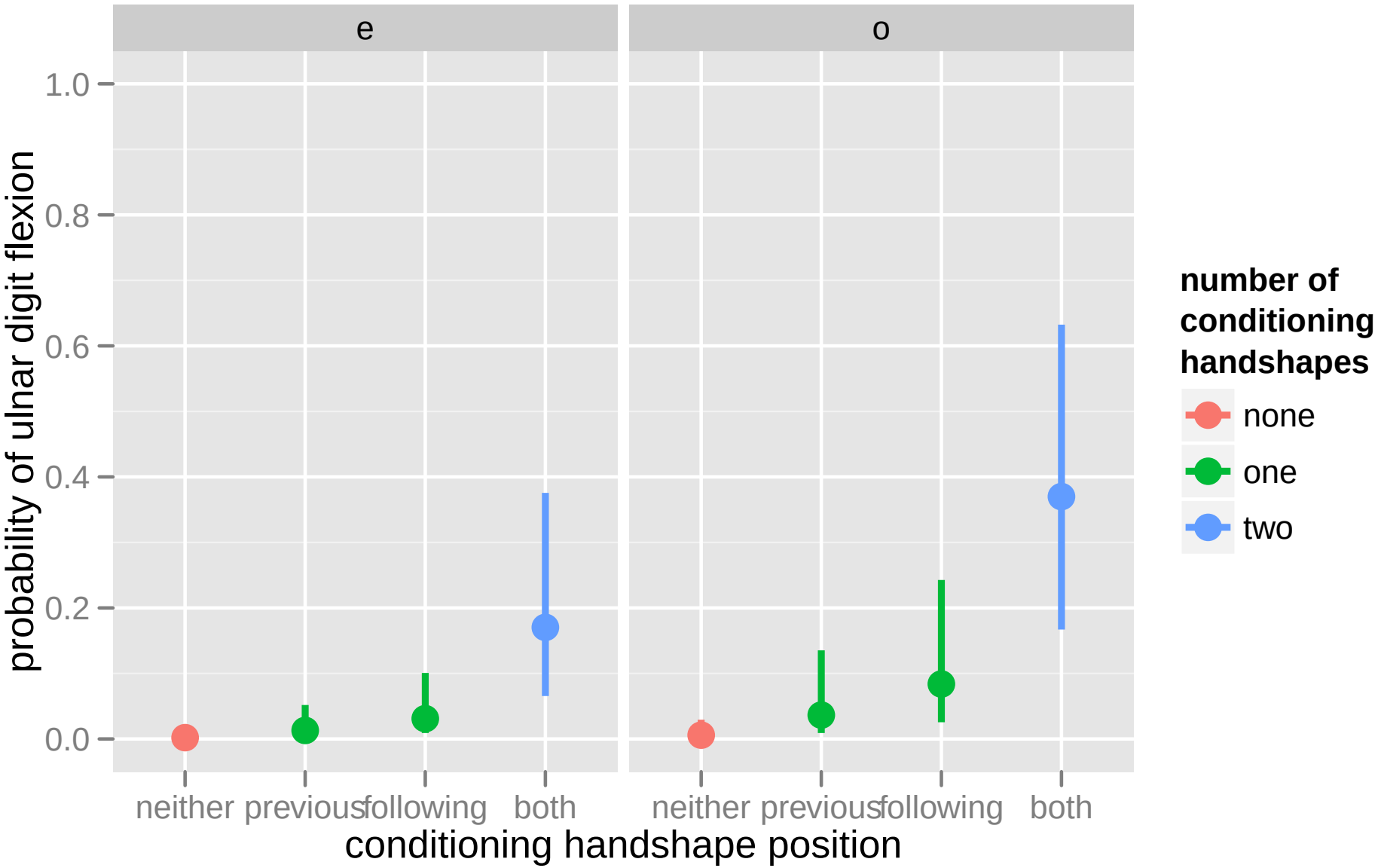
following handshape

interaction

following transition time

(Keane et al., 2012)

Model predictions for ulnar flexion (mean transition times)



Conditioning features

- Increased ulnar digit flexion occurs in the context of surrounding apogees with handshapes that have extended radial fingers and flexed ulnar fingers.
- It seems that flexed, nonselected ulnar fingers are spreading from surrounding apogees to -E- and -O-.

-T- -E- -R- -R- -O- -U-

Apogees from I-N-T-E-R-E-S-T and T-R-O-U-B-L-E

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Apogees from I-N-T-E-R-E-S-T and T-R-O-U-B-L-E

Conditioning nonselected fingers? Really?

Alternatively, the selected fingers specification assimilates from surrounding apogees, to apogees that are underspecified for selected fingers (*ie* [all]).

- Many phonological theories of handshape use underspecification, especially for [all] selected fingers.
- Underspecified features are traditionally assumed to be the most susceptible to assimilation (*cf* alveolar nasals).
- A similar phenomenon has been observed in sign errors (*eg* MUST SEE (Klima and Bellugi, 1979)).

Pushing the boundaries

Because of underspecification, handshapes that have [all] fingers selected should be more susceptible to assimilation.

Of the [all] fingers selected handshapes:

- -E- and -O- show variation.
- -A- and -S- show no variation, but all fingers completely flexed.
- -C- shows little variation, but this could be physiological, (CF lexical handshape contours).
- -B- (seemingly) shows no variation, has all fingers extended, this might be physiological or phonological blocking (EG -U-).

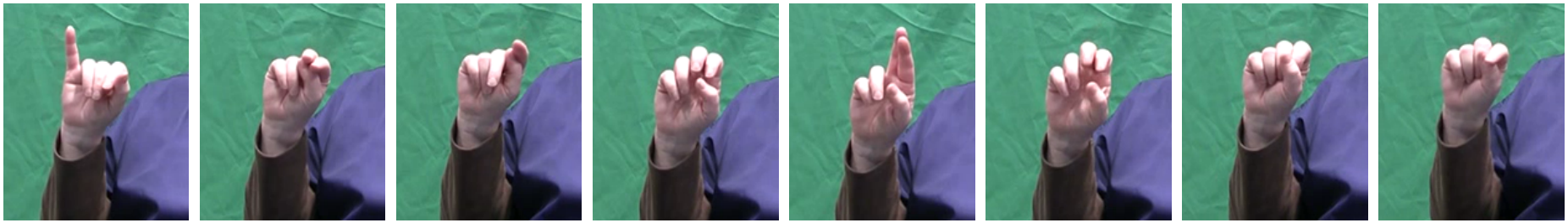
Predictions

If this phenomenon is the result of the assimilation of a phonological feature, and not the result of overlapping gestural constraints more like coarticulation, we expect:

- no temporal variation
- no effect of word category

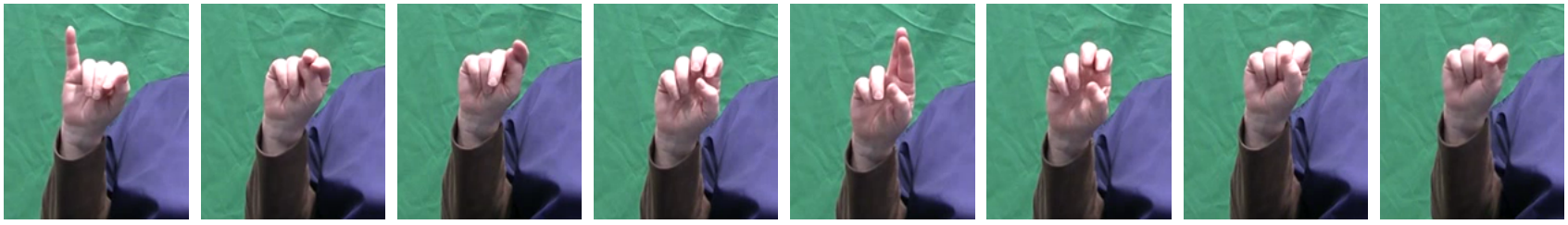
I-N-T-E-R-E-S-T; half speed

Clipsinterest.mp4

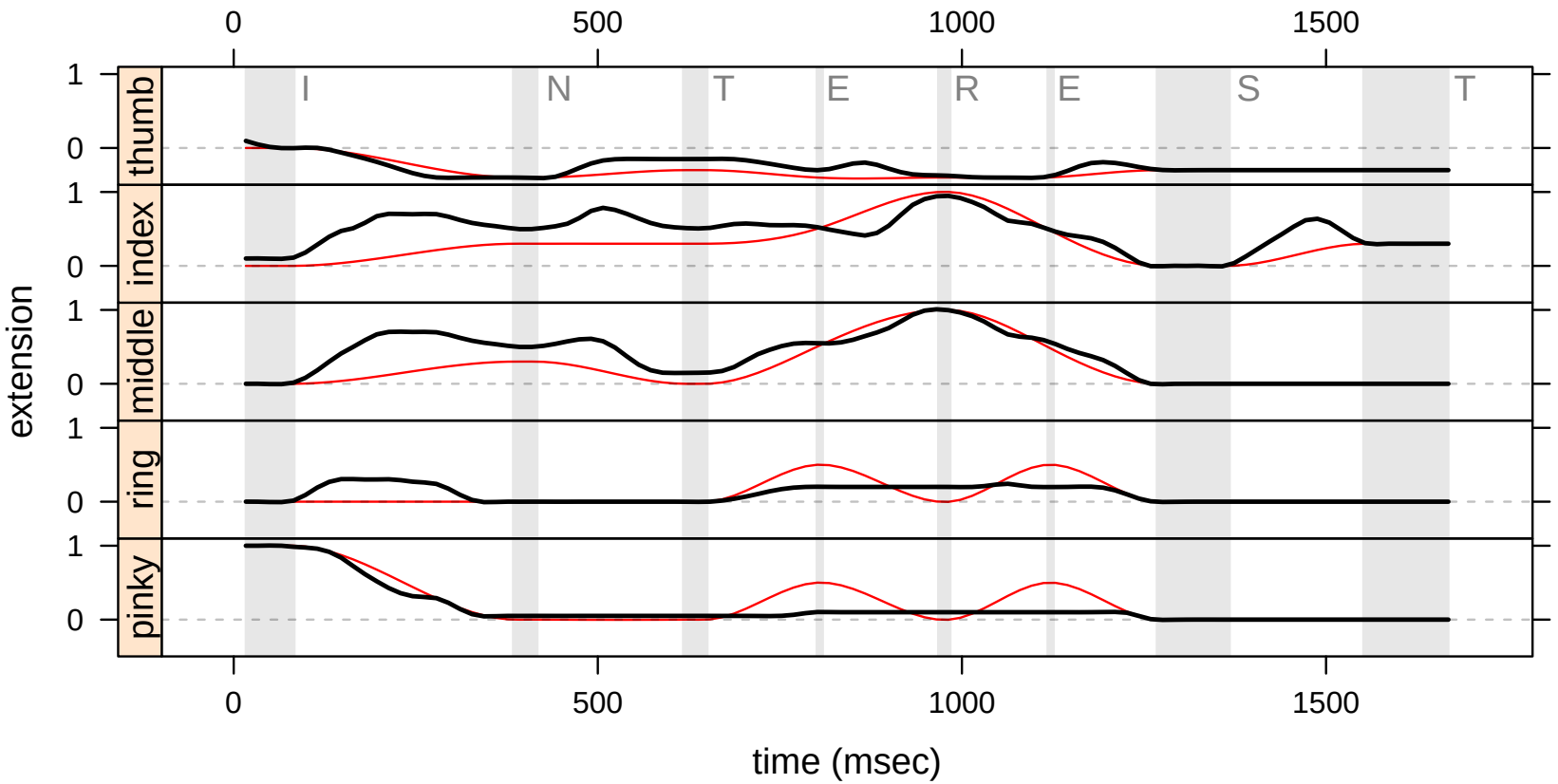


-I- -N- -T- -E- -R- -E- -S- -T-

Articulator trajectories



-I- -N- -T- -E- -R- -E- -S- -T-



Conclusions

For ulnar digit flexion, handshapes vary based on phonological properties of surrounding apogees.

This variation is similar to processes that are used to nativize fingerspelling loan signs.

This process reduces the number of changes to which fingers are selected, bringing the neutral fingerspelling more phonologically toward ASL, without other large scale reductions or deletions.

Fingerspelling is important to study to develop theories about coarticulation and assimilation of handshape, because it pushes the boundaries of what is allowed by ASL phonology.

Future Directions

- We need feature annotation between the apogees for a more concrete sense of temporal variation.
- We need more precise timing measurements to look at the systematicity of holds and transitions.
- We need more precise articulator movement measurements.

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

Jason Riggle and Diane Brentari

Other researchers

Susan Rizzo, Karen Livescu, Greg Shakhnarovich, Raquel Urtasun, Erin Dahlgren, and Katie Henry.

References

Akamatsu, Carol Tane. 1982. The acquisition of fingerspelling in pre-school children. University of Rochester dissertation.

Battison, Robbin. 1978. Lexical borrowing in american sign language. Silver Spring, Maryland: Linstock Press, Inc.

Brentari, Diane, and Carol Padden. 2001. Foreign vocabulary in sign languages: A cross-linguistic investigation of word formation, chap. Native and foreign vocabulary in American Sign Language: A lexicon with multiple origins, 87–119. Mahwah, NJ: Lawrence Erlbaum.

Keane, Jonathan, Diane Brentari, and Jason Riggle. 2012. Handshape and coarticulation in ASL fingerspelling. conference presentation. Linguistic Society of America 2012 Annual Meeting.

Keane, Jonathan, Susan Rizzo, Diane Brentari, and Jason Riggle. 2011. Phonetic coding of fingerspelling. conference presentation. Building sign language corpora in North America.

Klima, Edward, and Ursula Bellugi. 1979. The signs of language. Harvard University Press.

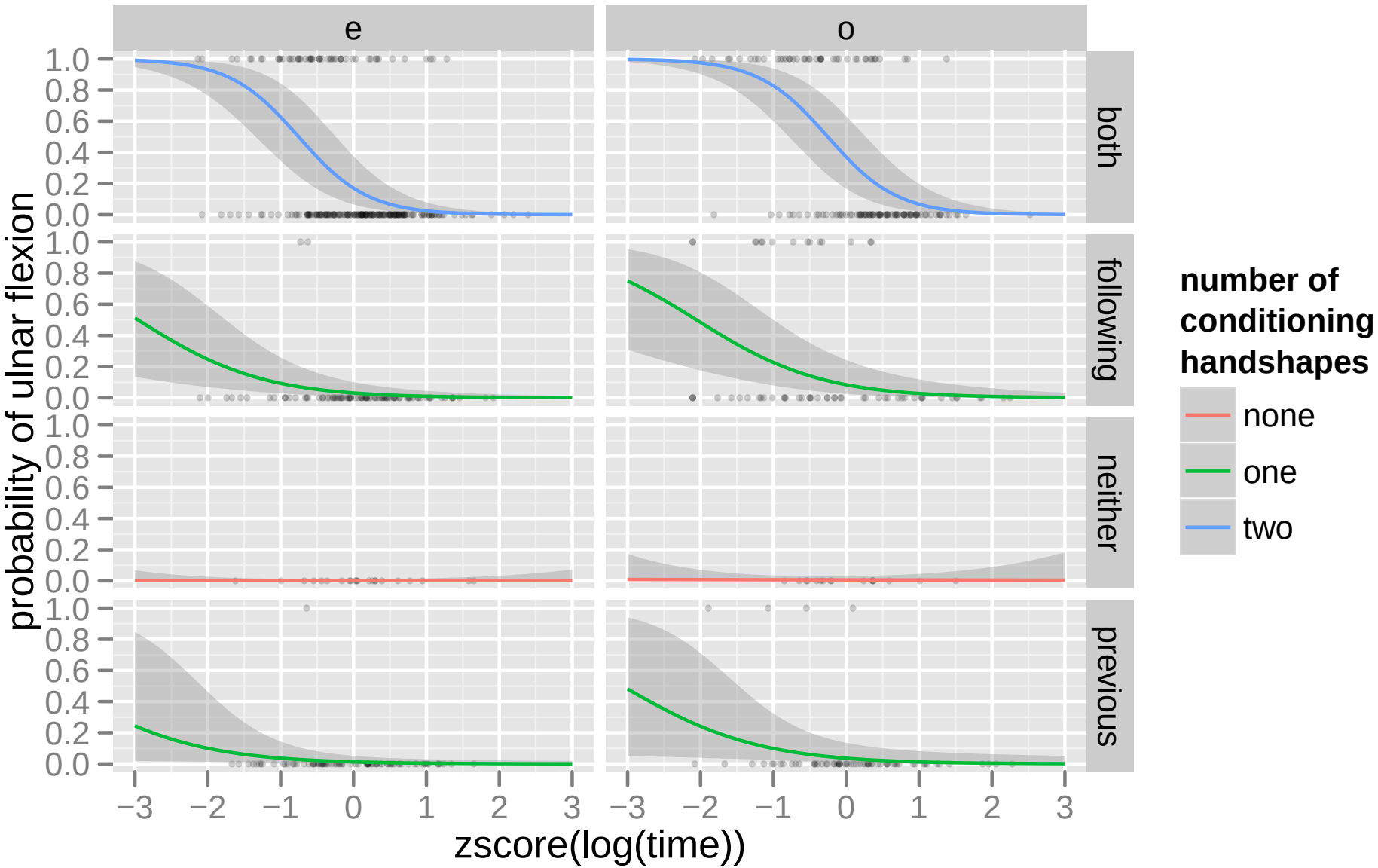
References

Padden, Carol. 1991. Theoretical issues in sign language research, chap. The Acquisition of Fingerspelling by Deaf Children, 191–210. The University of Chicago press.

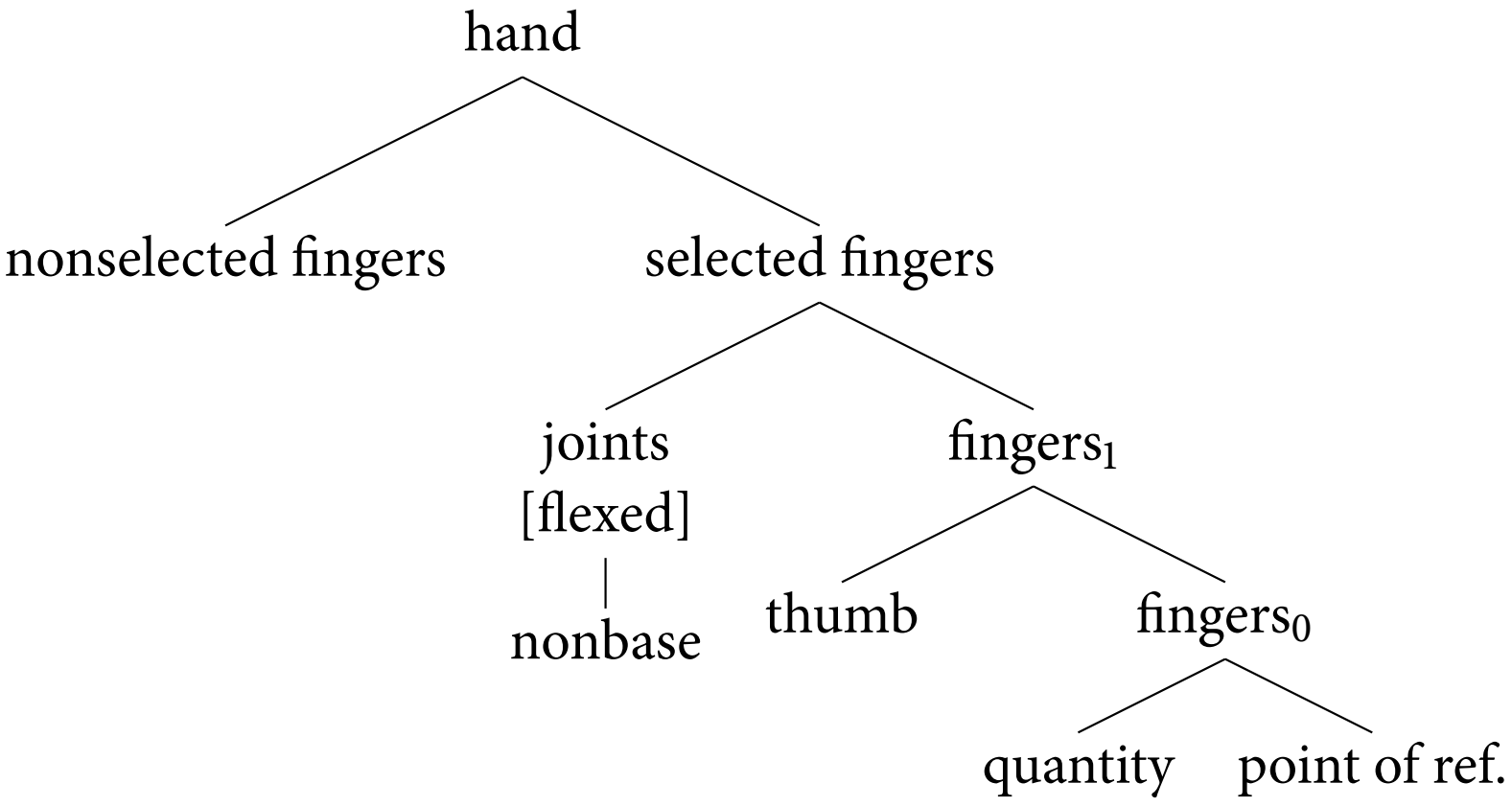
Padden, Carol, and Darline Clark Gunsauls. 2003. How the alphabet came to be used in a sign language. Sign Language Studies 4.10–33.

Wilcox, Sherman. 1992. The phonetics of fingerspelling. John Benjamins Publishing Company.

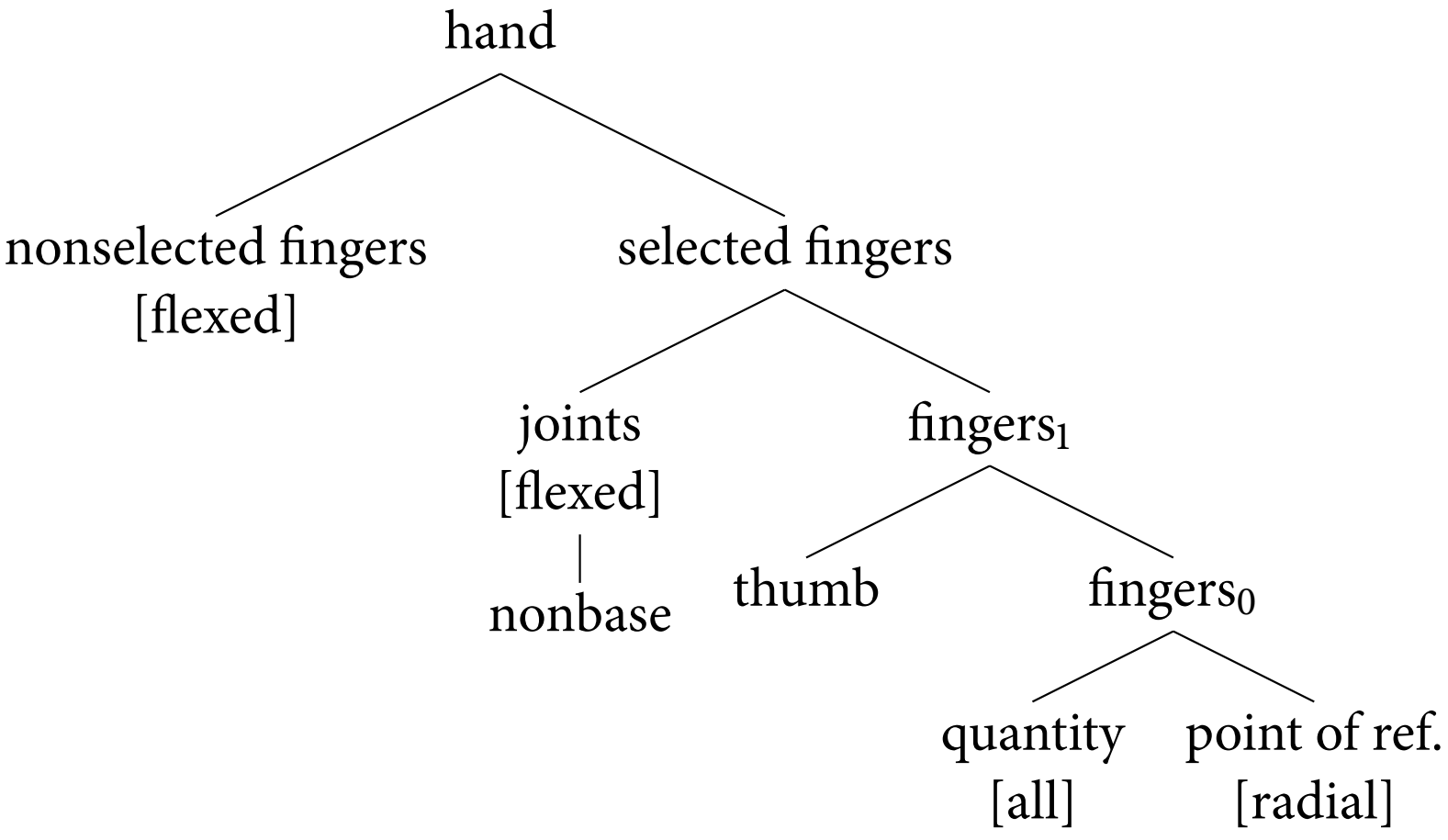
Model predictions based on transition time



Canonical -E- (no increased ulnar digit flexion)



Canonical -E- (no increased ulnar digit flexion)



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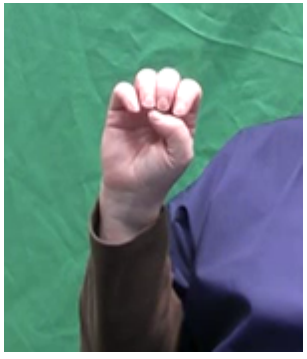
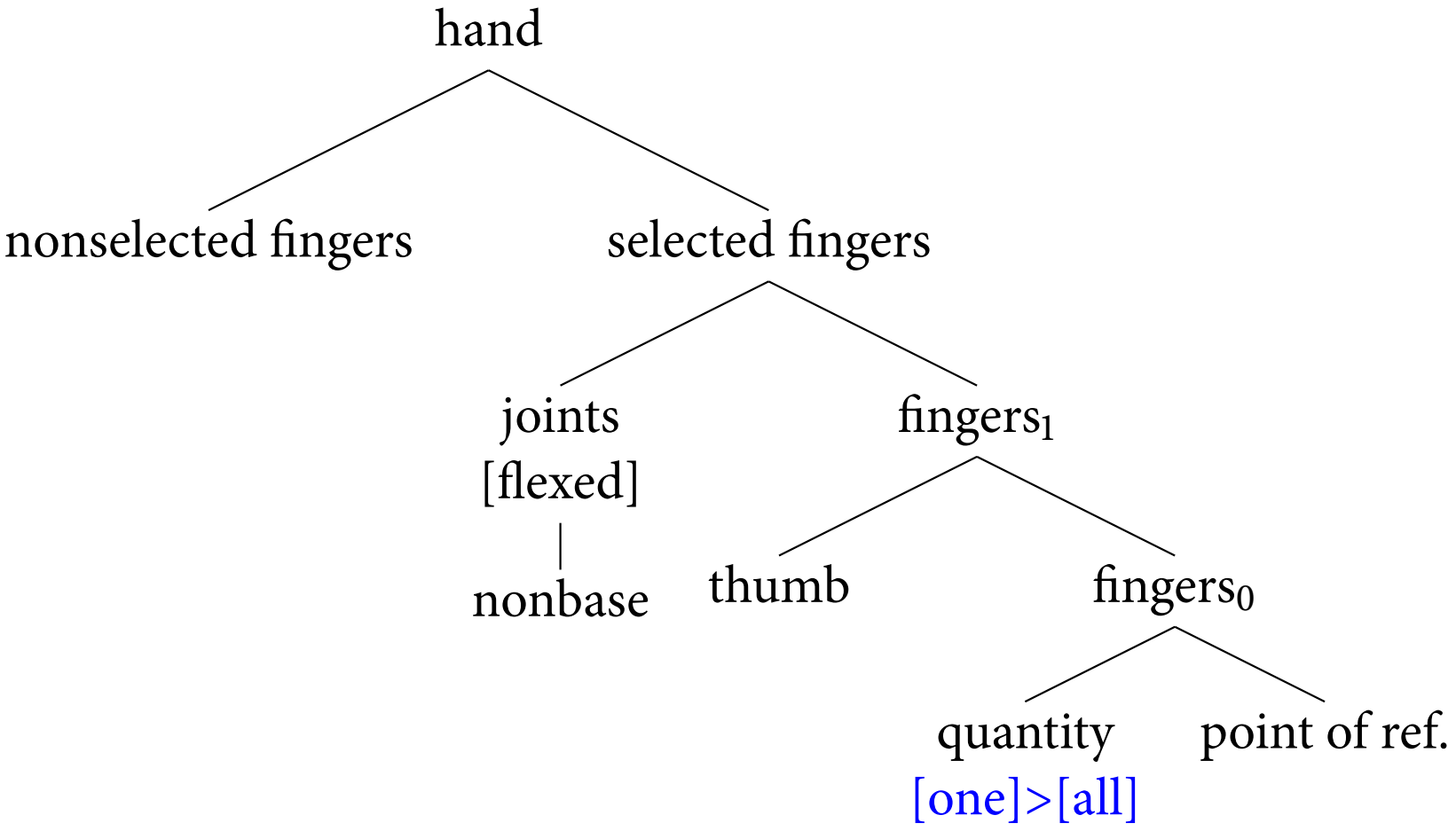
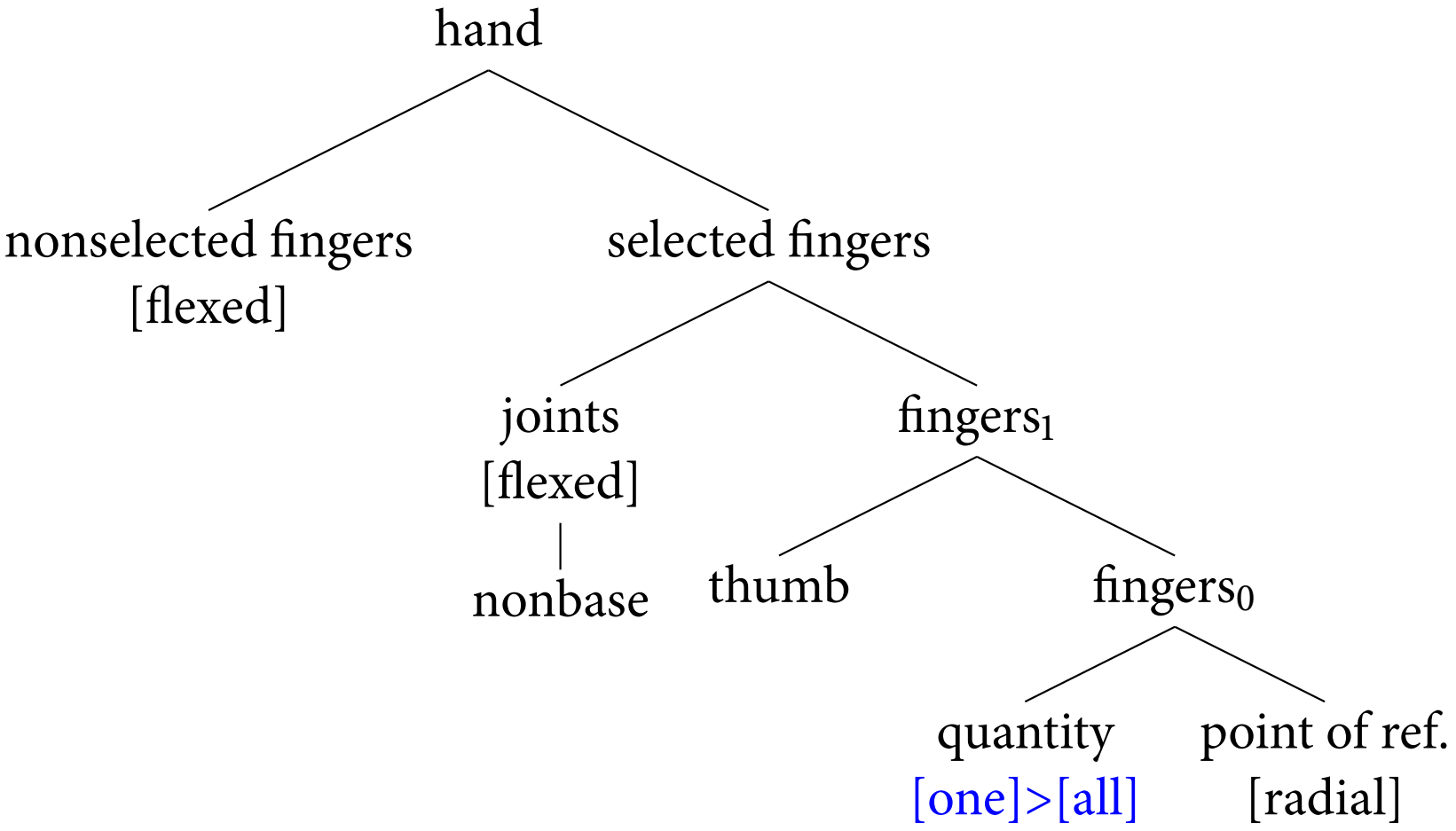


-E- with increased ulnar digit flexion



-E- with increased ulnar digit flexion



-E- with increased ulnar digit flexion