Testing two models of Sign Language phonology in ASL using data from Deaf L2 learners and naïve signers

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Phonological parameterization of signs

- Articulatory components of a sign unfold in a spatio-temporal configuration and include

HANDSHAPE

MOVEMENT

LOCATION

(ORIENTATION)

"mother" (ASL)

- Phonological categories are distributed across dynamic gestural units in SLs.

Phonological contrast in ASL

- <u>Contrastive feature</u>: LOCATION of the sign relative to the signer's body

"mother" (ASL)

"father" (ASL)

Despite the difference in modalities, a unification account supported for spoken & SL phonologies.

Cue weighing in **auditory categorization**

- Discrete auditory categories are defined along multiple acoustic dimensions (e.g, spectral and temporal acoustic cues);

- Some acoustic dimensions play a greater role in determining the category membership of a speech sound than others (Stevens & Keiser 1989, Holt & Lotto 2006).

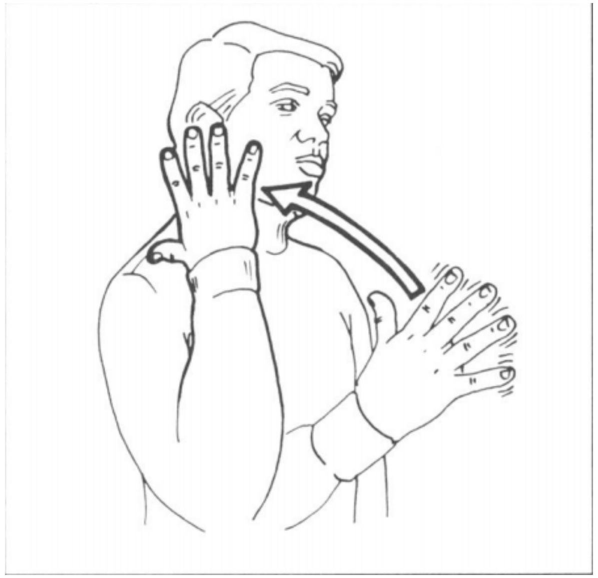
  - E.g., over 15 different cues to voicing but VOT is primary →
  - Acoustic dimensions are perceptually weighted

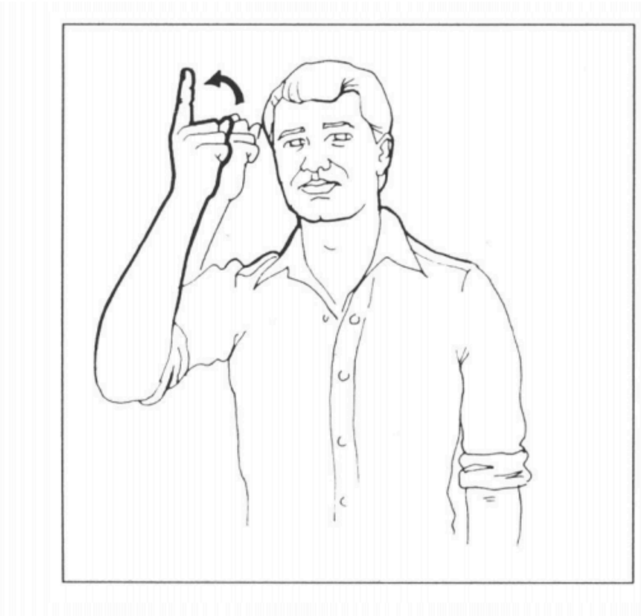
Perception of phonological contrasts in Sign L

- Hildebrandt & Corina (2002), a.o.: native deaf signers, hearing L2 learners, and hearing non-signers are responsive to articulatory dimensions of signs:
  - Perceivers may be receptive to the features which encode phonological contrasts in SL irrespective of whether they are sign-naïve or experienced.
- A unification account for spoken and sign language phonologies predicts differential perceptual weight for gestural units of signs.

Phonological categorization in Signed Ls

- Which articulatory dimensions of sign are perceptually the most salient?
- What phonological feature(s) may capitalize on such perceptual salience in languages which use kinetic signal?





Perceptual salience as a sonority requirement

- Sonority serves as a conceptual representation of perceptual salience in language (Williams, Newman 2016)
- Sonority: a non-binary phonological feature which sets the requirement for a min degree of perceptual salience/contrastiveness for adjacent segments.
- Phonetic basis - Kinetic-perceptual correlate(s): ?

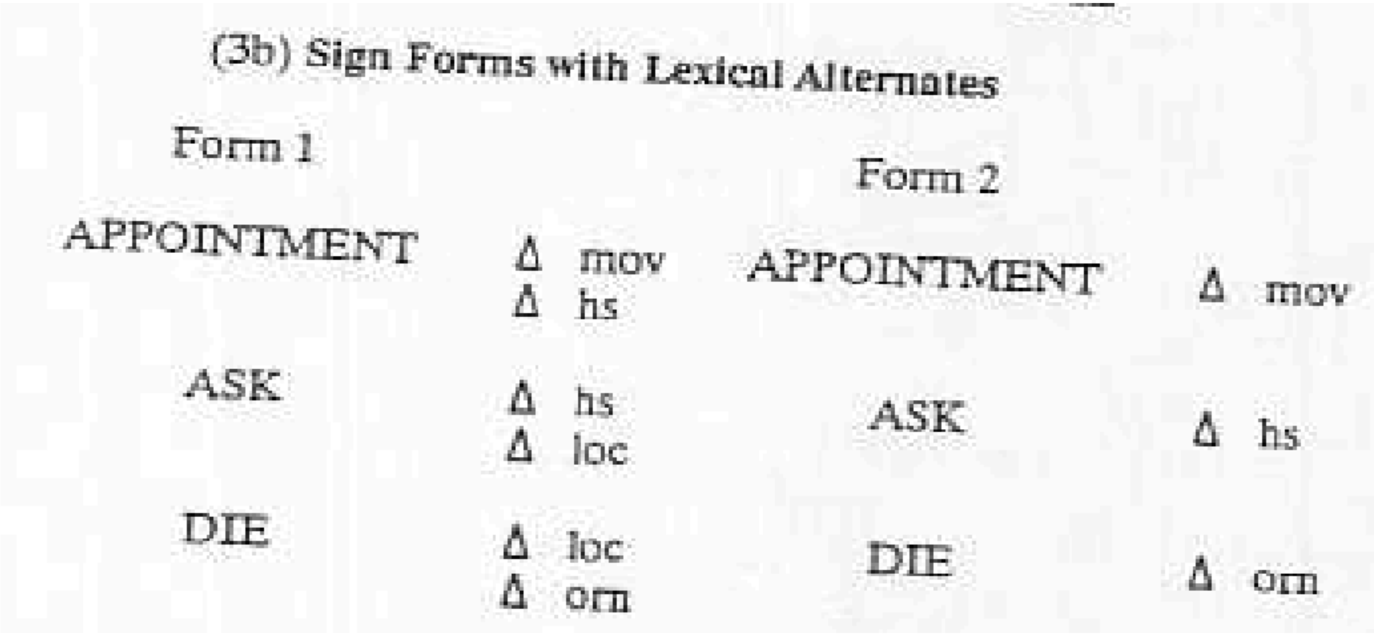
Visual sonority in SL

Phonetic basis:

A dynamic (changing) component of sign:

Corina (1990):

MOV is the optimal syllable nucleus


(3b) Sign Forms with Lexical Alternates

Form 1		Form 2	
APPOINTMENT	Δ mov Δ hs	APPOINTMENT	Δ mov
ASK	Δ hs Δ loc	ASK	Δ hs
DIE	Δ loc Δ orn	DIE	Δ orn

Sonority Hierarchies for SLs:

Corina (1990, 1996): Movement sequence > full handshape change > location change > partial handshape change

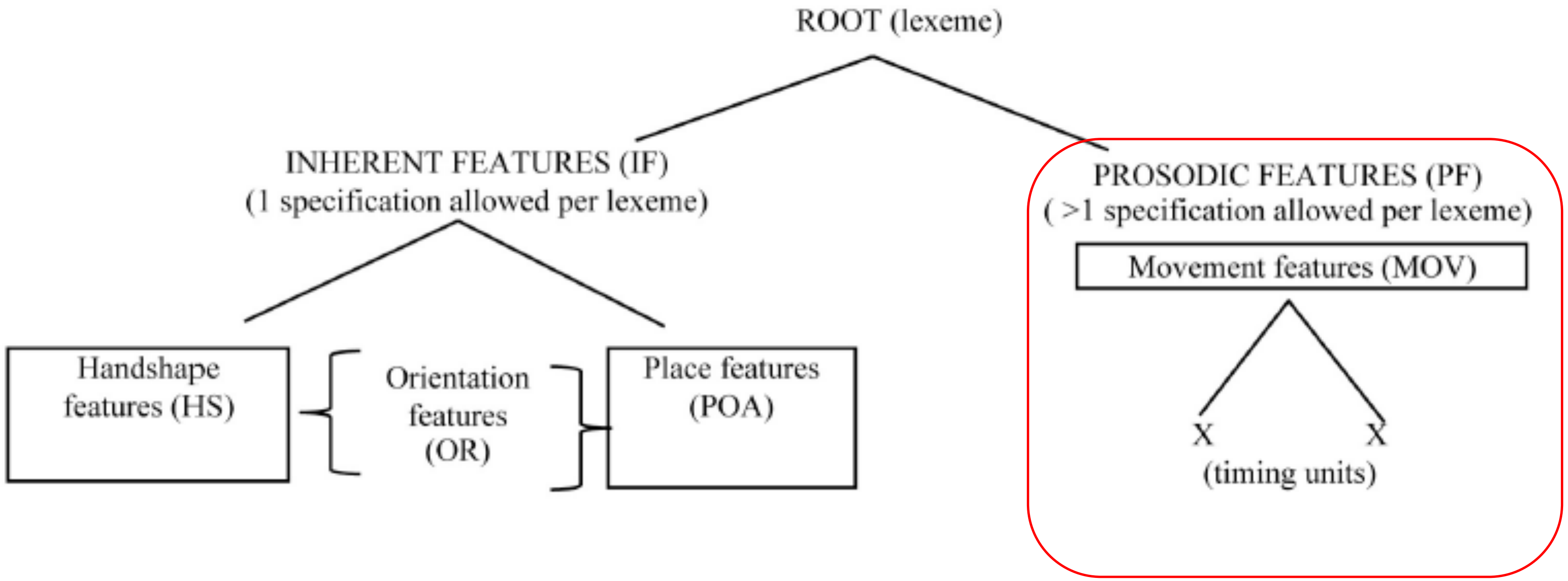
(≈ Movement > Handshape > Location)

Perlmutter (1992): Movement > Position (≈ Movement > Location)

Sandler (1993, 1996): Path movement > internal movement > locations > contacting locations

Prosodic Model for SL: Brentari (1998)

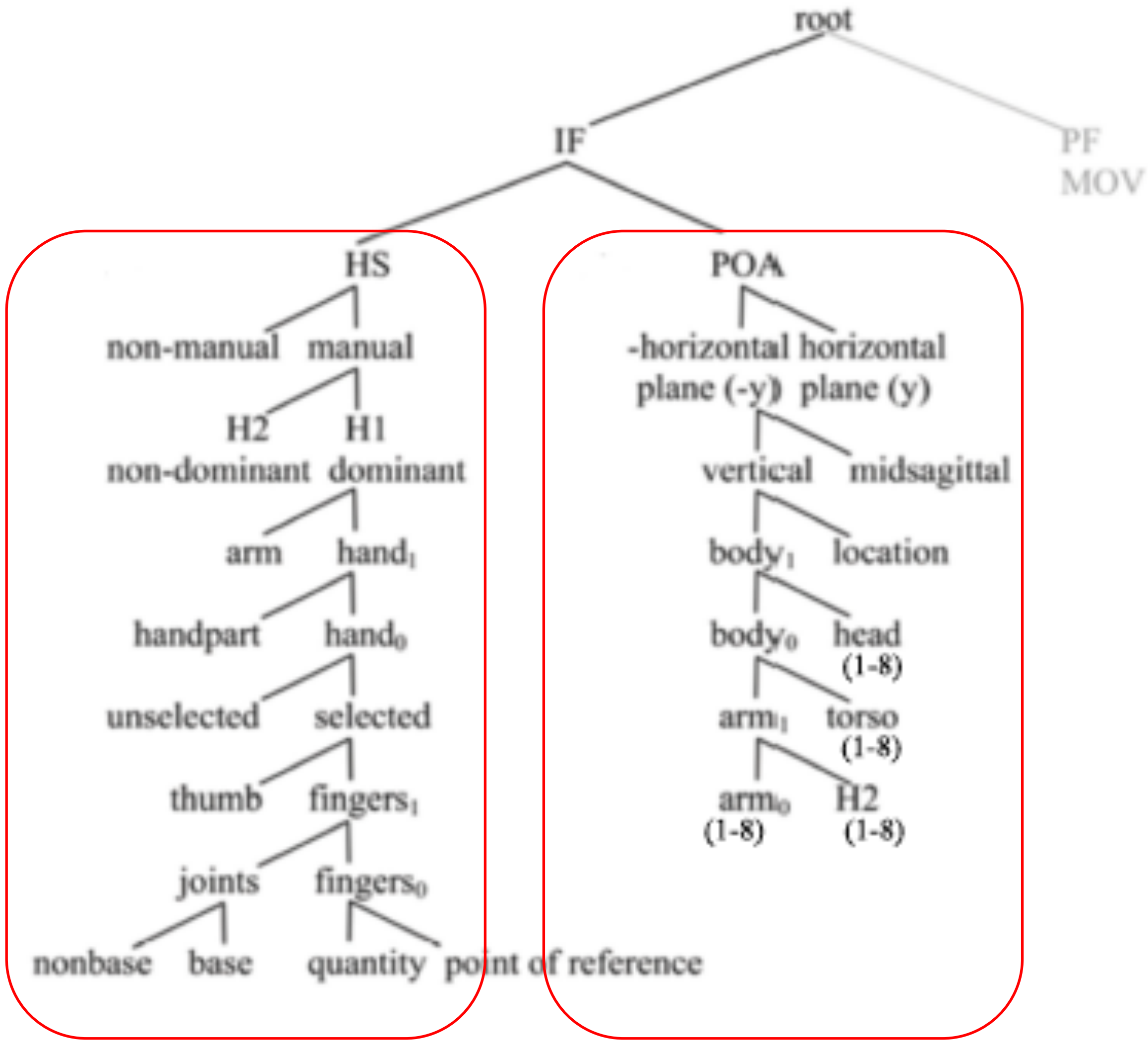
Treats MOVEMENT as a suprasegmental feature which may be reduced/augmented



HANDSHAPE & LOCATION

Feature geometry (Brentari 1998)

'inherent/underlying features'



Sonority Hierarchy for SL (Brentari 1993, 1998)

- The sonority value is determined by physiological adjacency of the active articulator to the signer's body:
  - Larger-scale articulators, including shoulder, elbow, and wrist joints deliver more perceptually salient phonological contrasts than smaller scale articulators, such as finger joints.

- Brentari (1998):

Distal joints ---Proximal joints

Aperture (hand) < Orientation (wrist) < Path (elbow) < Setting (shoulder)

HS ORI MOV LOC

The phonetic basis of sonority in SL:

- Kinetic-perceptual correlate: physiological adjacency

- The sign “understand” involves a HS change from 'closed' to 'open'
- The sign “parents” involves 2 locations: chin (“mother”) and forehead (“father”)

Perception data from signers:

- Native ASL signers: in visually degraded presentations of ASL utterances, contrasts in MOV and HS are more difficult than LOC (Fischer, Delhorne, & Reed, 1999; Fischer & Tartter, 1985; Tartter & Fischer, 1982).

- Children with delayed L1A: difficulties perceiving HS (Singleton, Morford, & Goldin-Meadow 1993)

- Hearing ASL L2ers: difficulty in discerning MOV contrasts, followed by HS and LOC (Williams & Newman 2015, Hilger et al. 2015).

Perception data from non-signers

- Hearing infants < 14 m.o. retain a high level of sensitivity to all aspects of sign:
  - Can detect subtle differences in the segmental cue of HS (Baker et al. 2006);

- Adult non-signers use superficial visual cues when processing SL input, perhaps drawing on their gestural competence & experience the most difficulty with processing HSs (e.g., Brentari 2006)

The present study: Goals

- Evaluate the relative perceptual salience of HS, MOV, and LOC in ASL for deaf ASL L2 learners and sign-naïve adult English speakers:
  - which sign features relay phonological contrasts perceptible for even the non-signers?
  - which sign features are likely to present areas of maximal difficulty in the non-native acquisition of SLs?

Research questions:

- Are perceivers sensitive to visual cues delivered through HS, MOV, LOC marking minimal pair contrasts in ASL?
  - If so, how are these cues weighted?

- How does performance compare across the following groups?
  - Deaf ASL L2 learners (the present study)
  - L1 English hearing non-signers (the present study)
  - ASL native signers (reported in Bochner et al. 2011)

Paired Comparison Sentence Discrimination Task (Bochner, Christie, Hauser, & Searls, 2011)

- Relative perceptual salience of articulatory components of ASL signs is proxied by the rate of successful discrimination of sentence pairs

- In a sentence pair, S1 and S2 contain a minimal pair =>
- S1 & S2 differ in terms of one aspect of the visuo-spatial configuration:
  - HANDSHAPE, MOVEMENT,
  - LOCATION ORIENTATION (mapping btw HS and LOC)

Procedure

- Participants were presented with video recordings of sentence pairs;

- Each trial contained a test sentence presented by a model native signer and reproduced, sequentially, by two different native signers: model→ signer1; model → signer2

- Participants judged each sentence pair as same or different (2 judgments per trial)

Procedure

- The total of 54 matching sentence pairs and 54 non-matching sentence pairs:
  - **6 practice trials,** during which feedback was provided and the relevant articulatory contrast was explained
  - **48 test trials**

- The difference between the sentences could be **lexical** (e.g, *MOTHER/FATHER, TOOTHACHE/HEADACHE*) or **morphological** (e.g., *singular form vs. plural form)*

Procedure

Example: HEADACHE and TOOTHACHE differ in **location** (jaw vs. temple)

(1) Model: *JOE a-IX TOOTHACHE*

Signer 1(a): JOE a-IX TOOTHACHE
Target: SAME

Signer 2(b): JOE a-IX HEADACHE
Target: DIFFERENT

Participants:

- **25 deaf L2 learners of ASL**

age(mean): 19;03;

length of (non-ASL) SL exposure (mean): approx. 16 years;

Emirati SL, Kuwait SL, Saudi SL, most - early learners.

Length of ASL exposure (mean): 15.2m;

- **28 hearing English speakers with no experience in any SL**

naïve signers, 21 females, age (mean): 27;09.

Predictions

Deaf L2 ASL signers: <u>Have proficiency in a different SL.</u>

- Expect better discrimination of all articulatory components of sign compared to non-signers

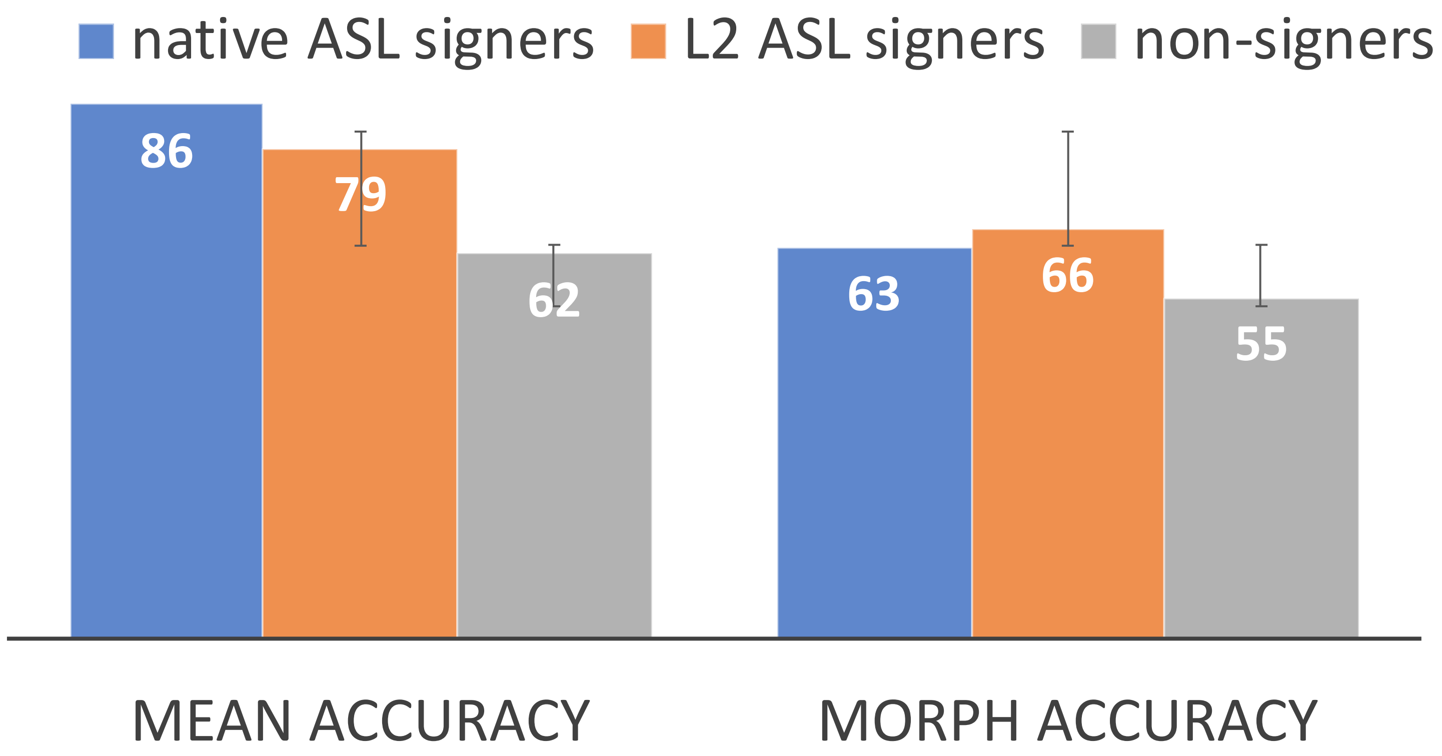
Adult hearing non-signers: <u>No prior exposure to any SL</u>

- Process SL input as visual (as opposed to) linguistic signal; Still expect sensitivity to perceptually salient phonological contrasts

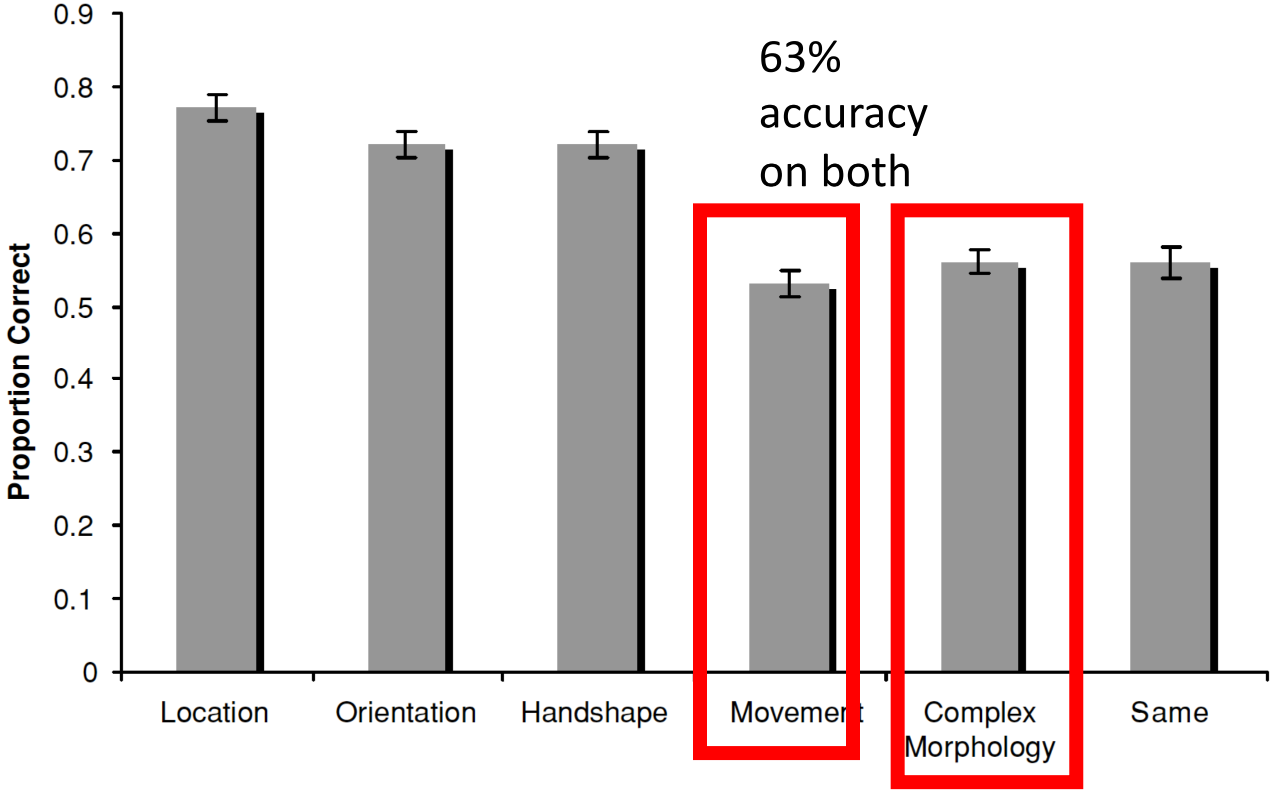
Predictions

- For both groups, expect differential contribution of the contrast type to successful discrimination: perceptually salient phonological contrasts should facilitate discrimination;
- If MOV presents the phonetic basis for sonority in SL,
  - *Expect significant contribution of MOV to the probability of successful discrimination between min pair contrasts*
- If Articulator Proximity presents the phonetic basis for sonority,
  - *Expect dissimilar contribution of the sign components HS (max distal) vs. LOC (max proximal)*

Descriptive statistics (non-signers vs. deaf ASL L2 learners)

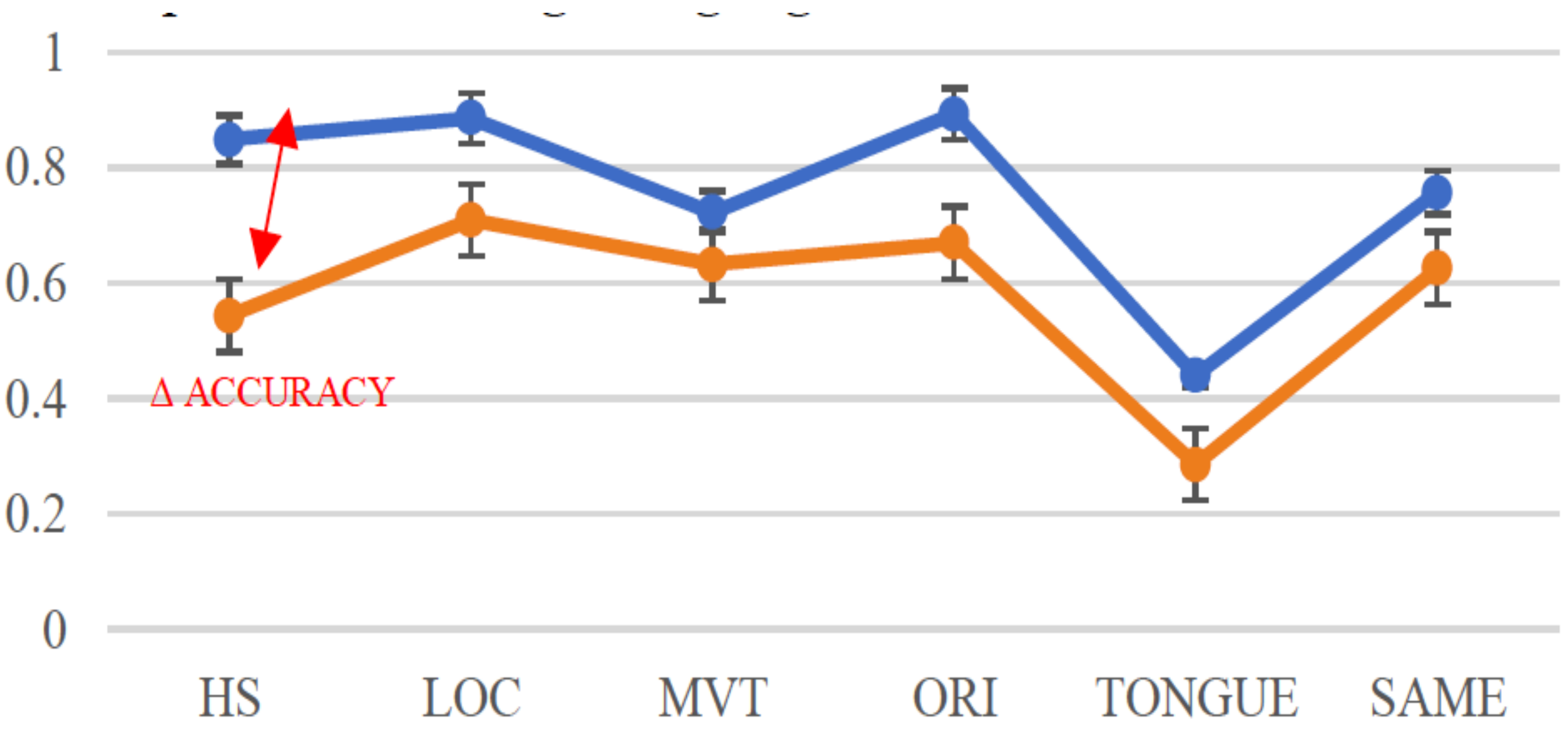


More results from Bochner et al. 2011:



Aggregated data from 127 hearing adult signers (beginning & intermediate levels) & 10 adult native signers;

Descriptive statistics

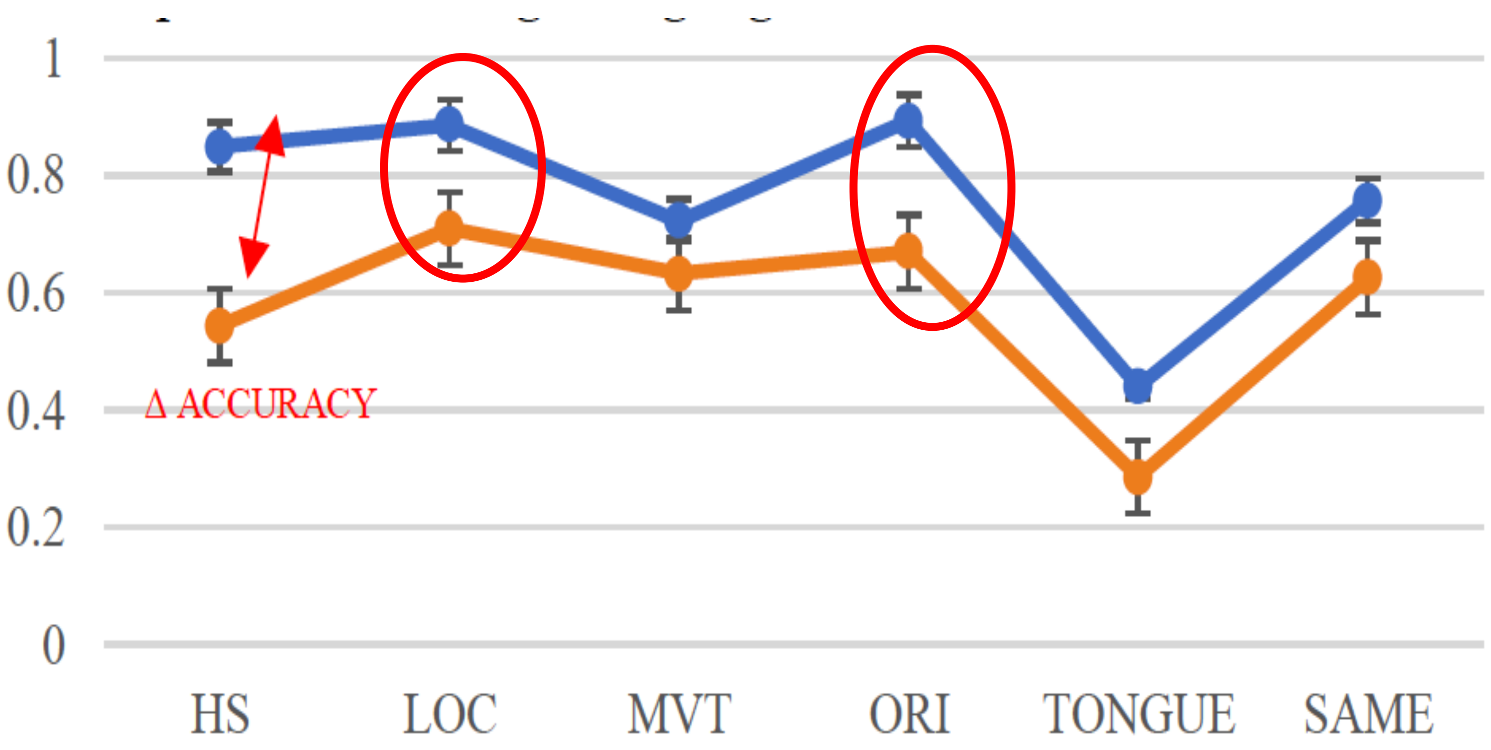


Blue line: mean accuracy scores for L2 ASL signers;

Orange line: mean accuracy scores for naïve signers

- Performance of deaf ASL learners on LOC, ORI, HS contrasts overall comparable to Bochner et al.;
- The difference in accuracy between deaf L2 ASL learners and non-signers, except to HS contrasts, fell within a narrow range 9-17%.

Descriptive statistics

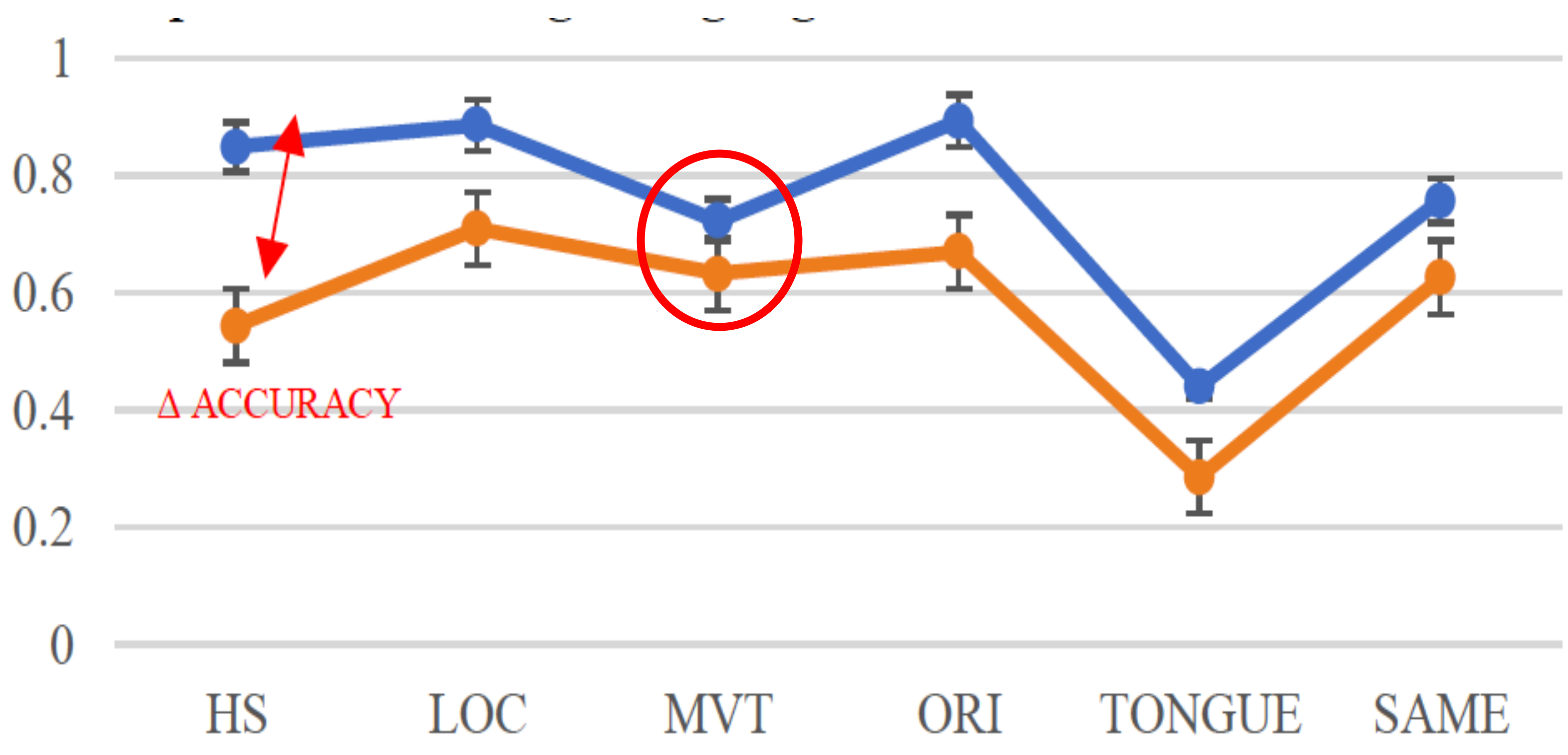


Blue line: mean accuracy scores for L2 ASL signers;

Orange line: mean accuracy scores for naïve signers

- For both participant groups, high accuracy rate on contrasts in LOC and ORN

Descriptive statistics

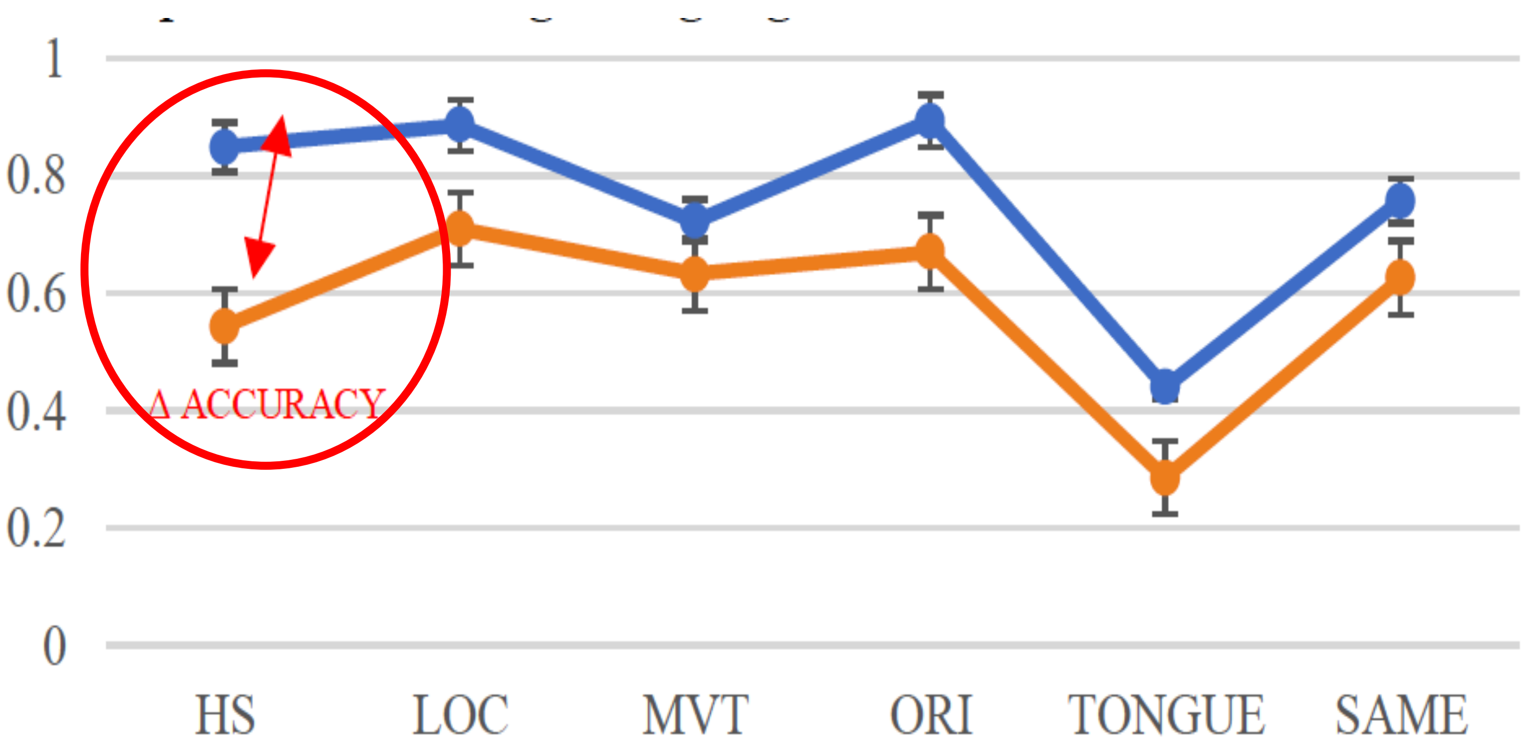


Blue line: mean accuracy scores for L2 ASL signers;

Orange line: mean accuracy scores for naïve signers

- Somewhat lower mean accuracy on MVT contrasts (both groups) and HS (non-signers);

Descriptive statistics



Blue line: mean accuracy scores for L2 ASL signers;

Orange line: mean accuracy scores for naïve signers

- A dissociation was observed in the accuracy of HS contrasts: HS, facilitated discrimination for deaf ASL L2 learners but not for non-signers;

- Responses (“hit”,“miss”) modeled separately for signers and non-signers using mixed-effects binary logistic regressions

DEP VAR	**FIXED EFFECTS**	**RANDOM EFFECTS (intercepts & slopes)**
log likelihood of correct identification of the sentences as SAME or DIFF	ARTICULATORY FEATURES	PARTICIPANT
	CONTRAST TYPE (lexical/morphological)	TEST ITEM

Statistical analysis of the paired comparison sentence discrimination task responses

	Coefficient		Standard error		*z*		*p*	
Fixed effects	**Naïve**	**Deaf L2**	**Naïve**	**Deaf L2**	**Naïve**	**Deaf L2**	**Naïve**	**Deaf L2**
Handshape	-.38	1.36	.12	.41	-3.06	3.33	.002	.001
Location	.34	1.92	.13	.43	2.59	4.48	.01	.001
Movement	.05	.517	.13	.38	.004	1.54	.97	.125
Orientation	.19	2.01	.13	.44	1.44	4.54	.1	.001
Contrast type (morphological)	.26	-.67	.2	.24	1.36	-2.85	.175	.004

Statistical analysis of the closed set discrimination task responses

	Coefficient		Standard error		*z*		*p*	
Fixed effects	**Naïve**	**Deaf L2**	**Naïve**	**Deaf L2**	**Naïve**	**Deaf L2**	**Naïve**	**Deaf L2**
Handshape	-.38	1.36	.12	.41	-3.06	3.33	.002	.001
Location	.34	1.92	.13	.43	2.59	4.48	.01	.001
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This study vs. prior studies:

<table>
<tr><td rowspan="2">LOCATION

ASL: parents</td><td>Successful discrimination! Deaf signers and hearing non-signers pattern similarly (Emmorey 2002);</td></tr>
<tr><td>This study: For non-signers and Deaf ASL L2ers, LOC was a highly robust categorical discriminator;</td></tr>
</table>

This study vs. prior studies:

<table>
<tr><td rowspan="2">HANDSHAPE

ASL: understand</td><td>Categorical perception by deaf signers and ASL L2ers, deaf or hearing, poor discrimination rates for hearing non-signers (Baker 2003, Brentari et al. 2010, 2011, Bochner et al. 2011);</td></tr>
<tr><td>This study: Perceptual saliency of HS was high for deaf ASL L2ers, but low for the non-signers.</td></tr>
</table>

This study vs. prior studies:

MOVEMENT 	MOV perception by native signers is affected the most in visually degraded utterances (Emmorey 2002);
	This study: MOV did not predict accurate discrimination for L2 ASL signers (p = .12) or non-signers (p=.97);

Back to predictions

Deaf L2 ASL signers: Expect better discrimination of all aspects of sign compared to non-signers

Adult hearing non-signers: Sensitivity to the most salient phonological contrasts

Borne out: systematically greater mean accuracy & larger effect sizes for deaf ASL L2ers; Prior exposure to sign leads signers to perceive ASL stimuli as linguistic.

Non-signers performed above chance – sensitivity to non-native contrasts in a different modality.

Back to predictions

- If MOV presents the phonetic basis for sonority in SL,

  Expect significant contribution of MOV to the probability of successful discrimination between members of a min pair

  - MOV failed to reach significance, possibly, due to…
    - its prosodic nature (is not inherently specified for signs and subject to greater inter-signer variability?)
    - relatively greater computational complexity/semblance to gestures?
    - how it is coded in our data (do not account for local vs. path MOV types/trajectories)?

Back to predictions

- If Articulator Proximity presents the phonetic basis for sonority,

  Expect dissimilar contribution of the inherent sign components HS (max distal, low in sonority) vs. LOC (max proximal, high in sonority)

  - True for LOCATION, for both participant groups;

  - Not entirely true for HandShape: while being configurationally complex and spatially compressed, HS is used successfully by experienced signers but leads to sign confusion in non-signers;

Conclusions

- In perception, non-signers who are also gesturers in their every day lives, show selective sensitivity to manual components of sign:
  - It is grounded in VISUAL SALIENCE or VISUAL ?SONORITY? →
  - Contrasts involving larger-scale articulators, high in sonority, are readily perceptible;
- Findings provide empirical support for Brentari's Sonority Hierarchy in SL (Brentari 1998, Sandler & LilloMartin 2006):

Conclusions:

- Phonological contrasts based on HS:
  - present a likely area of maximal difficulty for non-signers;
  - preserve informativeness for L2 ASL learners with rich experience in a different sign language - an L1 transfer effect;

- Sensitivity to HS may signify a shift from a gestural system to a sign language.

Suggestions for future research:

- Future research must focus on the contribution of the more fine-grained parametric elements of sign:
    - E.g., a more nuanced view of movement: accounting for movement which is more local (sign-internal) vs. greater in amplitude (path)
    - Accounting for joint type (proximal joints, high in sonority vs. distal joints, low in sonority) performing MOV
- Test if the relative cue weight of each sign feature may be affected by what other cues are in the sign with it

thank you

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Selected References: Bochner, J., Christie, K., Hauser, P., & Searls, J. (2011). When is a difference really different? Learners’ discrimination of linguistic contrasts in ASL. *Language Learning*, *61*(4), 1302-1327. Hildebrandt, U. & Corina, D. (2002). Phonological similarity in ASL. *Language and Cognitive Processes*, *17*, 593–612. Jaquez, T., Anible, B., & Occhino-Kehoe, C. (2014). The effects of sign language experience on hand-shape perception. Paper presented at SL2HUB Conference, Gallaudet, Washington, DC. Mayberry, R. & Lock, E. (2003). Age constraints on first versus second language acquisition: Evidence for linguistic plasticity and epigenesis. *Brain and language*, *87*(3), 369-384. Budding, C., Hoopes, R., Mueller, M., & Scarcello, K. (1995). Identification of ForeignSign Language Accents by the Deaf. In L. Byers, J. Chaiken, & M.Mueller (Eds.),

Gallaudet University Communication Forum 4 (pp. 1–160. Washington, D.C.: Gallaudet University Press. Cormier, K., Schembri, A., Vinson, D., & Orfanidou, E. (2012) First language acquisition differs from second language acquisition in prelingually deaf signers: Evidence from sensitivity to grammaticality judgment in British Sign Language. Cognition 124, 50–65. Pichler, D. C. (2010). Sources of Handshape Error in First-Time Signers of ASL. In Napoli & Mathur (Eds.), Deaf around the world: the impact of language (pp. 96-121). Oxford University Press.