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

Background: Research demonstrates that phonological and visual learning problems are resolved in similar ways [1] and with the use of the same cognitive processes. This 'unification account' makes two predictions: (i) that both native and hearing L2 signers, as well as non-signers are responsive to articulatory features of sign languages (SLs) and that (ii) both spoken and sign languages deliver perceptual cues used by learners similarly. Spoken language literature has shown that acoustic cues exhibit various degrees of perceptual validity in categorization, leading listeners to have perceptual biases when integrating multiple acoustic dimensions [2]. This suggests that we should also expect differential perceptual validity for dynamic gestural units produced by manual articulators in sign languages. [3] demonstrate (i) to be true for articulatory sign features HANDSHAPE, MOVEMENT, ORIENTATION, and LOCATION. In line with (ii), the responsiveness of both signers and non-signers to these articulatory features must be more readily available for the perceptually salient features.

Predictions: Two models of sign language phonology have been proposed: the Sonority Hierarchy [4] and the Prosodic Model [5]. According to [4], larger scale articulators (shoulder >> elbow >> wrist joints) deliver more perceptually salient phonemic contrasts than smaller scale articulators (e.g. finger joints). This means that contrasts in HANDSHAPE and ORIENTATION of the sign will disambiguate between the expert and non-expert/naïve signers better than location or movement. In contrast, [5] predicts movement to be the more salient because movement is suprasegmental. The aforementioned is expected to hold irrespective of whether the Deaf signers are proficient users of the language under examination.

In this study, we evaluate perceptual saliency of the gestural components of signs in American Sign Language (ASL) for naïve signers vis-à-vis deaf L2 learners of ASL with limited previous exposure to another sign language. Perceptual saliency estimates for articulatory sign features reveal which of these features relay phonemic contrasts perceptible for even naïve signers and which are likely to present areas of maximal difficulty in non-native acquisition of sign language.

Participants: 25 deaf L2 learners of ASL (age(μ):19;03; length of (non-ASL) SL exposure(μ):193.8m., length of ASL exposure(μ):15.2m) and 28 hearing English speakers with no experience in any SL (naïve signers, 21 females, age(μ):27;09).

Method: In a closed-set Sentence Discrimination Task [4] (48 test trials), relative perceptual saliency of articulatory features was proxied by the rate of successful discrimination of ASL sentence pairs which differed in terms of one aspect of the visuo-spatial configuration: HANDSHAPE, ORIENTATION, MOVEMENT, and LOCATION (Fig.1). Participants were presented with video recordings of sentence pairs in which the difference between the sentences, when present, was lexical (e.g, *mother/father*) or morphological (e.g., *1-month/6-months*). Each test trial contained a test sentence presented by a model native signer and reproduced, sequentially, by two different native signers. Participants judged each sentence pair as same or different, thus making 2 judgments per trial. Responses ("same","different") were modeled using a mixed-effects binary logistic regression.

Findings: The difference in accuracy (ΔACCURACY, Fig.2) between deaf L2 learners and naïve signers, except when localized to HANDSHAPE, fell within a narrow range 9-17%. For both groups, ORIENTATION and LOCATION, in that order, were the most salient contrastive features and substantiated robust categorical discriminators (see Table 2). Results revealed a dissociation in the perceptual saliency of HANDSHAPE, which facilitated discrimination for deaf L2 learners (as well as native deaf signers [6]) but not for naïve signers. MOVEMENT was not a contrastive feature.

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Conclusions: Results support that regardless of modality, phonological language processing is anchored in the relative perceptual saliency of the features marking phonemic contrasts [2] and provide empirical validation of the Sonority Hierarchy in sign languages [3]. In ASL, phonemic contrasts based on HANDSHAPE, configurationally complex but spatially compressed, and therefore low in sonority, present a likely area of maximal difficulty in non-native acquisition, unlike contrasts based on LOCATION and ORIENTATION, involving larger-scale articulators, high in sonority, and perceptible for even first-time signers. This finding is in line with previous research on the difficulty of HANDSHAPE perception/acquisition but offers a new explanation: deaf signers rely on HANDSHAPE to increase their performance, while the HANDSHAPE contrasts made the performance of naïve signers' worse overall. Finally, the findings suggest that ORIENTATION is something other than a 'secondary parameter', as previously argued – L2 deaf signers rely on it for contrast.

Figure 1a: "mother" (ASL)

Figure 1b: "father" (ASL)

Phonemically contrastive feature: LOCATION of the sign relative to the signer's body.

Figure 2: *Percent accuracy on sentence discrimination categories for experienced ASL signers and English speakers with no experience in a sign language.*

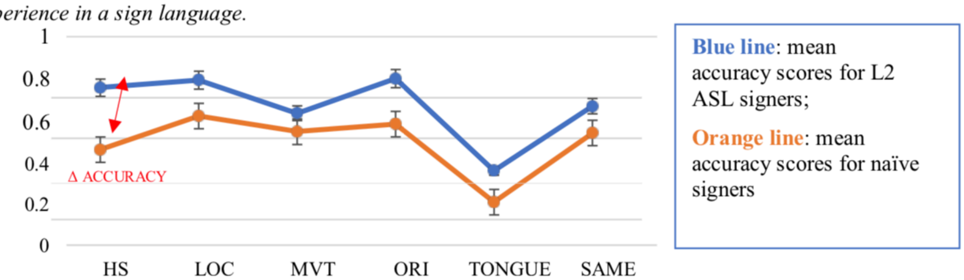

Table 1. *Results of the mixed-effects logistic regression (fixed effects) modeling responses of the sentence discrimination task. Dependent variable: log likelihood of correctly identifying a sentence pair as SAME or DIFFERENT.* Fixed effects: ARTICULATORY FEATURES and CONTRAST TYPE(lexical/morphological); random effects: PARTICIPANT and TEST ITEM.

	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

References: [1] Moreton, E., J. Pater and K. Pertsova. 2015. Phonological concept learning. *Cognitive Science*. 1-66. [2] Holt, L., & Lotto, A. (2006). Cue weighting in auditory categorization: Implications for first and second language acquisition. *The Journal of the Acoustical Society of America*, 119, 3059. [3] Hildebrandt, U., & Corina, D. (2002). Phonological similarity in ASL. *Language and Cognitive Processes*, 17(6), 593-612. [4]Brentari, D. (1993). Establishing a sonority hierarchy in American Sign Language: The use of simultaneous structure in phonology. *Phonology* 10. 281–306. [5] Brentari, D. (1998). A prosodic model of sign Language phonology. MIT Press. [6]Bochner, J. H., Christie, K., Hauser, P., & Searls, J. M. (2011). When is a difference really different? Learners' discrimination of linguistic contrasts in American Sign Language. Language Learning, 61(4), 1302-1327