



# Long-distance coarticulation in ASL: A production and perception study

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## Introduction

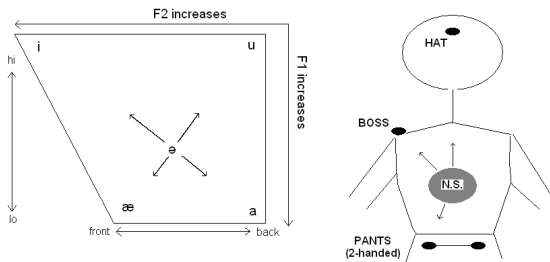
Coarticulation is relevant for issues as varied as lexical processing and language change. However, research to date has not determined the modality specificity of such effects, how perceptible they are, or how far they can extend.

This project examines the production and perception of location-related coarticulation effects in signed language, in parallel with a study of vowel-to-vowel coarticulation in English.

In the sign production study, five ASL users signed sentences while wearing motion-capture sensors. Coarticulatory effects of one sign on another were found across up to three intervening signs, but were sparser and weaker than effects found in the parallel spoken-language study. This difference appears to be due in part to greater variability among these signers in their articulatory behavior, relative to that of spoken language users.

The sign perception study used stimuli taken from filmed excerpts of the production experiment and found that some deaf signers and hearing non-signers were sensitive to these coarticulatory effects, though again results were weaker than those found for listeners in the speech study.

## Schwa and Neutral Signing Space



Signs can be described in terms of several parameters including Handshape, Location and Movement (Stokoe, 1960).

This study focuses on the Location parameter.

In particular, we examine coarticulatory effects on signs whose location is "Neutral Space" (N.S.), the area in front of the signer's body.

Neutral space was chosen as target location because of possible similarity to schwa in terms of behavior within the articulatory space. Schwa was used as target vowel for the speech study because of its high susceptibility to coarticulatory influence from other vowels (Fowler, 1981; Alfonso & Baer, 1982).

## Production study: English

18 native English speakers said these sentences 6 times: "It's fun to look up at a keep/cop." Context V = [ɪ]/[a]  
Distance-1 condition: Target V = [a] as in "a"  
Distance-2 condition: Target V = [ə] as in "at"  
Distance-3 condition: Target V = [ɪ] as in "up"

Results: Significant context-related formant differences common at distances 1 and 2 and possible even at distance 3:

| Subject | Distance 3 |    | Distance 2 |     | Distance 1 |     |
|---------|------------|----|------------|-----|------------|-----|
|         | F1         | F2 | F1         | F2  | F1         | F2  |
| 1       |            |    | *          | +   | ***        | *** |
| 2       |            |    | *          |     | **         | *** |
| 3       |            |    | *          | *** | ***        | *** |
| 4       |            |    |            | +   | **         | *** |
| 5       |            |    |            | +   | **         | *** |
| 6       |            |    |            |     | +          | **  |
| 7       | *          | +  |            | **  | +          | *** |
| 8       |            |    | *          | **  | ***        | *** |
| 9       |            |    |            | **  | **         | *** |
| 10      | **         | +  | +          | +   | ***        | *** |
| 11      |            |    | +          | **  | +          | *** |
| 12      |            |    |            | *   | **         | *** |
| 13      |            |    | *          | *** | ***        | *** |
| 14      |            |    | *          | *** | **         | *** |
| 15      | +          |    |            |     | **         | *** |
| 16      |            | +  | ***        |     | *          | *** |
| 17      | *          |    | **         | *** | *          | *** |
| 18      | *          |    | **         | +   | **         | *   |

\*\*\* p<.001, \*\* p<.01, \* p<.05, + marginal (p<.1)

## Perception study: English

- Listeners: all 18 production-study subjects.
- Stimuli: a subset of the [a]- and [ɪ]-colored schwas obtained in the production study.
- Stimuli normalized for f0, amplitude and duration, each lasting ~70 ms and separated by ISIs of about 1.4 s.
- Subjects responded to sounds they perceived as "[ɪ]-like."

Results: Effects were readily perceived by all listeners at distance 1, by most at distance 2, and by a few at distance 3. However, speakers' production and perception results were not correlated.

| Subject | Distance 3 | Distance 2 | Distance 1 |
|---------|------------|------------|------------|
| 1       | 0.41       | 0.70       | 4.15 ***   |
| 2       | 0.94 *     | 1.16 *     | 4.65 ***   |
| 3       | 0.10       | -0.07      | 2.56 ***   |
| 4       | 0.00       | 0.79       | 3.92 ***   |
| 5       | 0.33       | 1.15 *     | 4.65 ***   |
| 6       | 0.44       | 0.69 *     | 3.83 ***   |
| 7       | -0.05      | 1.03 *     | 3.38 ***   |
| 8       | -0.20      | -0.32      | 4.29 ***   |
| 9       | 0.49       | 0.57       | 2.89 ***   |
| 10      | -0.18      | 1.21 *     | 3.97 ***   |
| 11      | 0.44       | 0.53       | 4.65 ***   |
| 12      | 1.26 *     | 2.04 **    | 3.97 ***   |
| 13      | 0.17       | 0.53       | 4.29 ***   |
| 14      | -0.07      | 1.93 ***   | 4.63 ***   |
| 15      | 0.27       | 1.72 **    | 3.45 ***   |
| 16      | 0.40       | 0.94 *     | 3.97 ***   |
| 17      | 0.15       | 1.46 **    | 4.29 ***   |
| 18      | 0.59       | 0.80 *     | 4.65 ***   |

Results here and at right given in terms of d-prime statistic. \*\*\* p<.001, \*\* p<.01, \* p<.05, + p<.1

## Production study: ASL

The sign WANT was chosen as target sign for the ASL study because of its characteristic dip in the z-dimension. This is seen in the motion-capture data at right, taken from four ASL sentences of the form I WANT GO FIND (X) I, where (X) is the sign MOTHER in the leftmost and FATHER in the rightmost sentence (the others are fillers).

Five ASL users signed the following sentences 6 times each, with the context signs (X) contrasting in the left-right (x), front-back (y) or up-down (z) dimensions. The relevant contrasts are given in the table at lower right, which also gives results for the first signer at distance 1.

- Distance-1 condition: I WANT (X) I.
- Distance-2 condition: I WANT FIND (X) I.
- Distance-3 condition: I WANT GO FIND (X) I.
- Distance-4 condition: I WANT GO FIND OTHER (X) I.

Results: Unlike the speech study, even close-distance effects are rare, though there is also evidence of long-distance effects:

| Signer | Distance 4 |    |    | Distance 3 |   |   | Distance 2 |   |   | Distance 1 |   |   |
|--------|------------|----|----|------------|---|---|------------|---|---|------------|---|---|
|        | x          | y  | z  | x          | y | z | x          | y | z | x          | y | z |
| 1      | NA         | NA | NA | *          | * |   |            |   |   | **         | * | + |
| 2      |            |    |    | ***        |   |   | *          | * |   | ***        |   |   |
| 3      |            |    |    |            |   |   | *          | * |   | ***        |   |   |
| 4      |            |    |    |            |   |   | *          | * |   |            |   |   |
| 5      | +          |    | +  |            |   |   |            |   |   |            |   |   |

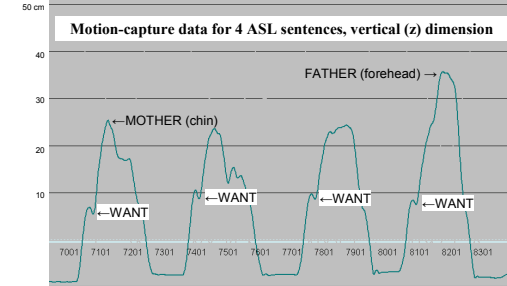
\*\*\* p<.001, \*\* p<.01, \* p<.05, + marginal (p<.1)

## Perception study: ASL

- Subjects: Four of the five production-study participants, plus 16 hearing non-signers.
- Stimuli: the sequence "I WANT" was excerpted from sentences signed and filmed during the production study.
- Task: subjects were played these clips and had to decide if the target forms had been produced in the context of a sign articulated at a "high" (e.g. forehead) or "low" (e.g. waist) body location.

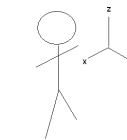
Results: In contrast to the speech study, significant outcomes for only a few subjects, both deaf and hearing:

| Subject       | Distance 3 | Distance 2 | Distance 1 |
|---------------|------------|------------|------------|
| 19 (Signer 1) | 0.00       | -0.23      | 0.00       |
| 20 (Signer 2) | NA         | NA         | NA         |
| 21 (Signer 3) | 0.99 *     | 1.64 **    | 0.54       |
| 22 (Signer 4) | -0.11      | -0.42      | -0.11      |
| 23 (Signer 5) | 0.32       | 1.47 **    | 0.60       |
| 24            | 0.64       | 1.40 *     | 0.67       |
| 25            | 0.00       | 0.21       | -0.43      |
| 26            | 0.64       | 0.21       | 0.00       |
| 27            | 0.00       | 0.43       | 1.11       |
| 28            | 0.76       | 0.76       | 0.00       |
| 29            | 1.17       | 0.67       | 0.00       |
| 30            | 0.67       | 1.18       | 0.67       |
| 31            | -0.22      | 1.35       | 0.43       |
| 32            | 0.00       | 1.11 *     | 1.06 *     |
| 33            | 0.00       | 0.10       | 1.05 *     |
| 34            | 0.65       | 0.46       | 0.34       |
| 35            | 0.11       | 0.34       | 0.00       |
| 36            | -0.23      | -0.21      | 0.10       |
| 37            | 0.32       | 0.10       | 0.21       |
| 38            | 0.32       | 1.24 *     | 0.64       |
| 39            | 0.11       | 0.44       | 0.11       |



Results for Signer 1 at distance 1:

| Context sign    | x        | y    | z     | Outcome   |
|-----------------|----------|------|-------|-----------|
| HAT (forehead)  |          |      | 17.76 | p=0.08    |
| PANTS (waist)   |          |      | 15.65 |           |
| DEER (head)     |          |      | 16.27 | *p<0.05   |
| RUSSIA (waist)  |          |      | 14.51 |           |
| BOSS (shoulder) | 36.55 cm | 0.20 |       | *p's<0.05 |
| CUPCAKE (N.S.)  | 34.54    | 1.43 |       |           |
| CLOWN (nose)    | 35.61    | 1.41 |       |           |



## Conclusion

- Other researchers have reported effects of coarticulation in ASL (Cheek, 2001; Mauk, 2003), but this study is the first to examine long-distance effects in signed language as well as their perceptibility.
- The ASL production study found evidence of long-distance coarticulation, but the effects seen were weaker than those seen in the spoken-language study.
- These location-based effects were sometimes perceptible to both signers and sign-naïve study participants, but to a lesser degree than vowel-to-vowel effects investigated in the speech study.
- One explanation for these differences may be that the visual modality offers more direct perceptual access to the relevant articulators, so users of sign languages might rely less than spoken-language perceivers on additional cues such as coarticulatory information.

### References

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