Errors in Second Language Learners' Production of Phonological Contrasts in American Sign Language

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Abstract

In this study, we investigated the performance of second language learners at beginning, intermediate and advanced levels of American Sign Language (ASL) proficiency on a sentence repetition task involving sets of items illustrating phonological contrasts. The findings revealed the rate of error across all second language learners is highest with movement, followed closely by location and palm orientation. The lowest rate of error by far was handshape. Advanced learners produced fewer phonological errors than both beginner and intermediate learners, yet unexpected results confounded our hypotheses regarding distribution of errors across phonological parameters. This study shows that the phonological complexity of ASL influences perception and production in second language acquisition.

Key Words: American Sign Language, phonological contrasts, sentence repetition task, second language acquisition.

1. Introduction

In this paper we address how second language (L2) learners acquire American Sign Language (ASL), a language expressed through the visual-spatial modality, when their first language (L1) is spoken English which uses the auditory-vocal modality (Fischer & Siple, 1990; Klima & Bellugi, 1990). Despite different modalities, ASL and English share similar phonological properties and processing (Brentari, 1999; Emmorey, 1999; Klima & Bellugi, 1979, 1990; Sandler & Lillo-Martin, 2006). There is a growing body of research into how modality affects phonological perception and production. However, the issue of phonological complexity remains a puzzling question. As Williams and Newman (2016) found, L2 learners often encounter perceptual and production difficulties, particularly within the visual-spatial (signed) modality. The goal of the present study was to test three hypotheses and investigate how L2 production is impacted by phonological nuance among L2 learners through an ASL sentence repetition task.

1.1 Background

Stokoe (1960) was the first to identify ASL as a linguistic system governed by its own rules. Klima and Bellugi (1979) analyzed rich phonological and morphological processes. Over the past 56 years, research on ASL structure has been well-documented. Today, ASL is generally considered a highly complex linguistic system the same as spoken languages. However, ASL differs markedly from spoken languages due to the difference in modality. Similar to polysynthetic spoken languages, ASL is a morphologically complex language, which packs complex meanings into a single sign, as well as changes to the internal grammatical structure (Klima & Bellugi 1979, 1990; Emmorey, 1999, T. Supalla, 1982). In his dissertation at University of California at San Diego, T. Supalla (1982) succinctly described verbs of motion in ASL involving the "class of objects involved in the event, the type of path traversed by the moving object, the manner of motion along this path, and the spatial relationship between the moving object and other landmarks" (Singleton & Newport, 2004, p. 377).

Unlike English, a single verb of motion can include seven or more distinct morphemes being articulated at the same time. For second language learners, the morphology of ASL verbs of motion is particularly difficult to acquire because it encompasses multiple independent morphemes expressed simultaneously.

1.1.2 Fingerspelling and Lexicalized Fingerspelling

Like languages with a writing system, fingerspelling represents English words through use of the manual alphabet. Fingerspelling is incorporated with ASL signs and links ASL to English orthography. ASL does not have a writing system. As such, linguists use gloss transcriptions in English to represent ASL in print. In glossing, the dashes between letters refer to fingerspelled words. Nouns, acronyms, names of places and people are fingerspelled. Apart from a representation of English orthography, lexicalized fingerspelling is also part of ASL grammar where "separate signs of finger spelling tend to blend together when they are produced in fingerspelled signs" (Valli et al., p.75). Lexicalized fingerspelling is glossed with a # hashtag. Such an example is W-H-E-N versus #WHEN. Battison (1978) noted the differences between these types of fingerspelling and argued that as long as fingerspelled words were altered or lexicalized, they represented "signs" in ASL with specific movements in space.

Arbitrary symbols can break down into smaller units that are meaningless by themselves and, in turn, can be recombined to create larger units that are attached to meaning. ASL has five basic features: handshape, location, movement, palm orientation, and non-manual signals (facial expression). These features are referred to as parameters (Valli et al., 2011). ASL phonology has been well-studied over the past two decades (Brentari, 1999, 2011; Liddell & Johnson, 1989; Sandler & Lillo-Martin, 2006).

1.1.3 Phonological Contrasts in ASL

The fine combination of handshape, location, and movement parameters makes each sign distinct, with phonological contrasts represented in the form of minimal pairs of signs. Brentari (2011) has stated that 'despite their different content, these parameters (i.e., phonemic groups of features) in sign languages are subject to operations that are similar to their counterparts in spoken languages' (p. 22). However, she pointed out that there are major differences based on modality and iconicity effects (p. 22). Battison (1978) explained that the two English words "skim" and "skin" are different words with different meanings, and are minimally different. Why is this so? It is because the difference between these two words occurs within the last sound segment: "m" or "n" (Valli et al., 2011, p. 247).

Studying phonology helps to distinguish the arrangement and structure of phonetic units in a spoken language. This is equally true for ASL. Minimal pairs of signs can be identified in only one aspect of their production. To illustrate an ASL minimal pair, consider the two-handed signs GOSSIP and DO-DO, which are similar with regards to handshape, location, and movement. The only difference between them is that the palm orientation of GOSSIP is horizontal whereas the palm orientation of DO-DO is vertical. As shown in Figure 1, the participant produced a palm orientation parameter error for the sign GOSSIP. Such an example shows how production errors made by L2 learners can be influenced by the other member of a minimal pair. These errors indicate the complex ways the internal structure of the language operates (Morford, Grieve-Smith, MacFarlane, Staley & Waters, 2008).

Figure 1: Sample substitution error with minimal pair GOSSIP/DO-DO

2. Research Methods

2.1 Hypotheses

Three hypotheses are presented below:

1. Movement and handshape contrasts would be the most difficult for L2 learners to acquire, therefore, they would persist to some degree even in advanced learners.
2. Palm orientation and location contrasts would be the easiest to learn, therefore, they would rarely occur in intermediate-advanced learners.
3. Beginners would make more production errors than intermediate learners, with advanced learners producing the fewest errors.

2.2 Stimulus Materials and Test Stimulus

The stimuli consisted of forty sentences performed by a native ASL user on a video-recording. In order to develop an effective task, a pilot study was conducted to ensure that the stimuli and procedures functioned for accuracy and reliability. Three native Deaf ASL instructors were asked to review the recordings and identify whether the utterances produced by the native signer were presented clearly, accurately, and consistently before the master DVD was released for the test. The pilot included two practice items and twenty test items.

All stimuli were recorded on DVD. The stimulus sentences were arranged in a random order. The participants were tasked with reproducing the sentences one at a time. Four categories of contrasts were included in minimal pairs: handshape, movement, location, and palm orientation (Appendix A). Forty sentences (20 sentence pairs) were presented to each participant, ten sentences (5 pairs) per parameter category.

Each parameter set of five minimal pairs contained at least three marked handshapes, with a total of 19 marked and 21 unmarked signs (see Table 1). For example, with the minimal pair WHITE/LIKE, two ASL sentences are written in gloss: "HOUSE (index) WHITE [handshape/5/unmarked]" and "HOUSE (index) LIKE [handshape/8/marked]." In English translation, the first sentence reads as, "The house is white" while the second sentence reads as, "I like the house." Note that ASL does not use the pronoun in the second sentence because the verb LIKE incorporates the verb phrase along with the first-person pronoun.

Table 1: Marked versus Unmarked by Parameter

Category	Marked	Unmarked
Handshape (10)	3	7
Location (10)	6	4
Movement (10)	6	4
Palm Orientation (10)	4	6
Total	19	21

Each sentence maintained identical structure and content except for the lexical item being tested, which only differed in one parameter. After analyzing the preliminary results of the pilot study, we identified several issues that informed our research design for the final stimulus.

2.2.1 Complex Morphology

First, nearly all students produced more errors in terms of complex morphology. As a result, this area was removed from the study for consistency purposes.

2.2.2 Lexicalized Signs and Fingerspelling

Lexicalized signs (e.g., #WHEN) and fingerspelled words (e.g., B-I-L-L) were found in two sentences from the pilot. Several students were observed perseverating on the fingerspelling, failing to complete the part of the task containing the phonological contrast. We avoided these in the final study to reduce errors of omission.

2.2.3 Memory Recall

Sentences with more than five signs increased the rate of omissions in the pilot study, evidence that length impacted memory and attention. To reduce errors due to omission in the final study, we limited sentence length to no greater than five signs.

2.3 Participants

In the pilot study, we recruited a sample of five participants using a sentence repetition task (SRT). All were college students taking Beginning ASL II (1) and Beginning ASL III (4) classes. Four out of five students had been learning ASL for two years whereas one student was reported to have learned ASL for approximately 3-5 years. The median age was 22 years (min/max= 19/30).

Based on the pilot findings, the SRT test was revised, and 55 participants were recruited for the main study. Of the 55 test recordings, three were lost due to technical and human errors, leaving us with 52 participants. The 52 participants were broken down into categories of skill level based on a demographic survey (see Table 2). There were 13 participants at the beginner level, 19 at the intermediate level, and 20 at the advanced level. The participants ranged in age from 18 to 57 years. The majority of participants were hearing native English speakers. However, six participants were oral deaf and two were hard-of-hearing, recruited from intermediate and advanced ASL classes. All were second language learners who had minimal exposure to ASL prior to enrollment in formal ASL instruction.

Table 2: Participant Characteristics (N=52)

	Advanced level (N=20)	Intermediate level (N=19)	Beginner level (N=13)	Total (N=52)
Gender F=Females M=Males	F = 13 M = 7	F = 13 M =6	F=8 M=5	F=34 M=18
Median age (min/max)	18 (18/31)	18 (18/28)	48 (26/57)	28 (18/57)
Hearing status H=Hearing D=Deaf HOH=Hard of hearing	 H = 16 D=4	 H=16 D=1 HOH=2	 H = 12 D =1	 H=44 D=6 HOH=2
Self-reported learning disability	2	1	2	5

2.4 Procedure

Each participant completed a one-page demographic survey prior to participating on the SRT task. Then the participants were shown how to record and save the video sample before entering the lab to begin the SRT. Participants were compensated in cash for their participation after they completed the test. The length of testing ranged from 15 to 25 minutes, but no limit was imposed. The video was displayed on a computer during a private video-recording lab session with two monitors and a video camera. One monitor displayed the camera feed of the participants' reproduction of each sentence, while the other displayed the native ASL model on the DVD. These two monitors were recorded in split screen format for documentation reliability. Of the 52 participants, data loss was negligible (1%). The results were documented by two ASL-fluent raters to confirm accuracy of the data collected.

3. Results

3.1 Unexpected Findings from Hypotheses

Our first two hypotheses predicted movement and handshape contrasts were more difficult for L2 learners than palm orientation and location. In contrast to our first hypothesis, the handshape parameter proved to be the least difficult to produce accurately (see Table 3). However, movement was clearly a challenge, as the hypothesis asserted. The findings confirm the rate of error across all L2 learners is highest with movement (25%), followed closely by location (22%) and palm orientation (18%). The lowest rate of error by far was handshape (14%).

Table 3: Data by Parameter

Total Pairs: 20	Number Correct	Number Incorrect	Mean Error % (Range)
Handshape: 5	442	69	14 (0 – 48)
Location: 5	402	111	22 (10– 51)
Movement: 5	384	131	25 (13 – 38)
Palm Orientation: 5	424	101	18 (2 – 35)

Our third hypothesis predicted L2 learner performance would match experience. The results support our third hypothesis. Figure 2 shows the beginner level participants demonstrated higher levels of production error (35%) than intermediate level participants (19%) followed by advanced level participants (10%). Specifically, the distribution of errors for each group is based on linguistic category and learner proficiency.

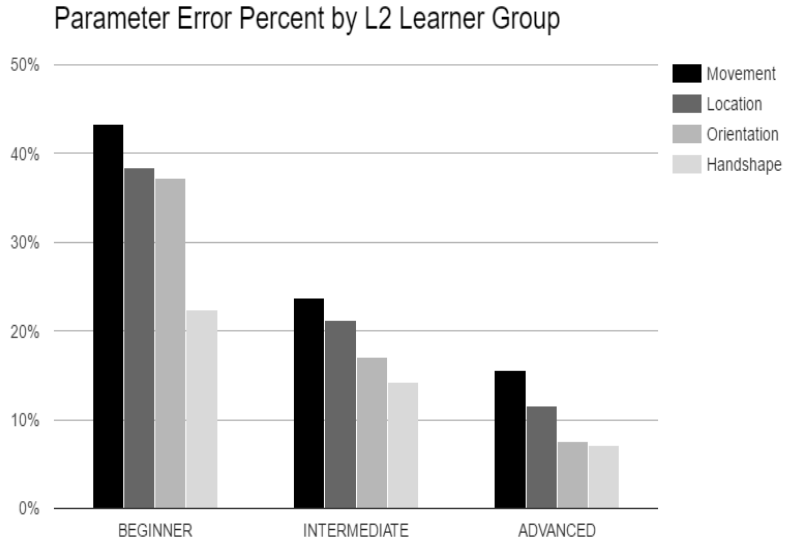

Figure 2: Error Distribution by linguistic category and learner proficiency

The secondary analysis cross-referenced error rates with participant demographic background to better understand the impact that factors such as a participant's language learning history and age can have on the production of phonological contrasts (see Table 4). The data shows that participants ages 30-60 had lower performance and broader distribution (.68, *SD* .14) than the two younger groups (20-29 [.85, *SD* .10], 18-19 [.83, *SD* .08]. Participants with fewer years of experience had the next lowest performance (.75 *SD* .14).

Table 4: L2 Learner Accuracy by Group

Sex	*N*	Mean number proportion	
		Correct	*SD*
Female	34	32.21 (82%)	4.44
Male	18	30.67 (78%)	6.53
Age	*N*	Correct	*SD*
18-19	17	32.71 (83%)	3.42
20-29	23	33.61 (85%)	4.41
30-60	12	26.50 (68%)	5.74
Years Exp.	*N*	Correct	*SD*
1-2	22	29.32 (75%)	5.60
3-5	22	33.41 (84%)	3.74
6+	8	33.38 (84%)	5.85

Observation notes were included to take into account participant behavior (e.g., production errors, comprehension issues, and/or recording problems). Notably, there were instances where participants paused after viewing a sentence and exhibited all of the nonverbal signals of confusion, before nodding and confidently producing a substitution error. There were a few instances where after completing a test item inaccurately, a participant would self-correct, restating with the correct item. One participant demonstrated limited mobility in his non-dominant wrist, performing some signs in a modified manner to accommodate for this. Both reviewers concluded that the modification did not significantly impact the signer's ability to perform.

There were also several instances where participants would attempt to copy the stimulus simultaneously, though invariably, they gave up after only a few test items. The last observation of note is the apparent comprehension of the correct lexical item, while producing an incorrect sign. Most of the indication came from participants mouthing an English gloss of the correct ASL term while producing the error. In some instances the inverse also occurred. The signer in the stimulus produced no manual markers on the mouth.

3.2 Disparity Value

To better understand the relationship between minimal pairs, we analyzed the difference in error rate between minimal pairs for each parameter. We labeled this Disparity Value (DV), as it is calculated by finding the difference in error rate between each minimal pair. For example, the location pair (MOTHER/FATHER) had an error rate of (9%/, 14%), making a Disparity Value of (5). Each parameter had five pairs that were averaged to calculate the mean Disparity Value per category. A comparison between parameters revealed that the handshape category had the highest overall Disparity Value, followed by location and palm orientation, with the lowest value in the movement category (see Table 5). Disparity Value is not directly indicative of the error rate; rather, it illuminates the balance of difficulty between minimal pairs and across phonological categories.

Table 5: Disparity Values by Phonological Parameter

Handshape	Error Rate (%)	Disparity Value
Pairs (5)	14	19
1	0	2
	2	
2	12	6
	6	
3	8	17
	25	
4	6	22
	28	
5	2	46
	48	

Movement	Error Rate (%)	Disparity Value
Pairs (5)	25	5
1	36	11
	25	
2	21	4
	26	
3	25	0
	25	
4	38	9
	29	
5	13	2
	15	

Location	Error Rate (%)	Disparity Value
Pairs (5)	22	14
1	35	18
	17	
2	12	2
	10	
3	51	34
	17	
4	32	10
	22	
5	14	6
	8	

Palm Orientation	Error Rate (%)	Disparity Value
Pairs (5)	18	10
1	35	33
	2	
2	27	4
	31	
3	16	2
	18	
4	10	7
	17	
5	12	4
	16	

4. *Discussion*

4.1 Parameter Analysis

The handshape category had the lowest error rate across each group of learners (14%). This is significant since our hypothesis and the results of other works (Ortega & Morgan, 2015; Bochner et al., 2011) saw relatively high error rates for handshape. Whereas Bochner's study focused on L2 learners' ability to discern the difference between two signs, our study looked to the final product of a multi-step process. Bochner et al. (2011) studied L2 learners at the initial phase: recognizing a difference between two signs. The next phase, and opportunity for error, is comprehension of the utterance. Comprehension of the parameters of handshape, location, and movement were studied by Williams & Newman (2016) finding results not dissimilar from Bochner's work.

Our study measured learners' ability to reproduce the stimulus, a process involving recognition, comprehension, and production.

While we were only able to measure the end result, this study builds upon others to discover how L2 learners of signed languages acquire phonological distinctions. A comparison between the results in the current study and those of previous studies would suggest that the error rate for handshape departs from previous works due to ease of production. While we argue that this is partially the case, recent research by Williams & Newman (2016) hints at a more complex underlying issue. In their work, they found that over half of minimal pair related errors fell in the handshape category. The high Disparity Value of handshape in the current study on production errors paired with the high error rate in handshape from earlier studies (Bochner et al., 2011, Ortega & Morgan, 2015) suggests that L2 learners have the most difficulty recognizing subtle differences between handshapes and were prone to substitution instead of misproduction.

For example, when confronted with a low frequency lexical item like ABORTION (49% error), nearly half of the participants substituted for a familiar sign like STUDENT (2% error). However, when faced with STUDENT, there were no substitution errors. This has implications for instruction of L2 learners of ASL. Further exploration of the discrete differences between signs and using comparison to delineate the boundaries of production may improve L2 learners' ability to recognize and incorporate new linguistic items. This finding supports Pichler's (2011) study, which showed that of all the parameters examined, the handshape parameter was the least troublesome for the participants, while handshape was reported to be the most difficult of all parameters in the Ortega & Morgan (2015) study. Note that the American manual alphabet is one-handed whereas the Ortega and Morgan study included British Sign Language, which has a two-handed alphabet system.

In the current study, L2 learners of ASL demonstrated a high rate of error in location tests, second only to movement, indicating a difficulty curve that climbs sharply in the production phase (Bochner et al., 2011, Williams & Newman, 2016). This increase in difficulty may stem from poor dexterity (Rosen, 2004). This also may be due, in part, to substitution. The disparity value was relatively high for location (14) suggesting a higher rate of substitution or a failure to self-monitor sign production. The observation notes detail multiple instances where location was incorrectly produced, but other non-manual cues such as mouth shape, (some even mouthing an English gloss for the correct item) indicated that comprehension was successful. We hypothesized palm orientation would be one of the categories with the lowest error rates. Participant performance in this category, along with movement, met expectations. It should be noted that the steepest drop in error rate between beginning level (37%) and advanced level students (8%) occurred in the palm orientation category, indicating the efficacy of experience and education on this parameter. Movement proved to be the most challenging category across all demographic groups (25%), but the Disparity Value (5) was by far the lowest of the four (if one part of a movement pair was misinterpreted by the subject, the other half followed a similar rate of error). It is clear from prior studies conducted by Bochner et al. (2011) and Williams & Newman (2016) that both found this category to be the most difficult for L2 learners.

From the observation notes, it was clear that participants have difficulty recognizing and reproducing signs without confusing the members of a minimal pair. For example, with the minimal sign pair of NOW and TODAY, each is performed in neutral space (in front of the chest at elbow height) with the /Y/ handshape. While these two signs look similar and both function as time markers, the vertical bobbing from the elbow found in TODAY and the single downward thrust of NOW distinguish their meanings. L2 learners see these two signs used in identical sentences regularly, but this study suggests that L2 learners fail to recognize this subtle complexity and reproduce it successfully. In our observations, there were multiple instances where participants would mutually substitute, that is, swap lexical items between minimal pairs. Their confidence in production and English gloss on the mouth indicates they understood the signal correctly, but in production, confused members of a pair. This means that participants are aware of how signs look when demonstrated to them, but they incorrectly assert that their reproduction of each sign is accurate across both members of a pair.

5. *Conclusion*

The results show that accuracy of signing improves as a function of learners' level of proficiency and that some sign parameters are produced accurately more often than others. Movement was the most difficult parameter to produce accurately, followed by location, then palm orientation, and finally handshape. While other studies showed that more advanced L2 learners make fewer errors across all parameters, the results of this study also demonstrated that parameter difficulty ranking remained unchanged across each group of learners.

This study reveals that there is a great need for future research in this area, especially with regard to: 1) the nature of physical production and perception systems and their influence on the phonology of a language; and 2) how markedness (Boyes Braem, 1990, Pichler, 2011) and variation (Bochner et al., 2011) in signed languages influence acquisition from the perspectives of both production and perception. Future research should address the ability of L2 learners to effectively distinguish contrastive from non-contrastive differences in production. Such research will bring new insights into the field of phonology and L2 teaching, especially with regard to improving ASL curricula to better suit students of different skill levels and backgrounds.

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Second Language Learners' Production

Appendix A

Example sentences from each stimulus category

Category	Example
Handshape -	YOU *STUDENT/*ABORTION BEFORE YOU? "Were you a student before?" "Had you an abortion before?"
Location -	HAND (didactic pointing) DRY/UGLY WHY? "Why is this hand dry?" "Why is this hand ugly?"
Orientation- (2 handed)	WOMAN (didactic pointing) GOSSIP/DO WHAT? "What did the woman gossip about?" "What did the woman do?"
Movement-	YESTERDAY CHILDREN PARTY/PLAY ENJOYS. "Yesterday the children enjoyed the party." "Yesterday the children enjoyed playing."

Note. Each example is an English gloss of an ASL sentence with each minimal pair underlined and an English translation below. *Grammatical note.* Unlike English, ASL has a grammatical non-manual signal indicating a *wh*-question. *Asterik** indicates unmarked versus marked handshapes. The same sentence was used in each pair.

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