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When Is a Difference Really Different? Learners' Discrimination of Linguistic Contrasts in American Sign Language

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Learners' ability to recognize linguistic contrasts in American Sign Language (ASL) was investigated using a paired-comparison discrimination task. Minimal pairs containing contrasts in five linguistic categories (i.e., the formational parameters of movement, handshape, orientation, and location in ASL phonology, and a category comprised of contrasts in complex morphology) were presented in sentence contexts to a sample of 127 hearing learners at beginning and intermediate levels of proficiency and 10 Deaf native signers. Participants' responses were analyzed to determine the relative difficulty of the linguistic categories and the effect of proficiency level on performance. The results indicated that movement contrasts were the most difficult and location contrasts the easiest, with the other categories of stimuli of intermediate difficulty. These findings have implications for language learning in situations in which the first language is a spoken language and the second language (L2) is a signed language. In such situations, the construct of language transfer does not apply to the acquisition of L2 phonology because of fundamental differences between the phonological systems of signed and spoken languages, which are associated with differences between the modalities of speech and sign.

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Introduction

Similarity and dissimilarity have historically played an important role in linguistics with regard to the classification of sound segments. In his postulates for the scientific study of language, Leonard Bloomfield (1926, p. 155) provided the following definition: "That which is alike will be called *same*. That which is not same is *different*."

Bloomfield's definition is vague and imprecise to be sure, in part, because the *perception* of difference is far more important to the description of language than actual physical differences. In this regard, it is clear that noticeable but noncontrastive acoustic differences in the linguistic signal pale in importance to contrastive differences for language processing and acquisition (Bohn, 2002).

This article addresses the age-old question "when is a difference really different?" within the context of language learning and with specific reference to the acquisition of American Sign Language (ASL). Like any other language learners, students of ASL must be able to recognize linguistic contrasts and overlook subphonemic (within-category) variation. In examining learners' ability to distinguish contrastive from noncontrastive variation in ASL, this article addresses a crucial topic for the acquisition of all languages—and signed languages in particular.

Background

American Sign Language is a native language for many Deaf[1] people and a cornerstone of the Deaf community in North America (Padden & Humphries, 1988). It is also a widely used second language (L2) for both hearing and Deaf/deaf people and is taught in numerous primary, secondary, and postsecondary academic programs. In fact, ASL is one of the most commonly taught languages in the United States and Canada. ASL and other natural sign languages are distinguished from spoken languages primarily by the modality or channel of communication that is used for the transmission of linguistic information; that is, whereas spoken languages transmit linguistic signals via the auditory channel, signed languages transmit linguistic signals via the visual channel. As such, phonetic properties such as location, handshape, and movement are used in ASL phonology, whereas properties such as place, manner, and voicing are used in spoken language phonology. With regard to syntax, ASL generally has been considered to have an SVO word order but relies heavily on topic-comment relations in discourse (Liddell, 1980). The morphology of ASL and other signed languages, in contrast to English, is nonconcatenative because combinatorial processes rely heavily on stem-internal changes rather than affixation (Fischer & Gough, 1978; Sandler, 1989, 1990).

Variation

Variation occurs naturally in both spoken and signed languages. Some variation is associated with aspects of language structure and can result in linguistic contrasts, such as the difference between one phoneme and another or one morpheme and another. Other variation, however, is not contrastive in the sense that it does not alter the identity of a linguistic unit or change the meaning of an utterance. For example, linguistic units at the levels of phonology and morphology sometimes are characterized by allophonic and allomorphic variation. In such situations, differences are noticeable and may even be systematic, but they are not contrastive.

Taking the concept of variation a step further, the production of sound segments varies both within and across individual speakers. In particular, the same sound segment can have very different acoustic (and phonetic) manifestations depending on speaker characteristics (e.g., gender, age, emotional state, and social/regional dialect), speaking rate, and the surrounding phonetic environment. The phonetic inventory of any given language, therefore, cannot be uniquely defined in terms of absolute or invariant properties of the speech signal. This is sometimes referred to as the problem of invariance.

The problem of invariance must be addressed in the description, processing, and acquisition of language. In particular, variation across linguistic categories must be recognized and differentiated from within-category variation in the segmentation and classification of linguistic units at the levels of phonology and morphology. For example, allophones and allomorphs must be properly identified in order for communication to be effective. Similarly, listeners must adjust to physical variations across individual speakers, such as acoustic differences among the voices of males, females, and children, a phenomenon known as speaker normalization. Failure to properly segment and classify linguistic units will result in an incorrect analysis of the linguistic signal, as will failure to properly engage in speaker normalization (see Kent, 1997, for a general discussion of invariance and speaker normalization).

Acquisition

The acquisition of speech perception and production abilities in L2 phonology has been studied for decades, especially with respect to nonnative pronunciation (i.e., foreign accent). Among the major issues addressed in the literature are the effects of age, the quality and quantity of L2 input, and interactions between the first language (L1) and L2 phonetic systems, including L1 transfer (Flege, 2002; Mack, 2003). Numerous empirical investigations have been conducted addressing segmental properties of speech pertaining to the perception and production of consonants and vowels in L2 learners (e.g., Bohn, 1995; Flege, 1992, 1995). In much of the literature, learners' performance on speech perception and/or production tasks has been studied in relation to variations in learner age, factors associated with input, and phonetic characteristics of the native and target languages. The results of such studies have informed both theory and practice by providing empirical evidence pertaining to the construction of models and pedagogical approaches.

Although the discussion thus far has focused on spoken language, similar issues apply to sign languages, such as ASL. However, a good deal is known about spoken language phonology and speech production and perception, whereas less is known about the production, perception, and phonology of ASL and other natural sign languages. Still, a number of studies have been conducted on sign perception with particular reference to the phonological parameters of location, handshape, and movement. The results of studies involving location generally show that Deaf signers and hearing nonsigners perform similarly on perceptual tasks (Emmorey, 2002). The perception of handshape, however, is more complicated since signers and nonsigners tend to perform similarly on some perceptual tasks, but not on others. In particular, there is evidence to suggest that the perception of handshape is categorical for Deaf signers, but not for hearing nonsigners (Baker, 2003; Emmorey, McCullough, & Brentari, 2003; also see Morford, Grieve-Smith, MacFarlane, Staley, & Waters, 2008). Finally, the results of various studies indicate that signers perceive movement differently than nonsigners and that knowledge of a signed language can influence the perception of motion (Emmorey, 2002; Poizner, 1981).

Linguistic Contrasts in ASL

This study addresses the issue of variation in ASL from a basic linguistic perspective involving minimal contrasts between signs (i.e., minimal pairs) with specific reference to sublexical properties of sign formation. As such, the study is similar in some respects to Miller and Nicely's (1955) classic analysis of perceptual confusions among English consonants. In Miller and Nicely's investigation, native speakers were asked to identify English consonants presented under degraded listening conditions created by filtering and background noise. Their results demonstrated that perceptual confusions do not occur in a random fashion; rather, they are associated with specific acoustic and phonetic properties of speech. In particular, data indicated that the phonetic feature of place of articulation is highly fragile in the sense that it is the most difficult feature to perceive under degraded listening conditions. Manner of articulation accounts for fewer perceptual confusions; hence, it is less fragile. The phonetic feature of voicing accounts for the fewest confusions and, therefore, is the least fragile (most salient) property of speech. These results are among Miller and Nicely's most notable and widely cited findings.

Following Miller and Nicely's (1955) study of perceptual confusions in speech, Tartter and Fischer (1982) and Fischer and Tartter (1985) studied perceptual confusions in ASL. In these two studies, the authors presented pairs of ASL utterances on videotape under normal and degraded viewing conditions to 14 highly proficient and native Deaf signers. The degraded utterances were recorded under special lighting conditions designed to reduce the visibility of the signer. A drawing depicting each utterance was prepared and, after viewing the utterance, participants were required to select the picture that best depicted the utterance from two alternatives. The utterances represented minimal pairs because they could only be differentiated with respect to a single contrast in one ASL parameter. The parameters of movement, handshape (hand configuration), location (place of articulation), and orientation were investigated. These sublexical features are an intrinsic part of the phonology of ASL, analogous to phonetic features in spoken language phonology (Brentari, 1998; Liddell & Johnson, 1989; Sandler, 1989; Stokoe, 1960). The results indicated that contrasts in movement and handshape were significantly more difficult to discern than contrasts in location and orientation. Consistent with this finding, Fischer, Delhorne, and Reed (1999) reported a similar result in a small-scale study of ASL utterances degraded by fast rates of presentation (i.e., time-compressed sign).

The acquisition of sublexical features in ASL and the ability to differentiate contrastive from noncontrastive differences in sign production represent a major challenge for learners. In order to distinguish among signs, learners must recognize contrastive differences and determine when variations in sign production should be overlooked because they are not contrastive. The importance of learning to recognize contrastive differences at the sublexical level of structure and distinguish them from noncontrastive differences is illustrated by data indicating that adult learners tend to make more phonological than semantic errors in the recall of ASL utterances, with the ratio of phonological to semantic errors increasing as the learners' experience with ASL decreases (Mayberry & Fischer, 1989; see also Mayberry, 1995). These data suggest that learners must allocate more processing resources to recognize the phonological shape of signs than native signers and that their allocation of processing resources to the recognition of sublexical features is inversely related to the length of their experience with ASL. In this and other studies (e.g., Mayberry & Eichen, 1991), the subjects consisted of early and late L1 learners, not L2 learners. Mayberry (1993) has addressed the distinction between L1 and L2 ASL learning elsewhere and, in a subsequent work, remarks that the effects of age are "significantly more pronounced for first as compared to second-language acquisition" (Mayberry, 1995, p. 364). She then goes on to treat L2 and late L1 learners as one group and differentiate them from native learners, stating that "language acquisition that occurs during childhood appears to be more likely to result in automatic, or easy and instantaneous, phonological processing than language acquisition that occurs at older ages" (Mayberry, 1995, p. 368). Because the greatest difference between signed and spoken languages pertains to the channel of information transmission, it is reasonable to expect that the greatest challenge for hearing adult learners would be acquiring the sensorimotor (visual and spatial) and phonological skills required for communication in a modality with which they have little or no experience.

In terms of second language acquisition, fundamental differences between signed and spoken languages associated with the channel of information transmission (i.e., differences in sensorimotor and phonological processing) create a situation in which the construct of language transfer has little or no discernable impact with respect to the domain of phonology (see Gass & Selinker, 1983, for an overview of language transfer). When L1 and L2 are both spoken languages, L1 serves as a basis for L2 acquisition, and language transfer is presumed to influence the learning process across all linguistic domains. In contrast, when L1 is a spoken language and L2 is a signed language, transfer cannot influence the acquisition of L2 phonology because of the fundamental differences associated with the channels of information transmission. Although language transfer does not appear to have any influence on the acquisition of L2 phonology in this situation, it generally would be assumed to influence the acquisition of other linguistic domains in the L2 (e.g., morphology and syntax).[2]

The purpose of the present study is to investigate the ability of adult learners to discern when differences in sign formation are contrastive and when they are not. In addressing this issue, we examine the relative difficulty of specific linguistic properties of ASL (i.e., the phonological properties of movement, handshape, location, and orientation, along with aspects of morphology), combined with natural (free) variation in the production of utterances across signers. As such, this study addresses variation from a very general perspective involving sublexical properties of ASL and natural differences in production across signers.

Method

Participants

A sample of 137 individuals participated in the study. The participant sample was composed of 127 hearing adult learners at beginning and intermediate levels of ASL proficiency and 10 Deaf adult native signers. Most of the learners were enrolled in credit-bearing college-level ASL courses in either the foreign language or interpreting education programs at the Rochester Institute of Technology, and a few were enrolled in noncredit courses designed for faculty and staff at the same institution. The hearing subjects' participation was completely voluntary and they were not compensated for their time. The Deaf subjects, however, were paid a nominal fee for their participation.

The hearing participants were drawn from three different sign language instructional programs. The curriculum and student learning outcomes differed from one ASL program to another. Student ability levels within a given course also tended to vary. Therefore, fine-grained distinctions in participants' ASL abilities could not be determined based on their course enrollment. Keeping this in mind, the distribution of the hearing participants' ASL ability is reported in highly general terms. Specifically, 111 participants were enrolled in courses designed for learners at beginning levels of proficiency (ASL I, II, and III) and 16 were enrolled in courses appropriate for students at the intermediate level (ASL V).

Stimuli

The stimuli consisted of 48 items, which were divided into six categories of 8 items each. Five of the categories included contrasts in specific linguistic properties of ASL, and one was a general response category. Four categories represented the parameters of location, orientation, handshape, and movement. The fifth category, referred to as complex morphology, contained contrasts in directionality, number incorporation, noun classifier usage, and verb inflection (two items each). The complex morphology category is defined very broadly because it covers a range of forms. Importantly, the contrasts in this category are associated with phonological changes in ASL formational parameters; that is, the contrasts in complex morphology reflect changes at both the phonological and morphological levels of structure and, as such, may be considered morphophonological contrasts. Even though the category of complex morphology differs from the purely phonological categories of location, orientation, handshape, and movement, it represents a class of important linguistic distinctions in ASL that must be recognized and acquired by learners in much the same manner as phonetic categories. The final category did not contain a linguistic contrast of any kind and is referred to as "Same." In the "Same" category, each trial consists of a repetition of the target (model) sentence; hence, the correct response to each trial is "Same."

The description of ASL phonology used in this investigation reflects approaches used prior to the Movement-Hold Model (Liddell & Johnson, 1989). As such, our approach to ASL phonology may be considered oversimplified from the current perspective of sign language linguistics. Nevertheless, the approach taken in this study is justified because it forms the basis of a useful pedagogical grammar and reflects an important dimension of sign language processing. More recent approaches to ASL phonology (e.g., Brentari, 1998; Liddell & Johnson, 1989) seem less suitable from a pedagogical perspective, and this point is pertinent because the present study focuses on learners. Additionally, the approach to ASL phonology adopted in this study enables comparisons to be made with previous research concerning native and highly skilled signers' processing of formational parameters (e.g., Fischer & Tartter, 1985; Tartter & Fisher, 1982).

Table 1 illustrates the linguistic contrasts included in the stimulus set by presenting English glosses of ASL sentences as exemplars of each category. Contrasting forms are <u>underlined</u>. The drawing in Figure 1 depicts the location contrast illustrated in Table 1 and in the example below. A complete list of the test items included within each linguistic category appears in Appendix S1 in the online Supporting Information. Neither Table 1 nor the appendix, however, includes "Same" items because these items do not contain linguistic contrasts, as mentioned earlier.

Each item was comprised of two pairs of ASL sentences. Each sentence pair consisted of a model (standard) sentence followed by a comparison sentence.

Table 1 Example sentences from each stimulus category

Category	Example
Orientation	IMPORTANT TIME, BALANCE/MAYBE "It is important to balance your time." "Your time may be important."
Handshape	FEEL HORSE WIN, MAN BET/AGREE "The man bet that the horse would win." "The man agreed that the horse would win."
Location	MY MOTHER/FATHER BLONDE "My mother has blonde hair." "My father has blonde hair."
Movement	YOUR APPOINTMENT/HABIT NEED CHANGE "You should change your appointment." "You should change your habit."
Complex morphology	THOSE THREE/THOSE FOUR NEED BUY TICKETS "The three of them need to buy tickets." "The four of them need to buy tickets."
Same[a]	SPAGHETTI, WE ORDER TOO-MUCH "We ordered too much spaghetti."

Note. Each example is an English gloss of an ASL sentence with contrasting linguistic elements underlined and an English translation below.
[a]"Same" items do not contain any contrasting linguistic elements.

The same model sentence was used in each pair. The procedure is illustrated below:

Trial 1

MY MOTHER BLONDE (Model Sentence)
MY FATHER BLONDE (First Comparison Sentence)

Trial 2

MY MOTHER BLONDE (Model Sentence)
MY MOTHER BLONDE (Second Comparison Sentence)

The model and each comparison sentence were produced by different individuals in order to include individual variation across utterances within the stimulus set. Each of the individuals was a native ASL user from a Deaf family. One was a 37-year-old third-generation Deaf male from Rochester, New York. One was a 24-year-old second-generation Deaf female from northern California. The third was a 30-year old second-generation Deaf male from

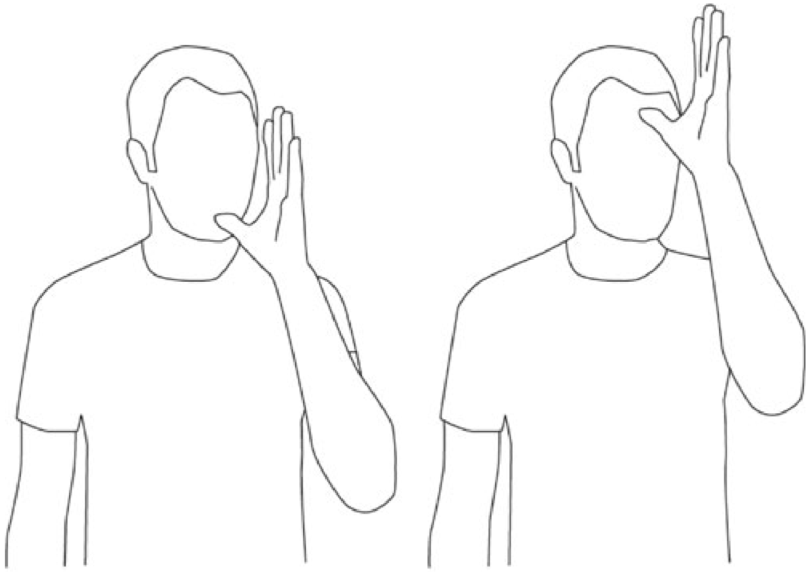

Figure 1 Location contrast illustrated by the minimal pair MOTHER-FATHER.

Lake Charles, Louisiana. One of the male signers always produced the model sentences. The female signer always produced the first comparison sentence, and the other male signer always produced the second comparison sentence.

Utterances were recorded over a 4-day period in which the signers and investigators worked together to ensure clarity, accuracy, and consistency of sign production. Specifically, the signers discussed the formational details of sign production with each other and three of the investigators who are fluent Deaf ASL users. During the recording sessions, the signers observed one another, paying particular attention to the production of the model sentences. At the same time, the three Deaf investigators monitored sign production across the three signers. The utterances were digitally recorded in a TV studio by a professional videographer. The lighting and background were carefully selected to provide high-quality images. Each signer produced at least three utterances (tokens) of each sentence in succession. After the recording sessions, the three Deaf investigators reviewed the recordings and identified specific utterances for presentation to participants using the criteria of clarity, accuracy, and consistency of sign production. The selected utterances were then excised from the master video and recorded on DVD in a randomized order. This procedure assured that the utterance tokens presented to participants were clear, accurate, and consistent and that the contrasts included within each linguistic category truly represented the category.

Natural variation was observed among the signers in their production of utterances; but this variation did not influence meaning. For example, one of the "Same" items included the sign for SISTER. Although all three signers clearly signed SISTER, minor, appropriate subphonemic variations in sign formation were observed. Specifically, two of the signers produced the sign beginning with contact at the side of the chin. The beginning place of contact for the other signer was at the middle of the chin. Similar variation across signers may have occurred in the form of small subphonemic (within-category) differences in the degree of finger splay, thumb opposition, joint activity, and other aspects of sign formation.

The recorded utterances were played to individuals and groups of participants in classroom settings. The groups ranged in size from 2 to 19 individuals. The recordings were played on a DVD player or computer, and the images were projected onto a large screen at the front of the room.

Procedure

A paired-comparison discrimination task was used in this investigation. Participants were presented with a model sentence immediately followed by a comparison sentence, and they were required to judge whether the stimuli were the "Same" or "Different." This procedure follows from previous work on the auditory recognition of speech. Bochner, Garrison, Sussman, and Burkard (2003) used a very similar paired-comparison discrimination task to study differences in listeners' ability to discriminate among spoken utterances as a function of linguistic (phonetic) properties of the signals as well as the sensory capabilities of the listeners (degree of hearing loss) and listening conditions (quiet vs. noise background). Bochner, Garrison, Palmer, Mackenzie, and Braveman (1997) also conducted a speech recognition study using a discrimination task resembling the one used in the present investigation.

As mentioned previously, each item consisted of two pairs of sentence stimuli. Participants were required to make a discrimination judgment for each pair of sentences. Therefore, each item consisted of two trials—one for each pair of stimuli. The model stimulus was presented first, followed by a one second interstimulus interval. The first comparison sentence was then presented, followed by a 3-second response interval. The participants responded to the first trial during this time by circling "S" or "D" on an answer sheet to indicate *same* or *different*. At the conclusion of the response interval, a brief flash of light was projected on the screen accompanied by an audible tone. These visual and auditory signals were intended to alert participants that the next stimulus was about to be presented. The same model stimulus was presented again, followed by a 1-second interstimulus interval and then the second comparison stimulus. Finally, the second response interval was presented (3 seconds), and participants indicated their response ("S" or "D") to the second trial on the answer sheet. The two trials comprising each item were presented consecutively (one after the other) because previous research using a very similar discrimination procedure indicated no influence attributable to memory (recency) effects (Bochner et al. 1997, 2003) and because using consecutive trials could lead directly to the development of an assessment protocol based on this procedure (e.g., a computerized adaptive test of ASL discrimination ability).

Each stimulus was labeled with a caption on the lower left portion of the screen. The model sentence was labeled "Model," and the comparison sentences were labeled to identify the item number and trial. The first trial for each item was labeled "a" and the second trial was labeled "b." For example, the first trial for the first item was labeled "1a" and the second trial for the first item was labeled "1b"; the first trial for the second item was labeled "2a" and the second trial for the second item was labeled "2b"; and so on. The captioned labels on the screen corresponded to the labels on the answer sheet.

After a brief explanation of the task in which participants were instructed to respond "Same" if the utterances in each pair had the same meaning and "Different" if the utterances in each pair had a different meaning, six practice items were presented to ensure understanding of the procedure. The practice items illustrated contrasts in movement, location, orientation, and complex morphology (one item each). Two practice items illustrated the "Same" category. In this way, the practice items exposed participants to every item category except handshape and provided them with a direct and practical orientation to the task. The combination of instructions and practice items, therefore, served to familiarize participants with the procedure. Data collection was begun after the practice items were presented and the examiner(s) was certain that the participants understood the task. The entire procedure required about 50 minutes to complete, including explanations and practice items.

For any item, every possible combination of "Same" and "Different" trials could occur; that is, an item could consist of two "Same" trials, two "Different" trials, or one trial of each. In order to reveal meaningful information using a discrimination procedure of the sort employed in this investigation, items must contain a linguistic contrast. Therefore, every item within each linguistic category (location, orientation, handshape, movement, and complex morphology) contained at least one contrast (i.e., at least one "Different" trial). In other words, within each linguistic category (location, orientation, handshape, movement, and complex morphology), an item could contain either two "Different" trials or one "Same" and one "Different" trial. Half of the eight test items within each linguistic category listed in Appendix S1 in the online Supporting Information contained one "Different" trial and the other half contained two "Different" trials. The determination of which specific items were assigned one "Different" trial and which were assigned two "Different" trials was done randomly. As mentioned previously, one category of items did not contain any linguistic contrasts; in other words, both trials were verbatim repetitions of the model sentence. It was necessary to include a category of items composed of two "Same" trials as foils to minimize the potential for response bias in the participant sample. The reader is referred to Appendix S1 in the online Supporting Information for additional details and clarification concerning the test items.

Results

Overall Performance

Each of the 48 items was composed of two trials, and participants' responses can be considered a set of 48 items or a set of 96 trials. Because the responses can be analyzed from either the perspective of 48 items or 96 trials, we begin by comparing scoring outcomes for the set of 48 items to the set of 96 trials. Each trial is simply scored correct or incorrect. Because a trial consists of two response alternatives ("S" or "D"), chance-level performance for a given trial is 50%. The mean number of correct trials across the entire participant sample was 73.82 ($SD = 9.06$). In contrast, an item is considered correct if and only if the response to both trials is correct. No partial credit is awarded. Scoring each item as a block of two trials reduces the chance level of performance to 25%. The mean number of correct items across the entire participant sample was 30.95 ($SD = 6.73$).

A correlation analysis was conducted to examine the relationship between participants' responses scored as a set of 96 trials and as a set of 48 items. The results indicated that the two scoring methods are essentially equivalent ($r = .98$, $p < .0001$). This finding indicates that no information is lost in treating the data as a set of 48 items and, following other studies using similar procedures (Bochner et al. 1997, 2003), all subsequent analyses are based on this dataset. Treating the data as a set of 48 items is considered preferable because it reduces chance-level performance and facilitates the interpretation of results.

Table 2 Mean number and proportion of items correct for each group of participants

		Mean number		Mean proportion	
Group	*N*	Correct	*SD*	Correct	*SD*
Beginning signers	111	29.03	5.72	.61	.12
Intermediate signers	16	37.69	3.77	.79	.08
Native signers	10	41.50	3.37	.86	.07

An item analysis was conducted to compare the relative difficulty of each of the 48 items. The results of this analysis indicated that the difficulty of individual items ranged from 20.4% to 92.7% correct. Eleven items had difficulty values less than 50% correct; 20 items had difficulty values in the range from 50% to 75%; and 17 items had difficulty values greater than 75%. Performance on only one item was below chance level, and this item involved a movement contrast (SERIOUS vs. DISAPPOINTING). Importantly, an estimate of internal consistency reliability was computed using Cronbach's coefficient alpha. The alpha reliability coefficient was .81, indicating a reasonably high degree of reliability and consistency within the item set. The alpha coefficient also indicates that, taken together, the items measure a single unidimensional latent construct, which we define as a measure of ASL discrimination ability.

The participant sample can be divided into three broad levels of ASL proficiency: a large group of beginners, a small group of intermediate-level learners, and a small group of native signers. Table 2 displays the mean number and proportion of correct responses (based on 48 items) for each group of participants along with the standard deviation. A one-way analysis of variance (ANOVA) was conducted to test for differences between groups, and the results were significant with $F(2{,}134) = 38.54$, $p < .0001$, and with an effect size of $\eta^2 = .365$. The results of post hoc tests indicated that the difference between the beginning and intermediate groups and the difference between the beginning and native groups were significant ($p < .0001$). The difference between the intermediate and native groups was not significant ($p = .0823$).

Linguistic Categories

The mean number and proportion of correct items within each linguistic category (eight items per category) and the associated standard deviation are displayed in Table 3. A one-way ANOVA was conducted on these data, and the results indicated significant differences between linguistic categories, with $F(5{,}816) = 34.89$, $p < .0001$, and with an effect size of $\eta^2 = .176$. The results of post hoc tests indicated the following: (a) The category of location was

Table 3 Mean number and proportion of items correct within each linguistic category ($N = 137$)

	Mean number		Mean proportion	
Category	Correct	*SD*	Correct	*SD*
Location	6.20	1.58	.77	.20
Orientation	5.74	1.60	.72	.20
Handshape	5.79	1.66	.72	.21
Movement	4.26	1.68	.53	.21
Complex morphology	4.52	1.51	.56	.19
Same	4.45	1.97	.56	.25

Table 4 Results of post hoc (Scheffe) statistical tests

Contrast	Probability
Location vs. Orientation	.0252
Location vs. Handshape	.0432
Location vs. Movement	<.0001
Location vs. Complex morphology	<.0001
Location vs. Same	<.0001
Orientation vs. Handshape	N/S
Orientation vs. Movement	<.0001
Orientation vs. Complex morphology	<.0001
Orientation vs. Same	<.0001
Handshape vs. Movement	<.0001
Handshape vs. Complex morphology	<.0001
Handshape vs. Same	<.0001
Movement vs. Complex morphology	N/S
Movement vs. Same	N/S
Complex morphology vs. Same	N/S

Note. N/S = Not Significant.

significantly different from every other category; (b) the category of movement was significantly different from every other category except complex morphology and "Same;" (c) the categories of handshape and orientation were significantly different from every other category except each other; and (d) the categories of complex morphology and "Same" were significantly different from location, orientation, and handshape. The level of significance of each post hoc test is indicated in Table 4, and a histogram showing the proportion of correct items within each category is displayed in Figure 2.

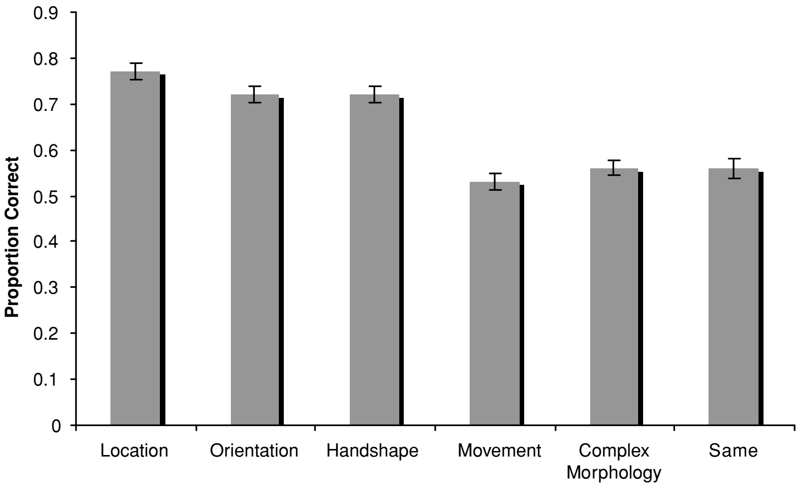

Figure 2 Proportion of items correct within each linguistic category ($N = 137$). Error bars denote one standard error of the mean.

Discussion

Unlike previous studies that involved the presentation of degraded signals to small samples of highly proficient Deaf signers, the present investigation used fully intelligible (normal) signals presented to a relatively large sample of hearing adult learners of ASL as an L2 and a small sample of Deaf native signers. The results indicated that the discrimination task distinguished beginners from participants classified at both the intermediate and native levels of ASL proficiency. The small sample size in the intermediate ($N = 16$) and native ($N = 10$) groups, however, prevented the difference between them from reaching statistical significance.

The overall pattern of results, including their consistency with previous research (e.g., Fischer & Tartter, 1985; Tartter & Fischer, 1982) and the superior performance of the native signers, attests to the validity of the task. Even though the native signers performed quite well on the task overall (86% correct), their performance as a group was slightly lower than expected. In particular, four members of the group scored below 63% on complex morphology contrasts and three scored below 63% on movement contrasts. This finding indicates that some complex morphology and movement contrasts were especially difficult, even for native signers. Nevertheless, the 10 native signers performed very well on four of the six item categories, scoring 90% or higher on location, handshape, orientation, and "Same" items.[3] In order to be absolutely certain that these findings are accurate, the investigators double-checked the data collection procedure, stimuli, and data analysis. No irregularities or anomalies were discovered. Therefore, it seems that just as some spoken utterances can be misinterpreted by native speakers as a result of phonetic confusions, some signed utterances can be misinterpreted by native signers for the same reason. In other words, just as two distinct utterances sometimes sound alike in speech, two distinct utterances sometimes look alike in sign. Moreover, data from this study show that perceptual confusions in sign are not randomly distributed; rather, they are most likely to occur within the categories of movement and complex morphology.

The distribution of scores across participant groups along with the effect of group membership ($\eta^2 = .365$) show that the task is sensitive to a wide range of differences in ability. The sensitivity of the task, in turn, follows from the fact that item difficulty is distributed in a fairly uniform manner, with similar numbers of items classified at low (greater than 75% correct), moderate (50–75% correct), and high (less than 50% correct) levels of difficulty. Given the results presented in Table 3 and Figure 2, it is not surprising that 11 of the 12 most difficult items were members of the movement, complex morphology, and "Same" categories. Similarly, 9 of the 12 easiest items were members of the location, orientation, and handshape categories.

With regard to performance across linguistic categories, the results of this study indicate the following hierarchy of difficulty: (a) Movement contrasts are the most difficult; (b) complex morphology and "Same" contrasts are moderately difficult; (c) handshape and orientation contrasts are relatively easy; and (d) location contrasts are easiest. These findings are largely consistent with those of studies using highly proficient and native Deaf signers presented with signals under normal and degraded viewing conditions. Specifically, movement contrasts generally have been found to be the most difficult, location contrasts the easiest, and handshape and orientation contrasts of intermediate difficulty in studies reported by Tartter and Fischer (1982), Fischer and Tartter (1985), and Fischer et al. (1999).

The relative difficulty of movement contrasts is consistent with Brentari's (1998) analysis of ASL phonology. In her analysis, Brentari associated the parameter of movement with perceptual salience/visibility, proposing "the more proximal the joint articulating the movement is to the midline of the body, the greater the degree of sonority" (p. 217). In terms of Brentari's sonority hierarchy for ASL, the movement contrasts included in this study, for the most part, are associated with moderate perceptual salience/visibility. Many of these contrasts involve the wrist joint and have sonority values in the vicinity of 4 on Brentari's 6-point scale (also see Emmorey's, 2002, analysis of movement, and Hildebrandt & Corina, 2002). Similarly, the difficulty of handshape contrasts appears generally consistent with findings regarding the role of experience with ASL in the perception of handshape (Baker, 2003; Emmorey et al., 2003; also see Morford et al., 2008). The performance of native signers on handshape contrasts was 92.5% correct; the performance of intermediate learners was 85.9% correct; and the performance of beginning learners was 68.5% correct. Finally, the relative ease with which location contrasts are perceived is consistent with data on the acquisition of ASL as an L1 (Conlin, Mirus, Mauk, & Meier, 2000; Marentette & Mayberry, 2000).

Unlike previous research, the present study included morphological contrasts, and the results indicated that contrasts involving complex morphology were relatively difficult. Complex morphology is known to pose a challenge for ASL learners (especially late learners) because the distinctions included in this domain of ASL grammar are relatively subtle and acquired fairly late in the acquisition process (Emmorey, 2002; Gee & Goodhart, 1988). Because complex morphology contrasts generally co-occurred with contrasts in one of the phonological parameters included in this investigation, the dataset was examined to compare performance on specific complex morphology contrasts to performance on items including contrasts in the corresponding phonological parameter. In particular, performance on items containing contrasts in number incorporation (69.3% correct) was found to be comparable to performance on items containing contrasts in handshape (72% correct); performance on items containing contrasts in verb inflection (39.1% correct) was slightly worse than performance on items containing contrasts in movement (53%); and performance on items containing contrasts in directionality (83.9% correct), which is described in terms of the location parameter in current approaches to ASL phonology, was slightly better than performance on items containing contrasts in location (77% correct). This pattern of results suggests that the difficulty of complex morphology contrasts may tend to reflect the difficulty of recognizing a contrast in the associated phonological parameter.[4] In this regard, the results indicate that the subcategory of directionality within complex morphology tends to be comparatively easy (as is the case with location contrasts); the subcategory of number incorporation tends to be of intermediate difficulty (as is the case with handshape contrasts); and the subcategory of verb inflection tends to be most difficult (as is the case with movement contrasts). However, it also must be mentioned that performance on the category of noun classifier usage was quite poor (less than 35% correct), suggesting that other factors influence the difficulty of complex morphology contrasts in addition to the inherent difficulty of the associated phonological parameter.

The present study also included a category without any contrasting linguistic information. Data indicate that "Same" items were approximately equal in difficulty to complex morphology contrasts. The relative difficulty of "Same" items in this study is surprising given the fact that "Same" items have proven to be exceptionally easy in previous research using a similar discrimination task with speech stimuli (Bochner et al. 1997, 2003) as well as in numerous other studies using *same-different* judgments in perceptual comparisons (Bochner, Garrison, & Palmer, 1992; Farell, 1985). Careful inspection of the data, however, indicates that the performance of the native signers is consistent with expectations based on previous research using discrimination tasks. The native signers' responses to "Same" items were correct 90% of the time, demonstrating that these items were very easy for them. Therefore, the surprisingly poor performance on "Same" items in this study may be attributed to the fact that the participant sample was comprised primarily of language learners, especially beginners, whose experience with ASL was very limited.

It is likely that learners often attend to small subphonemic differences in sign production and incorrectly perceive utterance tokens that are the same as being similar (but not identical) to one another. In this regard, Bohn (2002) pointed out that the perception of phonetic similarity depends on factors such as the observer's language background and experience and that similar utterance tokens (i.e., utterances that are in close proximity to one another in phonetic space) are more difficult for L2 learners to categorize than dissimilar utterance tokens (i.e., utterances distal from one another in phonetic space). Therefore, it is reasonable to conclude that the difficulty of "Same" items in the present study follows from participants' background as spoken language users and their lack of experience with signed languages. As occurs in the acquisition of L2 speech, learners' background and experience with the target language influence their processing of phonetic similarity in the acquisition of a signed language as an L2.

Conclusion

Practical Implications

The hierarchy of difficulty among linguistic properties of ASL found in this study has potential application in projects involving the development and use of communication technology for signed languages. For example, the hierarchy of difficulty may be used in evaluating the efficacy of information transmission for sign language communication via video technologies, such as computer video, video conferencing, and videophones. Specifically, technologies that are best at transmitting movement information are likely to provide the most effective media for communication using signed languages.

The results of this study emphasize the importance of distinguishing contrastive from noncontrastive differences in the acquisition of signed languages. Differentiating contrastive from noncontrastive differences in sign formation presents an especially formidable challenge for learners at beginning levels of proficiency (Mayberry, 1995). For learners having no prior experience with signed languages, acquiring the sensorimotor (visual and spatial) and phonological skills necessary for attaining proficiency is a need that educational programs must address in a deliberate and systematic manner (Mirus, Rathmann, & Meier, 2001; Rosen, 2004). Students must learn to detect contrastive differences and overlook noncontrastive differences in the course of acquiring linguistic knowledge. Therefore, the development of ASL curricula and delivery of ASL instruction should strive to facilitate learners' ability to identify fundamental linguistic contrasts of the sort addressed in this study and, in so doing, address the important issue of variation from the perspective of both allophonic variation and variation across signers. Moreover, approaches to the assessment of ASL proficiency could benefit from the evaluation of learners' ability to discriminate linguistic contrasts. In particular, the discrimination procedure used in this study appears very promising and should be considered in the development of a practical receptive measure of ASL ability.

Theoretical Implications

The construct of language transfer plays an important role in the acquisition of L2 phonology in spoken languages. In contrast, the acquisition of ASL and other natural sign languages does not involve phonological transfer in situations in which L1 is a spoken language and L2 is a signed language because of fundamental differences between signed and spoken languages associated with the channel of information transmission.[5] Such differences are readily apparent when approached from the perspective of contrastive linguistics. Taking a contrastive linguistics approach and combining it with Mayberry's (1995) findings concerning the relationship of phonological errors to learners' experience with ASL (especially in childhood) leads to the prediction that L2 learners of signed languages, especially adult learners, will face a formidable challenge in acquiring the phonology of the signed language in situations in which their L1 is a spoken language. Of course, the relative difficulty of ASL phonology is ultimately a question that must be addressed in empirical studies. At this point, however, our prediction concerning the difficulty of ASL phonology may be considered a working hypothesis, and the results of the present investigation are consistent with this hypothesis.[6]

One specific challenge facing learners of signed languages related to the difference between speech and sign might pertain to the fact that the production of signs is directly observable, but the production of speech is not. Speech production occurs largely within the oral cavity, so the articulation of speech sounds cannot be directly observed. In contrast, the production of signs occurs outside the body and is fully accessible to observers. This distinction might have important implications with regard to learners' processing of variation and the acquisition of phonetic categories. In particular, Stevens (1972, 1989) described nonlinearities in the relationship between vocal articulation (input) and the acoustic signal (output) in terms of a quantal theory of speech. Quantal theory is associated with nonlinearities in speech pertaining to the fact that large changes in articulation sometimes have small effects on the acoustic characteristics of the signal, whereas, conversely, small changes in articulation sometimes result in large changes in acoustic output. In short, the quantal theory of speech is based largely on the fact that "articulatory movements are not equal in their acoustic consequences" (Kent, 1997, p. 412) as well as on data indicating similar nonlinearities in auditory-acoustic relations. Importantly, the nonlinear relationship between articulation and the acoustic signal accommodates variation in vocal tract configurations and works synergistically with auditory perception so that speech sounds with certain well-defined acoustic attributes are perceived categorically. It also has been suggested from a developmental and evolutionary perspective that the tendency for nonlinear (quantal) relations among "acoustic, auditory and articulatory parameters is a principal factor shaping the inventory of acoustic and articulatory attributes that are used to signal distinctions in language" (Stevens, 1989, p. 3).

Because the production of signs is directly observable, the relationship between the articulation of signs and the manual signal is completely linear because the articulation of signs *is* the signal. The linear relationship between articulation and the signal may have specific consequences for signed languages with regard to phonological variation and the development of phonetic categories. If a nonlinear relationship accommodates variation in speech, it may be assumed that a linear relationship would have the opposite effect in sign, providing relatively limited tolerance for variation. This is a provocative assumption, but it is clearly speculative and greatly oversimplified because variation is abundant in ASL and other signed languages. An important area for future research, therefore, is to describe variation in signed languages and its impact on their acquisition from the perspectives of both production and perception. In this regard, it is likely that a highly detailed phonetic transcription system for signed languages recently developed by Johnson (2008) can facilitate such research (Chen Pichler, 2009).

Languages associate linguistic signals with meaning through a set of principles or rules described by a grammar. Acoustic signals are associated with meaning in the case of spoken languages, and visual-manual signals are associated with meaning in the case of signed languages. In either case, users, especially learners, must determine when changes in the linguistic signal correspond to changes in meaning; that is, they must be able to discern when a difference is really different. Accordingly, the use and acquisition of language depend crucially on individuals' ability to effectively distinguish contrastive from noncontrastive differences. The results of the present study strongly emphasize this point. The ability to differentiate contrastive from noncontrastive differences in ASL, as in any other language, serves as a foundation for communication and acquisition. As such, the results of this study contribute to the field of applied linguistics, in general, and have special relevance for the acquisition of signed languages, in particular.

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Notes

1 Uppercase *Deaf* denotes a group of people who share a common language (ASL) and culture. Lowercase *deaf* denotes people with hearing loss (Padden & Humphries, 1988).

2 Although phonological transfer cannot occur in the situation in which L1 is a spoken language and L2 is a signed language, phonological (and cognitive) universals can still influence the course of acquisition at an abstract, underlying level of structure.

3 Native signers' performance on each of the six item categories was as follows: location = 95% correct; handshape = 92.5% correct; orientation = 92.5% correct; movement = 76.3% correct; complex morphology = 72.5% correct; "Same" = 90% correct.

4 For the two items reflecting noun classifier usage, one contained a contrast in handshape and the other contained a contrast in location. As such, a single comparison involving both of these items was not possible. Performance on this category was very poor, with participants scoring less than 35% correct.

5 It has been suggested that hearing adult learners' familiarity with conventional communicative gestures may influence their acquisition of handshape contrasts in ASL through the mechanism of transfer (Chen Pichler, 2009, 2011). Even if this

suggestion is supported by additional data, the influence of communicative gestures cannot be considered a form of *language* transfer because gestures fall outside the realm of language and within the domain of paralinguistic or extralinguistic behavior.

6 The effect of group membership ($\eta^2 = .365$) in this study indicates that performance on the discrimination task is associated with participants' ASL proficiency and, as such, provides further evidence that the effects of phonological processing observed in Mayberry's (1995) studies are not limited to late L1 acquisition. Specifically, this finding shows that phonological processing also has an important influence on L2 acquisition.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Test Items and Contrasts within Each Linguistic Category.

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