1. INTRODUCTION

This chapter addresses how a phonological system might emerge in a sign language; in other words, it asks the question, “What are some potential paths to phonological contrast?” Distinctive contrasts (those that achieve minimal pairs) and allophonic alternations (those used in phonological rules) are the two most commonly studied types of distributions in phonological systems. Both exist in sign languages, but we will argue that we can learn a great deal about how the human mind comes to create phonology if we look beyond these types of distribution, (i.e., those most common in spoken languages). In particular, we will describe two phenomena that involve grammatical interfaces and propose that the interfaces are a good place to look for the seeds of phonology in homesign systems and in young sign languages. One phenomenon occurs at the morphology-phonology interface and is based on both language internal and crosslinguistic data as well as data from homesigners. The other addresses the phonetics-phonology interface which is based on data from ASL but also has implications for homesign research.

The general argument is as follows. Distinctive and allophonic distributions are common in spoken languages but not in sign languages (Brentari & Eccarius 2010, Eccarius & Brentari 2008). A distinctive distribution is a case where unrelated lexemes are distinguished by the presence or absence of a feature or feature structure. For example, in English [b[t] (verb/past tense) and [p[t] (definite noun) are distinguished by [voice]. In ASL CAR (noun) and WHICH (wh-word) is a similar case of distinctive contrast in which two unrelated lexical items are distinguished by the absence or presence of the thumb. It has been observed that sign languages have very few minimal pairs, even in well-established sign languages (van der Kooij 2002, van der Hulst & van der Kooij 2006, Eccarius 2008). Van der Hulst and van der Kooij (2006) argue that this is, in part, due to phonetic possibilities; there is a larger number of different articulators and a larger perceptual space that contribute to the phonological system compared with that of spoken languages. They argue that it may also be due, in part, to iconicity; meaning and form are more often related in signed than in spoken languages (e.g., Padden 1988, Meir 2002, Aronoff et al. 2005, Brentari in press, Wilbur 2010, P. Wilcox, 2005, Russo, 2005, Taub, 2001, Cuxac & Sallandre 2007). The other common distribution found in spoken languages is an allophonic distribution, in which a structure is predictable and captured by rules or constraints; in its most canonical form, the context for the application of a rule is also phonological. There are sometimes exceptions to allophonic elements in spoken languages, but these operations are largely obligatory. Aspiration in English is a good example of this because the [spread glottis] feature appears only in the context of the beginning of a syllable when followed by a vowel. A purely allophonic distribution in many sign languages is that of the Handshape Sequencing Constraint, which requires open and closed variants to vary predictably within a single monomorphemic sign (Sander 1989, Brentari 1998). However, despite their existence in sign languages, purely allophonic distributions that are not optional are also relatively rare in sign languages (Brentari & Eccarius 2010, Eccarius & Brentari 2008).

These facts concerning the relative rarity of distinctive and purely allophonic behavior in well-established sign languages might suggest that the first indicators of phonology would not appear as distinctive or allophonic distribution, but rather as interface phenomena—between morphology-phonology and phonetics-phonology. We define an interface phenomenon as one that must refer to more than one grammatical component. We consider these analyses to concern interface phenomena because the phonology must refer to other grammatical components. In the first study we argue that the morphological status of handshape across different parts of the lexicon can affect the number and location of distinctive contrasts in the phonology, potentially affecting featural representation. We also argue that systematic phonetic variation based on the origin of signs may be a first step towards a phonological distinction, similar to the way that socio-phonetic variation can lead to historical change.
Yu 2007). In the second study we argue that a morphological distinction between two handshape types grounded in iconicity (object handshapes and handling handshapes) provides the environment for a phonological distribution of handshape, and that this distribution is beginning to appear in homesigners.

We have chosen to focus on handshape for two reasons. First, of the parameters of a sign (handshape, location, movement, orientation, nonmanuals), handshape has a well described set of features on which there is agreement among models, hence there is a well developed literature of what is and is not phonological (e.g., Brentari 1998, Sandler & Lillo-Martin 2006 and references cited therein). Second, handshape is the parameter on which gesturers, signers, and homesigners differ the most, and so would be most likely to display featural differences of the sort we are investigating here (e.g., Singleton et al.1993, Schembri et al. 2005).

An introduction to two fundamental aspects of handshape in sign language phonology is necessary in order to proceed. First, handshape behaves differently across the lexicon of a sign language (Brentari & Padden 2001). Figure 1 illustrates the three grammatical components proposed for sign languages—the core component, the foreign component, and the spatial component. The circles partially overlap across components in historical origins as well as synchronic morphological and phonological properties. For example, the handshape inventories of the three components overlap considerably, but there are some differences as well. Core forms are lexical forms that would be listed in a dictionary as stems. Foreign forms have the forms derived from an external source (e.g. written systems, another sign language, even a gesture from the surrounding spoken language community). Spatial forms include classifier constructions, which are productive polymorphemic forms, containing a verbal root (a movement) and a handshape affix that represent morphosyntactic properties of the arguments. Examples from each component with the same handshapes—in this case, \( \text{O} \) and \( \text{F} \)—are shown in Figure 1.

![Figure 1](insert Figure 1 around here)

The second aspect of sign language phonology that will serve as background for this chapter is the basic structure of handshape. The main components of handshape are given in Figure 2. The features of joints and selected fingers will be the focus of this work. The first study focuses primarily on joint features, and the second study focuses on selected finger features.

![Figure 2](insert Figure 2 around here)

**2. DIFFERENCES IN CONTRASTS AND PHONETIC TARGETS ACROSS SUB-COMPONENTS OF THE LEXICON**

This study is taken from Eccarius (2008) and Eccarius and Brentari (2008). The purpose of the investigation was to determine whether joint features are perceived the same way across the lexical components shown in Figure 1. Specifically, we wanted to know if 1) the number of distinctive contrasts and 2) their phonetic targets would be consistent across lexical components for ranges of handshapes common to all ASL lexical components. Differences such as these could affect the number of features required for the representation in the foreign, core, and spatial components of the grammar.

Although the original study examined additional handshapes, here we focus on the results of two handshape ranges, which we refer to as the O and F ranges (see Figure 3). These groups were chosen because the handshapes within them are relatively common handshapes (Hara 2003) for which the feature \([+\text{contact}]\) could be held constant while altering the joint positions of the selected fingers (either all fingers in the O group or just the index finger in the F group).

![Figure 3](insert Figure 3 around here)

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1 Extended methodology and results can be found in these two sources.
In our attempts to identify phonologic contrasts across the lexicon in these handshape ranges, we first looked for differences in meaning based solely on handshape variation, (since differences in meaning indicate distinctive contrast). However, because sign languages tend to have very few minimal pairs (even for well established contrasts), determining contrasts via meaning differences was not always straightforward. For example, there is a known meaning distinction in ASL between O and flat-O (HS1 and HS3 in the O group) in classifiers used to describe round and flat shaped objects (e.g. the description of a cardboard tube vs. a sheet of cardboard, see Figure 4 in the next section). However, we could find no such minimal pairs in the foreign component or in core lexical items. For forms that did not have viable minimal pairs, it was unclear whether the missing forms were the result of contrast differences across lexical components or were merely due to large accidental gaps.

This imbalance in lexical competition throughout the lexicon has the potential to affect signers’ responses in meaning identification tasks. Along these lines, Allen and Miller (2001) conducted a series of perceptual rating tasks on spoken English and found that the location of category boundaries for voice onset time between /p/ and /b/ shifted as the result of a lack of lexical competition (testing word vs. non-word status, e.g. beef vs. peef), indicating that the location of a contrast could be affected if no competition was present. However, they also found that the mapping of “best exemplars” within those boundaries remained comparatively stable regardless of the presence of competition. For that reason, we also included a form-rating task, which mapped (at a very basic level) the phonetic target preferences for forms within the same meaning group. This helped us determine how good a fit each phonetic variant was for the meaning chosen, thus beginning to establish the best phonetic exemplars within categories and helping to further identify the existence and location of meaningful contrasts.

Two competing hypotheses existed for this study. If phonemic contrasts are consistent across lexical components, then we would expect the phonetic targets for those contrasts to remain constant across components. For example, if the O vs. flat-O contrast found in the classifiers persists throughout the lexicon of ASL, and those handshapes are highly rated as exemplars for the members of that contrast, we would expect the same handshape preferences to be found for items from other lexical components, regardless of whether or not there was a minimal pair available. In other words, for a core sign without a corresponding minimal pair (e.g. TEACH, Figure 1), signers would rate either O or flat-O as highest, matching one of the best exemplars from the classifier contrast. Conversely, if we find phonetic target for TEACH that is different from that of the classifiers, it would be an indication that the phonological contrast is not homogenous cross-componentially, and that a more complicated phonological relationship may be at play in the ASL lexicon.

2.1 Participants

Twelve Deaf adult, native or early learners of ASL participated in this experiment. All were students or employees at Gallaudet University at the time of testing.

2.2 Stimuli and procedures

The stimuli relevant to this work consisted of video clips of signs chosen to represent the three lexical components of the ASL lexicon. Each ‘sign’ was produced by a Deaf signer three times using each of the variants from the handshape groups—one with the round handshape (HS1), one with the intermediate handshape (HS2), and one with the flat handshape (HS3)—while the values for movement and location remained the same (see Figure 4 for an example). These three signed forms constituted one ‘item’ for purposes of comparison, and there were three items included for each of the lexical components—foreign (in this case, all were initialized signs), core (lexical items) and spatial (classifier handshapes). As much as possible, items were balanced with regard to place of articulation, movement, orientation, and sign type (one handed, symmetrical two-handed, etc.). For each item, there was at least one, and sometimes more than one, attested meaning (depending on the

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2 An ’early learner’ is defined here as someone who learned ASL before age 5.
contrast number and location per handshape group).

The combination of variables (handshape group, handshape variant, lexical component, and item within component) resulted in 54 stimulus clips from the O and F groups. These test stimuli (in addition to those for the other handshapes tested in the larger study) were then added to distracter signs, which were balanced across the lexical components and used a variety of handshapes, some well-formed for their signs and others not (so that distractors as well as test stimuli would receive a variety of goodness rankings).

(insert Figure 4 around here)

Each video clip was embedded in a pair of PowerPoint slides. The first slide of the pair addressed the meaning-choice task. Participants were asked, "What is the best English meaning for this sign?" Two possible meanings were provided, along with the possibility of supplying a meaning that was not provided. In cases where a minimal pair was available (e.g. round vs. flat objects for the classifiers), both meanings were possible choices. In cases where there was only one possible meaning for a given item across handshape variants, (e.g. TEACH), a second meaning choice was provided that was a minimal or near-minimal pair and differed in handshape alone if possible (e.g., TEACH vs. PAY-ATTENTION). The second slide addressed the form rating task. Participants were asked to "Please rate the handshape for this sign" on a five-point scale from very bad (1) to very good (5).

2.3 Results

The results for both the O and F handshape groups are presented in Figure 5.¹

(insert Figure 5 around here)

2.3.1 The Meaning Choice Task

Because the test items differed in the number of ‘correct’ meanings possible for a given handshape range, only the responses for one meaning were used for statistical comparisons. In cases where there was no minimal pair, the meaning used was the only ‘correct’ meaning for the signed form. However, where a minimal pair did exist (e.g. for classifier forms), the meaning response analyzed was the choice expected for the rounder of the two endpoints (e.g. ‘cardboard tube’ instead of ‘sheet of cardboard’).² Results of the meaning choice task report the average proportion of times the round meaning was chosen for each of the three handshapes (HS1, HS2, and HS3) across the three components, and a Fishers Exact Test was used to determine significance.

For the O (top left) and F (bottom left) handshape groups, the items from the foreign and core lexical components do not show a significant difference from one another in the proportion of round responses across the three handshapes (i.e. all handshape variants elicited the same meaning response). However, the items from the classifier component for these groups differed significantly from the core and foreign forms for the proportion of round responses at HS2 and HS3, the intermediate and flat forms (p < .01, α = .05) (i.e. some proportion of non-round meanings were chosen for these handshape variants).

2.3.2 Form Rating Task

Results of the form rating task report the average “goodness-of-fit” rating (1-5) for the three handshapes in the core and foreign groups (i.e. those groups that showed no distinctive/meaningful contrasts using the meaning choice task). As previously indicated, the rating task was used to help locate contrasts in the absence of meaningful competition. For the rating task, a Mixed Model ANOVA with a Bonferroni adjustment of a = .0167 was used to determine significance.

For the O Group (top right) a significant difference was found at HS3 for form rating responses between core and initialized items (t = 3.74, df = 197, p < .01), although all handshape variants

⁴ These expectations were formed based solely on prior knowledge of ASL vocabulary and not on the experimental results themselves.
received an average rating of above 3. The average goodness-of-fit rating for all handshape variants in the F group (bottom right) were also all above 3, but with no significant differences between the core and foreign lexical components.

2.4 Discussion

Significant differences in the meaning choice task (supported by the form ratings) provide evidence for the number of distinctive contrasts, which was our first research question. For stimuli in the two handshape groups (O and F), the classifier component for all groups demonstrated a progressively lower proportion of round meaning responses on HS2 or HS3. In other words H2 and H3 elicited different meanings than H1 for classifiers, but crucially all three handshape variants elicited the same meaning responses for core and foreign (initialized) forms. These results suggest that certain changes to the features needed in each component may be warranted; the feature [+contact] may be sufficient to define each phonemic category (‘O’ and ‘F’) represented by these handshape ranges for core and initialized forms, making the features used to distinguish flat from round (e.g., flexion of the intrapharangeal joints) unnecessary in these components for handshapes with contact. (Future work can determine if this is actually the case.) In contrast, these joint features are needed in the classifier component, where a morphological contrast between HS1 and HS3 exists.

With respect to the form rating task results, we found that phonetic targets were not always stable across components. While all handshape variants were rated relatively high across the core and foreign items (suggesting that a distinctive contrast does not exist), there was a significant difference in the average suitability rating of HS3 (the flat O) for initialized signs as compared to core signs, suggesting a phonetic target closer to the round end of the handshape range in the foreign component (at least in forms borrowing a fingerspelled ‘O’). However, this kind of phonetic difference was not found when comparing core and foreign forms in the F handshape group. Why could this be? The joint configurations for these handshapes are the same—they only differ in the number of selected fingers. One possibility is that the phonetic targets are influenced by the iconic relationship between the borrowed orthographic letters and their representative handshapes. The letter ‘O’ is round and therefore has the potential to elicit the phonetically rounder handshape variant, while the handshape used to represent the letter ‘F’ has no iconic link to the written letter, and is therefore immune to such external influence.

This study has implications for two theoretical domains. The first is Dispersion Theory (Flemming 2002). The principle of Maximum Dispersion within this theory proposes that, all things being equal, when forms express a meaningful difference (as they do in the classifier system here) the system is more well formed if the phonetic targets are as far away from one another as possible (fully round vs. fully flat). Again, all things being equal, when forms do not express a meaningful difference (as in the core and foreign components most of the time) there would be no need for the form to gravitate to either end. Our results support the principle of Maximum Dispersion. This work also has implications for a second theoretical area, namely socio-phonetics, where sub-phonemic systematicity has implications for the emergence of a phonological system. Trends in sub-phonemic perception can have important implications for historical change in a phonological system. Using Exemplar Theory, Yu (2007) has demonstrated that sub-phonemic systematicity can help us better understand the historical phenomenon of near-merger in Cantonese. We add to this work considering the systematic difference in phonetic preference among the subcomponents in the experiment on ASL. While this experiment included no data from homesign or emerging sign language systems, the implications on the emergence of phonology are as follows. As the vocabulary grows in a new system, one mechanism that might be employed by the system to keep track of the source of the form is a difference in phonetic target. In other words, while there is a great deal of variability in homesign and young sign systems (e.g. Coppola & Senghas 2010, Aronoff et al. 2008), two signs—one originating in the gestures of the hearing people and one created within the community itself—might have different phonetic targets. Moreover, this sub-phonemic type of sytematicity might well appear in a single user before it manifests itself in a whole community. The distribution of phonetic targets might not count as “phonology” by some definitions, but it might be the type of socio-phonetic phenomenon that could be a precursor to a phonological alternation.

This study is taken from Brentari, Coppola, Mazzoni and Goldin-Meadow (in press). The purpose of the study was to investigate how gesturers, signers and homesigners use handshapes to describe objects and how objects are handled, particularly in the area of selected finger features. First we studied whether gesturers and signers used handshapes in the same way, and then we examined whether homesigners looked more like gesturers or more like signers in their pattern of productive handshape use.  

The morphological categories for Object and Handling might or might not be paralleled by a corresponding phonological pattern. For example, if the following hypothetical set of handshapes— comprise a particular classifier type in a sign language, the set would form a phonological class because the handshapes in the set share a phonological property (they are all fully extended). New handshapes that enter the set would be predicted to be fully extended as well. In contrast, if the following handshapes— comprise the classifier type, the set would not form a phonological class as there is no common property that the handshapes share. In this event, the handshapes would constitute a morphological but not a phonological class. Because the phonological patterns are associated with specific morphological categories, the study we are about to describe concerns a morpho-phonological phenomenon, as described in the introduction.  

We classified handshapes into three levels of finger complexity based on several criteria. Low complexity handshapes have the simplest phonological representation (Brentari 1998), are the most frequent handshapes crosslinguistically (Hara 2003, Battison 1978, Eccarius and Brentari 2007), and are the earliest handshapes acquired by native signers (Boyes Braem 1981). These three criteria converge on these selected finger groups: all fingers, index finger, and thumb. Interestingly, these three groups of selected fingers have also been found to be frequent in the spontaneous gestures that accompany speech (Singleton et al. 1993, Goldin-Meadow et al. 1996) and in child homesign (Goldin-Meadow et al. 1995).  

Medium complexity handshapes include one additional elaboration of the representation of a [one]-finger handshape, either a branching structure or an extra association line. The elaboration can indicate that the single selected digit is not on the 'radial' (thumb) side of the hand, which is the default position for all finger groups, e.g., in the selected finger is on the 'ulnar' (pinky) side of the hand, and is 'middle'. The elaboration can also indicate that there is an additional finger selected, as in where two fingers are extended rather than one. These are also the next most frequent sets of selected fingers after the low frequency selected finger groups (c.f. Hara 2003).  

High complexity handshapes would include all other handshapes, such as and . These are the least frequent sets of selected fingers (Hara 2003) and can exhibit a wide range of further elaborations of the representation.  

In sign languages, handshapes that represent objects (ObjectHSs) show a higher degree of selected finger complexity than handshapes that represent how objects are manipulated (HandlingHSs). Data collected from American, Swiss German, and Hong Kong Sign Languages (ASL, DSGS, and HKSL) revealed that whole entity classifiers (Engberg-Pedersen 1993; called ObjectHSs) have a larger set of finger distinctions and more finger complexity than handling classifiers (Supalla 1982; called HandlingHSs). Eccarius (2008) and Brentari and Eccarius (2010) have found that ObjectHSs and HandlingHSs differ in their distribution of finger and joint complexity (Figure 6).  

In this second study, the handshape font is used to describe “finger groups” rather than individual handshapes. For example, the finger group represents the set of handshapes that includes the whole range of joint configurations for handshapes using the index and middle fingers, e.g., , , , , and . The thumb is ignored in designations of finger group unless it is the only digit selected.  

Henceforth in this second study,
A task was designed to elicit handshapes that represent either an object or a hand manipulating an object with three goals in mind: (1) to replicate the finger complexity patterns found by Eccarius (2008) and Brentari and Eccarius (2010) in signers using an experimental probe; (2) to use the same probe to determine whether hearing individuals asked to describe objects using only their hands and no speech would display the same or different finger complexity patterns; (3) to see whether the home signers pattern like gesturers or like signers.

3.1 Participants

The participants in this study were adults from 5 groups and 3 countries (age range: 22-55). The language groups were ASL, Italian Sign Language (LIS), spoken English, and spoken Italian; all participants were native users of the language in question. In addition there was the group of Nicaraguan homesigners. The three American (i.e. English-using) gesturers were graduate students at Purdue University, and the three native ASL signers were from the greater Chicago area. The three Italian gesturers were students at the Università di Firenze, and the three native LIS signers were from the greater Milan metropolitan area. Four homesigners in Nicaragua also participated in our study. At the time of the study, they were 20, 24, 29 and 29 years old, and they displayed no apparent cognitive deficits. The homesigners did not know each other, did not interact regularly with other deaf people, and were not part of the Deaf community in Nicaragua that uses Nicaraguan Sign Language (Coppola 2002).

3.2. Stimuli and procedures

The stimuli consisted of 131 photographs or short movie clips (henceforth vignettes). Eleven objects were used in the vignettes: airplanes, books, cigars, lollipops, marbles, pens, strings, tapes, television sets, and tweezers. The shape of the hand used by the actor in the vignettes was intentionally ambiguous and could be represented by either a T, L, or B finger group. The objects exhibited a range of colors, shapes, and sizes. Each object was portrayed in 10 conditions: 5 depicted a stationary or moving object moving on its own without an agent, and 5 depicted an object being moved by the hand of an agent (Figure 7).

(insert Figure 7 around here)

The gesturers were instructed to “describe what you see using your hands”. Signers were instructed in sign to “describe what you see.” The instructions to the homesigners involved indicating the computer screen and indicating with gestures that they should describe what they see. Data collection sessions were videotaped, then captured using iMovie and clipped into individual files, one file for each vignette description. The video files containing the participants’ responses were transcribed using ELAN (EUDICO Linguistic Annotator), a tool developed at the Max Planck Institute for Psycholinguistics, Nijmegen, for the analysis of language, sign language, and gesture. Three data sets were selected for analysis: the 'falling' condition (#5) for all 11 objects, and the 'airplane' and 'lollipop' objects for all 10 conditions. The falling condition provides opportunities to produce an unaccusative-like construction depicting a theme moving without an agent. Responses to the objects 'airplanes' and 'lollipops' were analyzed because they tend to elicit high complexity handshapes. We focused on the gestures and signs used to describe the objects, their manipulation, and their spatial arrangements. Gestures and signs that were used to label the object or describe its color or number were not included in the analyses, as they are not comparable to productive classifiers, the focus of our study.

Each handshape was first coded according to meaning type: (1) ObjectHSs represented the whole object, part of the object, or its physical characteristics, such as size and shape; (2) HandlingHSs represented the manipulation or handling of the object. Participants also produced a number of handshapes that were not relevant to our analyses and thus were excluded: the index finger or neutral handshape was used to trace the object’s path or indicate its location; the whole body was
used to substitute for an object in motion (e.g., falling off the chair to indicate the object falling); a lexical sign in LIS or ASL rather than a classifier form was used (relevant only to signers). We included in the analyses only handshape types that matched the intent of the stimulus, that is, ObjectHSs that were produced in response to 'no agent' stimulus events, and HandlingHSs that were produced in response to 'agent' stimulus events. These criteria resulted in 595 handshapes across the four language groups.6

Each handshape was then assigned a finger complexity based on the criteria described in Figure 6. Low complexity handshapes were assigned a score of 1; medium complexity handshapes were assigned a score of 2; high complexity handshapes were all remaining forms, and were assigned a score of 3. A handshape was given an extra point for complexity if there was a change in the selected fingers used over the course of the gesture or sign, e.g., the gesture began in a \( \text{✓} \) handshape and ended in a \( \text{✓} \). Thus, finger complexity values ranged from 1 to 4.

### 3.3. Results

Results will be reported first for the gesture/sign comparison in Section 3.3.1. The results on the gesture/homesigner/sign comparison will be reported in Section 3.3.2.

#### 3.3.1. Gesture vs. Sign

Finger complexity was averaged for each participant, and then again for each language group. A Mixed Linear Model was used that allows grouping of interdependent samples. Group (Sign, Gesture), Country (US, Italy), and Handshape Type (Object, Handling) were treated as fixed effects, and Participant and Stimulus Item were treated as random effects. Figure 8 displays the estimated mean finger complexity for ObjectHSs and HandlingHSs for signers and gesturers by Country.

The model revealed a significant interaction between Group and Handshape Type, indicating that the signers and gesturers differed in their patterns of finger complexity for ObjectHSs vs. HandlingHSs (see Figure 8). Specifically, signers showed significantly higher finger complexity for ObjectHSs than for HandlingHSs, \( t(5) = 7.35, p < .001 \), whereas gesturers showed the opposite pattern, lower finger complexity for ObjectHSs than for HandlingHSs, \( t(5) = -3.81, p < .05 \). The main effect for Country was marginally significant, indicating that signers and gesturers from the US tended to produce higher finger complexity than signers and gesturers from Italy \( t(10) = -2.02, p = .064 \). However, the lack of interaction between Country and Handshape Type \( t = -0.915, p = .38 \) indicates that the overall pattern in finger complexity for the different Handshape Types did not differ by Country. Post-hoc contrasts indicated significant differences between signers and gesturers in both Handshape Types: signers showed higher finger complexity for ObjectHSs than gesturers, \( t(10) = 4.16, p < .05 \), and lower finger complexity for HandlingHSs, \( t(10) = -5.05, p < .001 \), than gesturers.

There were no other significant effects.

#### 3.3.2 Homesigners

The observed average finger complexity for ObjectHSs and HandlingHSs for each homesigner is displayed in Table 1.

The homesigners displayed individual variation in how they used finger complexity across the two handshape types. Three of the four homesigners displayed higher finger complexity in ObjectHSs than in HandlingHSs, the signers’ pattern. However, the fourth homesigner displayed the gesturers’ pattern, producing higher finger complexity in HandlingHSs than in ObjectHSs.

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6 Importantly, if we include all handshapes regardless of the type of stimulus that elicited them (i.e., Object HSs produced in response to both types of stimuli, and Handling HSs produced in response to both types of stimuli), the results described below are unchanged.
To compare the homesigners’ performance to the performances of the signers and gesturers, we contrasted the 156 observations from the Nicaraguan homesigners to the 595 observations from the native signers and gesturers described in Study 1 (a total of 751 observations) using the Mixed Linear Model described in Study 1. Because the factor Country (US, Italy) revealed no significant interaction with Group (Sign, Gesture) in Study 1, this factor was ignored in this analysis. Figure 9 shows the estimated mean finger complexity for ObjectHSs and HandlingHSs in homesigners, signers, and gesturers (collapsing across country).

(insert Figure 9 around here)

The homesigners displayed a marginally significant tendency to produce more finger complexity in ObjectHSs than in HandlingHSs, $t(3) = 2.31, p = 0.10$. To situate the homesigners’ levels of finger complexity within the levels for the other two groups, we conducted the following post-hoc pairwise comparisons. Homesigners did not differ significantly from signers on finger complexity in either ObjectHSs, $t(8) = -1.02, p = 0.34$, or HandlingHSs, $t(8) = 1.6, p = 0.15$. And they did differ from gesturers: they displayed significantly lower finger complexity than gesturers in HandlingHSs, $t(8) = 2.62, p < .05$, and higher finger complexity than gesturers in ObjectHSs, $t(8) = 2.24, p = 0.055$. Thus, the homesigners’ finger complexity levels were closer to the signers’ levels than to the gesturers’ levels.

3.4 Discussion

The results for the ASL and LIS signers repicate previously found patterns (Eccarius 2008, Brentari and Eccarius 2010), and illustrate the morpho-phonological distinction in finger complexity for ObjectHSs vs. HandlingHSs described in Section 1.1.3. All six of the signers, regardless of country, displayed a higher finger complexity in ObjectHSs than in HandlingHSs. We have thus succeeded in creating a reliable experimental task that can be used to probe handshape use in groups who cannot provide grammaticality judgments. In addition, we show that the pattern previously reported for sign languages is not inevitable whenever the hands are used to communicate—the gesturers in our study did not show it and, in fact, displayed the opposite pattern, more finger complexity in HandlingHSs than in ObjectHSs. The different pattern found in gesturers vs. signers underscores the fact that different processes can be recruited when objects are represented in the manual modality. When gesturers view the vignettes containing an agent, they replicate to a large extent the actual configuration of the hand in the vignette and, as a result, they display a fair amount of finger complexity in these Handle handshapes. They are using the hand to represent the hand, and thus are relying on an accessible mimetic process. In contrast, signers display more finger complexity in their Object handshapes, where handshapes take on the properties of the objects themselves. Gesturers do not use much finger complexity here, as they must abstract features of the object and display them in the hand. These hand-as-object representations seem to rely on a more abstract process than the mimetic process underlying hand-as-hand representations.

The discontinuity in finger complexity between gesturers on the one hand and homesigners and signers on the other provides clues to the changes that might have taken place in the evolution of the morpho-phonological system underlying handshape in sign languages. We see the first indicators of a phonologization process in the homesigners’ Object handshapes: homesigners increase finger complexity in their Object handshapes from the gesturers’ level to the signers’ level. We also see change in the homesigners’ Handling handshapes: homesigners decrease finger complexity in Handling handshapes from the gesturers’ level, although not yet to the signers’ level.

What accounts for the sign-like pattern observed in the homesigners? It is possible that the sign-like pattern that the homesigners display in their handshapes is the result of influence from Nicaraguan Sign Language (NSL). We think this possibility unlikely because none of the homesigners had regular contact with individuals who knew and used NSL. There are two factors that distinguish the homesigners from the gesturers: They have been using their gestures to communicate over a long period of time, and gesture is their primary means of communication. Although intertwined, these two factors can be distinguished and will be explored in future work.
Although homesigners have achieved sign-like levels of finger complexity in their Object handshapes, their Handling handshapes still appear to be in transition. Homesigners’ finger complexity levels in Handling handshapes are significantly lower than gesturer levels, but they have not yet fully decreased to the sign level. It is possible that achieving the sign level of finger complexity in Handling handshapes, which has the effect of maximizing the distinction between Object and Handling handshapes, may require a linguistic community where some sort of negotiation might take place. The homesigners’ regular communication partners are their hearing family members and friends, none of whom uses the homesign system as a primary means of communication. Thus, it is difficult to characterize homesigners as having access to a shared linguistic community. Moreover, the homesigners do not know or interact with one another. There is consequently no pressure to arrive at the most efficient solution for a whole community. The fact that homesigners’ complexity level is closer to the gesturer level for Handling handshapes than for Object handshapes suggests that a shared linguistic community may play a greater role in “losing” the hand-as-hand iconicity displayed so robustly by the gesturers.

4. Conclusions

The two experiments reported in this chapter serve as evidence suggesting that the most obvious elements of phonology—minimal pairs and phonological distribution—might not be the ways that an emerging phonology would first show itself. We have argued that interface phenomena may precede an autonomous phonological component. Two studies have been described that suggest that the first indicators of phonology might emerge at the grammatical interfaces between phonology and another component of the grammar.

In the first experiment involving both the morphology-phonology and phonetics-phonology interfaces, our results suggest that there can be both a different number of distinctive contrasts and different phonetic targets across lexical subcomponents. These subcomponents are based in part on their morphological and phonological behavior, so the sub-lexical phonetic properties described are relevant for both grammatical interfaces. The different distinctive contrasts and phonetic targets across the lexicon indicate a differential use of feature [flexed] at the intraphalangeal joints. Moreover, the number of contrasts and the preferred variants show sub-lexical systematicity that may be relevant for historical change.

The second experiment involving selected finger complexity addresses the morphology-phonology interface. It was found that the changes from gesture to homesign and from homesign to sign language involve not only loss of iconicity (Frishberg 1975) but also reorganization of phonological information over time. One reason that this occurs might be that the type of iconicity present in sign languages leads to early development (historically speaking) of a morpho-phonological interface. In other words, meaningful differences originating in iconicity are not completely lost but rather are both organized into productive morphological structures and subjected to phonological restructuring (e.g., by the differential use of selected finger features mapping to different morphology categories). This is true crosslinguistically in sign languages, and as we have shown here, the Nicaraguan homesigners have begun to display a sign-like pattern in finger complexity distribution; in this sense, they can be said to display the seeds of morpho-phonological structure.

Thus far, there have been no minimal pairs reported in homesign or in Al-Sayyid Bedouin Sign Language (ABSL), the young sign language currently under investigation in Israel (Sandler et al. 2005). No doubt, given the relatively high levels of many types of variation found in homesign and young sign languages (e.g., Coppola & Senghas 2010, Aronoff et al. 2008), applying the type of investigation described in this chapter to those cases would involve teasing apart different patterns of variation—those that are within the individual vs. those that are within the community. It would be expected that hints of both uses of these interface phenomena would appear in a single system before appearing in a language as a whole, thus providing a way for us to track the path toward phonology first from a single individual and later into a community.

5. References


Brentari Diane, Marie Coppola, Laura Mazzoni, and Susan Goldin-Meadow (in press). When does a system become phonological? Handshape production in gesturers, signers, and homesigners. Natural Language and Linguistic Theory


unpublished Ph.D. dissertation, University of Chicago, Chicago, IL.
Table and Figure Captions

Table 1. Observed average finger complexity for each individual homesigner and the group average for all four homesigners.

Figure 1. The core, foreign and spatial components of the sign language lexicon, with examples using the same phonological handshapes O and F.

Figure 2. Basic structure of Handshape (cf. Brentari 1998).

Figure 3. The round, intermediate and flat variants used for the O and F handshape groups.

Figure 4. Examples of stimulus ‘items’ using handshape variants from the O group.

Figure 5. Results for the meaning choice task for O (top left) and F (bottom left) groups, and for the form rating task for O (top right) and F (bottom right) groups. The graphs of the meaning choice task show the average proportion of round (vs. non-round) responses for each of the three handshape variants. The graphs of the form rating task show the average “goodness-of-fit” rating for each each variant.

Figure 6. Handshapes found in Object (whole entity) and Handle classifiers in ASL, HKSL, and DSGS (cf. Eccarius 2008). The finger complexity score for each handshape is listed below it.

Figure 7. Description of the 10 conditions in which each of the 11 objects appeared (top), and examples of two airplane vignettes (a frame from 'no agent' condition #3; a frame from the corresponding 'agent' condition #8).

Figure 8. Estimated mean finger complexity for ObjectHSs and HandlingHSs in signers and gesturers by Country. Signers in both countries replicated the previous cross-linguistic findings (higher finger complexity for ObjectHSs than for HandlingHSs). Gesturers in both countries showed the opposite pattern (higher finger complexity for HandlingHSs than for ObjectHSs).

Figure 9. Estimated mean finger complexity for ObjectHSs and HandlingHSs in signers, homesigners, and gesturers. The homesigners’ pattern resembled the signers’ pattern and was significantly different from the gesturers’ pattern. The estimated values provided by the model reflect the effects of removing covariates (such as stimulus item and participant) and, in this sense, provide a more accurate picture of the underlying patterns in the dataset than the observed values. Because these are estimated values provided by the model, their values can be less than 1, which was the minimum finger complexity value assigned in our system.
### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Homesigners</th>
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<td>1</td>
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<td>3</td>
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**Figure 1**

```
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<thead>
<tr>
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<th>Core</th>
<th>Spatial</th>
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<tr>
<td>GET-AN'-F'</td>
<td>BENEFIT</td>
<td>long-thin-flat-object</td>
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```
Figure 2

- HS
  - joints
    - [stacked] [spread] [flexed] [crossed]
  - selected fingers
    - base [one] [all]
    - nonbase [ulnar] [mid]

Figure 3

<table>
<thead>
<tr>
<th>“O” HANDSHAPES</th>
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<tr>
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<tr>
<td>HS1</td>
<td>HS2</td>
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Figure 4

Initialized form: e.g. OPINION

Core lexical form: e.g. TEACH

Classifier form: e.g. Long, thin object
Figure 5
<table>
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<td>Handling CL-HSs</td>
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<td>1</td>
<td>1</td>
<td>2</td>
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<table>
<thead>
<tr>
<th>Scenes without an agent</th>
<th>Scenes with an agent</th>
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<tbody>
<tr>
<td>2. [object] on table upside down</td>
<td>7. Put [object] on table upside down</td>
</tr>
<tr>
<td>3. Multiple [objects] on table (regular arrangement in row/s)</td>
<td>8. Put multiple [objects] on table (regular arrangement in row/s)</td>
</tr>
<tr>
<td>5. [object] falling</td>
<td>10. Demonstrate function of [object]</td>
</tr>
</tbody>
</table>

*Figure 7*

*Condition 3: Planes in a row*  
*Condition 8: Put planes in a row*
Figure 8

![Graph showing the comparison between Signers and Gesturers in terms of estimated finger complexity. The x-axis represents different regions and types of handshapes, and the y-axis represents the estimated finger complexity. The graph includes bars for both Object handshapes and Handling handshapes.]
Figure 9