# Phonological category resolution:
## A study of handshapes in younger and older sign languages*
## *Categorias fonológicas:*
### *um estudo sobre orientação manual em línguas gestuais antigas e novas*

*Assaf Israel[1]** and Wendy Sandler[1]****

[1] University of Haifa / Sign Language Research Lab

### ▰▰ **Resumo**

A existência de um sistema fonológico – um sistema em que se articulam unidades com um significado mínimo para a criação de palavras significantes – é, muitas vezes, considerada como um pré-requisito para a linguagem. A descoberta de que as línguas gestuais contêm um nível de estrutura significante convenceu, definitivamente, os linguistas de que tratava de verdadeiras línguas.

Contudo, a questão da emergência do sistema fonológico não foi ainda tratada, tendo em conta que, por um lado, as línguas orais são línguas antigas ou descendentes de línguas antigas e, por outro lado, a maior parte das línguas gestuais que foram estudadas até aos dias de hoje, já têm algum tempo de existência.

O presente estudo constitui-se como um passo que documenta a formação de categorias fonológicas numa nova língua gestual: a Língua Gestual Al-Sayid Beduína (ABSL). Esta nova língua emergiu recentemente numa comunidade isolada com uma grande incidência de Surdez.

Este trabalho foi motivado pela observação de que esta nova língua parece exibir uma variação na formação de gestos entre os gestuantes (Aronoff *et al*. 2008). Para dar conta deste fenómeno, medimos a variação de 10 gestuantes relativamente à produção de uma categoria fonológica – configuração – em 15 gestos de ABSL, comparando os resultados com a produção da configuração em duas outras línguas mais estabelecidas – a ISL (Língua Gestual Israelita) e a ASI (Língua Gestual Americana).

A nossa metodologia mede o grau de consenso entre os gestuantes, relativamente a cada característica fonética da configuração e ao número de variantes exibido, revelando um padrão consistente nas três línguas em estudo.

A maior quantidade de variação foi encontrada em ABSL, seguida da ISL. A ASL foi a língua que apresentou menos variação na produção da categoria configuração. Estes resultados sugerem que as categorias fonológicas ainda se encontram em processo de formação numa nova língua e acreditamos que a combinação de factores históricos e sociais podem explicar a gradação exibida ABSL > ISL > ASL. Os nossos achados

### ▰▰ *Abstract*

*The existence of a phonological system – a system of meaningless building blocks that make up meaningful words – is often considered a prerequisite for language, and the discovery that sign languages used by deaf people have a meaningless level of structure convinced linguists that they are real languages.*

*But the question of how a phonological system arises has not previously been addressed, since all spoken languages are old or descended from old languages, and most sign languages that have been studied have also been around for some time.*

*The present study is a step toward documentation of the formation of phonological categories in a new sign language, Al-Sayyid Bedouin Sign Language (ABSL), which arose recently in an insular community with a high incidence of deafness.*

*The work is motivated by the observation that this new language appears to exhibit a good deal of cross-signer variation in the formation of signs (Aronoff et al 2008).*

*To put this observation to the test, we measure the amount of variation across 10 signers in the production of one phonological category – handshape – in 15 signs of ABSL, and compare it with handshape production in two other, more established sign languages: Israeli Sign Language (ISL) and American Sign Language (ASL).*

*Our methodology measures the degree of cross-signer consensus with respect to each meaningless phonetic feature of handshape as well as the number of variants (indicating the range of variation), and reveals a consistent pattern across the three languages:*

*The largest amount of variation is found in ABSL; ISL is next; and ASL shows the least amount of cross-signer variation in production of the handshape category.*

*These results suggest that phonological categories are still in the process of being formed in the new language, and we appeal to a combination of historical and social factors to explain this ABSL > ISL > ASL cline.*

*The findings and analysis offer a glimpse into the development of phonological categories in a new language.*

e a sua análise oferecem um primeiro olhar relativamente ao desenvolvimento das categorias fonológicas numa nova língua.

**Palavras Chave:** Fonologia das Línguas Gestuais, variação fonética, Lingua Gestual Beduína AL – Sayyid, emergência da linguagem ⇤

**Keywords:** *Sign language phonology, phonetic variation, Al-Sayyid Bedouin Sign Language, language emergence* ⇤

Linguists began to take sign languages seriously as an object of study after William Stokoe demonstrated that the words of these visual languages are constructed from a discrete and finite list of meaningless units – that they have phonology (Stokoe, 1960). This discovery dispelled the myth that sign languages were comprised of iconic gestures, holistic in form. But do those meaningless units that Stokoe identified exist in a new sign language? Or does it take time for a phonological system to self-organize? Investigating a new sign language gives us insight into this question, and to the broader question of whether it is necessary to have phonology in order to have language.

The myth that established sign languages like American Sign Language (ASL) were holistic gesture systems was based on iconic properties that are readily observable in many signs: A sign for *book* looks like opening a book and a sign for *eat* looks like putting food in the mouth, to take examples shown in Figure 1 from Israeli Sign Language (ISL).

**Figure 1** – BOOK, EAT, and LEARN/STUDY in ISL.



But Stokoe showed that the handshapes, locations, and movements of signs perform the same role in the lexicons of sign languages as do the meaningless sounds that make up spoken words, coming together in different combinations to create new lexical items. So, ISL LEARN is distinguished from EAT by being articulated at a different location, and ISL ASK and SAY in Figure 2 are a minimal pair, distinguished by aspects of handshape.

Stokoe posited handshape, location, and movement as the three major categories of meaningless formational elements in ASL, each with a finite list of contrastive formational elements, to which we return in Section 2. Since then, a good deal of evidence has

**Figure 2** – ISL ASK and SAY, minimally distinguished by handshape



accrued for the existence of a phonological level of structure in sign languages, one which consists of categories and features (Liddell & Johnson, 1989), as well as constraints on their form and combination (e.g., Mandel, 191,; Battison, 198,; Sandler, 199,; Corina, 193,; Brentari, 198,; Sandler, 1999). Further, researchers found evidence for hierarchical organization of feature classes based on their behavior in assimilation and other phenomena (Sandler, 197,; 1989; Corind & Sagey, 1989). These constraints and processes hold on elements of form, irrespective of meaning, showing that sign languages have a meaningful and a meaningless level of structure, a characteristic that Hockett (1960) called 'duality of patterning' and proposed as a basic design feature of human language.

Although it is assumed that all sign languages have iconic roots – and it would be an inefficient visual language indeed that did not take advantage of this possibility – it has been shown that diachronically signs become less and less iconic (Frishberg, 1995). Over time, they become more restricted and symmetrical, and signs that once involved other parts of the body came to be represented as symbolic images conveyed only by the hands. The changes are in the direction of the self organization of a formal system of meaningless units.

But how does this process take place? More specifically, how does a language develop phonological categories? The answer to this question cannot be discovered empirically in spoken languages, as they are all very old. Even pidgin speakers have full command of the phonology of their millennia-old native languages. But sign languages arise anew whenever the right conditions are met – whenever a group of deaf people have an opportunity to gather

and communicate regularly. And as new languages, sign languages have much to teach us about the emergence of linguistic form.

Here we examine in detail the formational characteristics of signs in a new language – Al-Sayyid Bedouin Sign Language (ABSL) – and compare them to those of two other sign languages with different social histories, American Sign Langauge and Israeli Sign Language. Initial observation of vocabulary items signed by different people across the Al-Sayyid village revealed unexpected variation – both in the choice of lexical items and in the form of the same lexical item. Following up on this observation, we conducted a detailed analysis of the form of sign productions in isolation.

We focus on handshape in the present study, and describe our investigation, which confirmed our impression of considerable variation along most of the parameters involved in this category. By comparing sign productions with those of two other sign languages, we see a cline, with ABSL exhibiting the most variation in the formation of handshapes, ISL next, and ASL showing the least variation across signers. Taken together with other evidence, we hypothesize that ABSL signers are aiming for a holistic iconic image, and that discrete phonological categories are not yet robust in the language.

We begin with a description of ABSL in Section 1, and illustrate with some of the variation in sign production that was discovered in the broader ABSL research project (Aronoff et al., 2008; Sandler et al., 2009). We then turn to the study of handshape, coding and analyzing handshapes in 15 signs for ten signers in each of the three languages. Section 2 describes the handshape features of interest and the methodology is the topic of §3. Results and discussion follow, in §4. Alongside the variation in sign production, the ABSL team has also observed early indications of formal organization, and we describe some of these in this section. In Section 5, we consider some explanations for differences across languages, including language age, community size and other social characteristics. While our results suggest that ABSL has not yet formed discrete phonological categories, we see some evidence pointing in that direction, which we exemplify in Section 6. Section 7 is a summary and conclusion.

## 1. Al-Sayyid Bedouin Sign Language

The only languages that arise de novo with no model are sign languages, and we have much to learn by observing their early evolution. A sign language emerges whenever a community of deaf individuals is formed, and there are two different routes through which this happens (Meir et al., 2009). A common route is through establishment of schools for deaf children, where local sign languages (and sometimes foreign sign languages like French Sign Language in the case of ASL) together with home sign systems mingle to give rise to national sign languages. Most of the sign languages that have been well studied are deaf community languages of this kind, formed within the past 75 to 300 years. Another setting in which sign languages develop is that of relatively isolated communities with higher than average rates of deafness, where village sign languages are born. Meir et al. (2009) describe six village sign languages in different parts of the world in their survey of new sign languages, but there are many more.

The best known deaf community sign language that is new is Nicaraguan Sign Language (NSL), forged from home sign systems when deaf children were first brought together in a school in Managua in 1977. Research on this language has shown that systematic language structure arises when children were brought to the school at a young age, with older children using a more idiosyncratic system as a language model. Spatial modulation – the use of space to indicate the different grammatical roles in a sentence – is one way in which NSL gradually became more systematic at the morpho-syntactic level (Senghas, Coppola & Newport, 1997; Senghas, 2003).

The present study focuses on a young village sign language, ABSL. The language took root in the Al-Sayyid Bedouin village in the Negev Desert of present day Israel, when four deaf children were born in a single household about 75 years ago. Due to its insular social structure, consanguineous marriage patterns and high birth rate, genetic deafness spread in the population (Scott et al., 1995), and today, there are about 120-150 deaf people in the village. An indigenous sign language arose among the deaf people and is used by many of the hearing villagers as well (Kisch, 2000).

ABSL functions as a full fledged language, used for a range of social interactions, for instructions and plans, and to discuss such topics as personal histories, folk remedies, national insurance, childcare, or how to cajole a husband. The sentences of the second generation of ABSL signers are verb-final, with SOV word order in sentences with all three constituents, and noun-modifier order in noun phrases (Sandler et al., 2005).

While typical sign language morphological structures such as verb agreement and classifier predicate constructions have not been found to exist in this young language, a kind of size and shape classifier affixation is common across the village (Meir et al., to appear; Sandler et al., 2009).

The ABSL research team began to learn about the lexicon of this language as part of a dictionary project in which several hundred lexical items were recorded. This project had two surprises in store for the team. One was the degree of variation in lexical items themselves. Even signs for everyday items sometimes had several variants. There is, of course, a vocabulary of conventionalized signs, but this conventionalization seemed to the researchers to hold at the level of the overall image depicted by the sign. Aronoff et al. (2008) observed that across tokens produced by different signers there is variation in sublexical components, which, according to the authors' impression, is greater than what they would expect in more established sign languages, such as ISL and ASL. Moreover, tokens seem to vary across features that are potentially contrastive in established sign language. One example is variation in place of articulation found in different tokens for ABSL DOG. The example is repeated in Figure 3.

**Figure 3** – Variation in location across ABSL tokens for DOG.



(a) DOG          (b) DOG
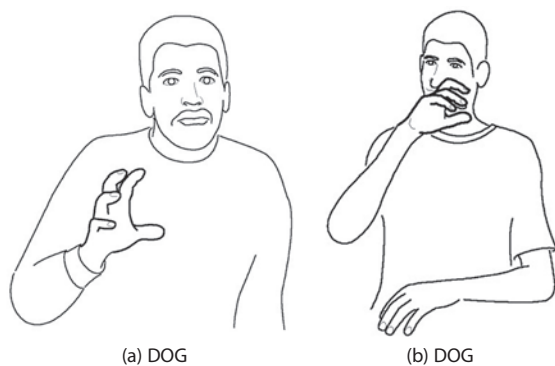
The variant in (a) is articulated in neutral space and the variant in (b) is signed in front of the mouth.[1]

Variation in ABSL such as illustrated above may be compared to variation in the pronunciation of the English word *route*, [rut] and [raut]. In the English example, we tend to associate the variation with different varieties or dialects. However, in the case of ABSL, the different signers whom we have recorded are members of the same extended family within a small, closely-knit community, and we suspect that variation is not 'sociolinguistic' in the normal sense

of subgroups within a language community. Rather, it seems to us that this variation is an indication that the ABSL lexicon has not yet developed discrete, meaningless formational categories. No minimal pairs have surfaced in all the recorded forms. In other words, we hypothesize that it takes time for users of a new language to converge on a relatively fixed set of primitives for forming lexical items.[2]

In fact, closer examination of productions of the sign DOG shows variation along all parameters, as reflected in Table 1, from Sandler et al. (2009).

Table 1 – variation across sublexical parameters in different productions of the ABSL sign DOG.

| | hand shape | orienta-tion | # hands | location | movement | # movements |
|---|---|---|---|---|---|---|
| Signer B | | Outward/ downward | 1 | Torso (low) | Closing (thumb restraint) | 2 |
| Signer A | | Contralateral sideways | 1 | Torso (high) | Curving | 1 |
| Signer M | | Contralateral sideways | 1 | Torso (mid) | Closing | 2 |
| Signer S | | Outward | 2 | Torso (mid) | Clawing | 2 |
| Signer I | | Contralateral sideways | 1 | Head (side of mouth) | Curving | 3 |
| Signer Mh | | Contralateral sideways | 1 | Head (center of mouth) | Clawing | 1 |
| Signer R | | Facing each Other (contra-lateral sideways) | 2 | Torso (mid) | Curving | 3 |
| Signer F | | Facing each Other (contra-lateralsideways) | 2 | Torso (mid) | Curving | 2 |
| Signer Sm | | Outward | 1 | Torso (mid) | Nodding (wrist) | 1 |
| Signer Z | | Outward | 2 | Head (near mouth) | Path Movement forward | 2 |

In order to test the hypothesis that distinct formational categories are not yet defined in ABSL, it is necessary to record and analyze the amount of variation at different points along the development of a language. We expect that the ongoing research on ABSL will provide us with insights into this issue as the language develops further. At present, we choose to use other, more established languages as points of reference against which variation in ABSL may be compared.

---

[1]  The figures are taken from Aronoff et al. (2008).

[2]  Models of linguistic communication proposed in a number of computational studies produce gradual convergence across different "language users" (see, for example, Barr, 2004; Hutchins & Hazlehurst, 1995)

The current study, taken from a larger project (Israel, 2009), focuses on one sublexical component – hand configuration. In the next section, we discuss briefly the internal structure of this component as a way of introducing the phonetic features that we will use for the coding of signs. This will be followed by a discussion on the measures of variation and the way to compare them across languages.

## 2. Sublexical structure in sign language: hand Configuration

As noted in the introduction, the most influential study in the field of sign linguistics was William Stokoe's analysis of the internal structure of signs in ASL. Stokoe (1960) was the first to show that signs could be broken into sublexical components, much as spoken words are analyzed as combinations of different sounds. In his analysis, Stokoe referred to three different parameters – hand configuration, location and movement – whose different specifications were proposed to be sign language analogues of phonemes. In other words, Stokoe showed that contrasts between different signs were made by substituting one sublexical component for another, similar to the way spoken words are distinguished by different consonants and vowels. Figures 1 and 2 above showed minimal pairs for location (the mouth for EAT and the forehead for LEARN) and for hand configuration ( in ASK and in SAY) in a different sign language, ISL.

Stokoe's unraveling of the systematic patterning of sublexical components in ASL led to widespread recognition of sign languages as bona fide human languages. That recognition motivated extensive research of sign language structure at all levels of organization. According to more recent accounts, noted above, sublexical components are organized in more complex structures, and each component has its own internal structure. In this study, we are concerned with variation in one complex component – hand configuration.[3] We begin by discussing the internal structure of hand configuration. The purpose of the discussion is to arrive at a set of features that may be used for a transparent coding of hand configuration which can capture phonetic variation.

A considerable portion of the sign language phonology literature has been dedicated to the lexical representation of hand configuration. Although the specific representation of this component is different across models, there is consensus among phonologists about certain generalizations that should be captured. A fundamental distinction is made between finger selection and finger position: while the position of the fingers may change within a sign, the selection of fingers remains fixed (Mandel, 1981), unless the sign is multimorphemic, in which case finger specification may change across morphemes (Sandler, 1989). This distinction is maintained in several models (Sandler, 1989; van der Hulst, 1993; van der Kooij, 2002; Brentari, 1998).

The first complex model of hand configuration was proposed by Sandler (1987; 1989). In that model, finger selection was represented by a set of five features – one for each finger. That is, if a certain handshape selects the index and middle fingers, then the underlying specification of finger selection for this handshape is [+thumb/+index]. This transparent form of representation comes at the expense of economy and explanatory power (cf. later proposals by Sandler 1995; 1996 and van der Kooij, 2002), but it serves well the purpose of representing phonetic variation, the current focus. In the coding of finger selection for the analysis of variation described below, we shall use the unary features [index], [middle], [ring], [pinky] and [thumb].

As for the position of the fingers, we distinguish between the four different degrees of flexion illustrated in Figure 4. The hand's anatomy allows for flexion at the Metacarpophalangeal joints (or, 'base joints') only, at the proximal and distal Interphalangeal joints (also referred to as the 'non-base joints') only, or at both base and non-base joints at the same time (Ann, 1996). The four positions in Figure 4 are examples for the four combinations of binary specifications for each type of joints.

**Figure 4** – Four flexion positions in handshapes with all the fingers selected.

The [extended] position has no flexion of the fingers; in a [bent] position, only the base joints are flexed; in a [clawed] position only the non-base joints are flexed; and in the [curved] position, base and non-base joints are flexed.



[extended]     [bent]     [clawed]     [curved]

---
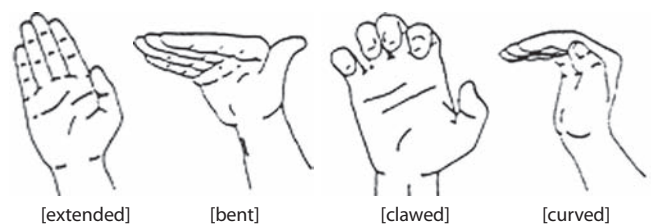
[3] The full study compares variation across the three languages in all three major categories, location and movement in addition to handshape (Israel, 2009).

A generalization which concerns the position of the unselected fingers was stated as the Unselected Fingers Constraint (Corina, 1993) in (1).

### 1. Unselected Fingers Redundancy Rule:

If the selected fingers are in a closed position, then the unselected fingers are open, as in 🖐 and 🖐; otherwise, the unselected fingers are usually closed, as in 🖐 and 🖐.

This generalization means that an underlying specification of the unselected fingers' position would be redundant. Still, there are cases in which the position of the unselected fingers is not predictable. For example, handshapes with contact between the thumb and the index finger as the only selected finger sometimes vary across signers, with the unselected fingers kept closed by some and open by others (🖐 🖐).

The position of the thumb is yet another feature which is considered redundant. In handshapes with less than all fingers selected, the thumb is often crossed over the closed unselected fingers (Figure 5a). If the position of the selected finger(s) changes from 'open' to 'closed' during the sign, the thumb will often be in an 'opposed' position (Figure 5b). In addition, some suggestions have been made regarding an 'extended' position of the thumb (Figure 5c). Battison et al. (1975) indentified six features associated with variation in the position of the thumb in ASL signs with the index finger or the index and middle fingers selected. Importantly, though, those phonological environments did not fully predict thumb position, as different signers produced different variants for the same signs. Battison et al.'s interpretation of that variation is that it reflects a process of diachronic change. Rules for the phonetic implementation of thumb position have also been proposed by van der Kooij (2002). In her model, the 'extended' position of the thumb is realized a) when the thumb itself is selected, or b) when the selected fingers are spread.

**Figure 5** – Thumb position features.



a. [crossed]       b. [opposed]       c. [extended]
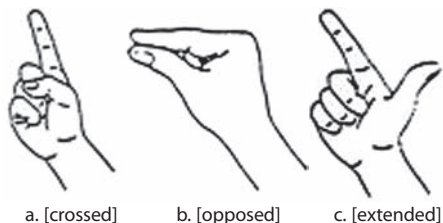
Another hand configuration feature is finger spreading. According to van der Kooij, a 'spread'

position of the fingers tends to occur in dynamic signs with all fingers selected, while in static signs fingers are mostly adducted (or, 'non-spread'). Again, this is a generalization; phonological context does not fully predict the surface form for this feature. For example, one of our ISL consultants did not accept a variant of the sign FISH – a dynamic sign with all fingers selected – in which fingers were in a spread rather than adducted position.

The last component of hand configuration to be presented is orientation. This component is used contrastively in sign languages that have been studied. An example from ISL of a minimal pair with different hand orientations is shown in Figure 6.

**Figure 6** – A minimal pair in ISL with two different orientations of the hand.



COMPARE                    VACILLATE
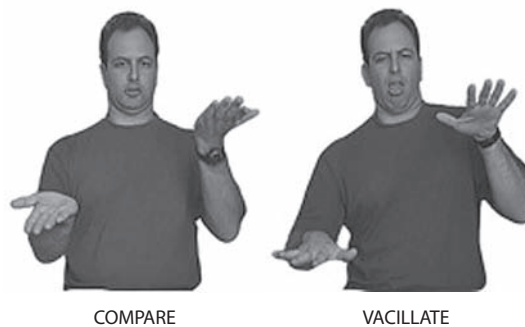
There is no consensus on how orientation should be represented in phonological models of sign language. The option which seems to account best for variation in this component refers to orientation in relative terms, for example by indicating the part of the hand which faces or contacts the place of articulation or that which faces the direction of movement (e.g., Mandel, 1981; Crasborn, 2001; Crasborn & van der Kooij, 1997). However, since in this study we are interested in capturing variation

**Figure 7** – degrees of freedom in the representation of orientation.

The figure shows the position of the hand in the ISL sign SUNDAY. The hand is oriented so that the metacarpal bones point upward (specified as [up]), and the palm faces the contralateral side (specified as [contralateral]), as indicated with solid arrows.

in form, representing orientation in absolute terms (i.e., in relation to the three dimensional space or to the signer's body) is more suitable. Therefore, we shall specify orientation with the following features: [up], [down], [in] (faces signer's body), [out] (faces away from signer), and [contralateral]. These features will used to specify two degrees of freedom: the side faced by the palm side of the hand and the direction in which the hand's metacarpal bones (i.e., the bones connecting the wrist and MCP joints) point, as illustrated in Figure 7.

Table 2 summarizes the subcategories of hand configuration and their respective features.

**Table 2** – Hand Configuration subcategories and features.

| Handshape | |
|---|---|
| Selected Fingers | [index], [middle], [ring], [pinky], [thumb], [*any combination of fingers*] |
| Flexion | [extended], [bent], [curved], [clawed] |
| Aperture | [open], [closed] |
| Spreading | [spread], [non-spread] |
| Unselected Fingers | [open], [closed] |
| Thumb | [extended], [opposed], [adducted], [crossed] |
| Orientation | [up], [down], [in], [out], [contralateral] |

As this study addresses convergence on the production of basic phonological elements, we are not concerned here with models of the internal organization of these features, which are based partly on the behavior of phonological elements in forms and rules.

## 3.Methodology

In order to determine whether there is indeed more blurring of possible category distinctions in ABSL than in other sign languages, we investigated sign productions in three sign languages: ABSL, ISL, and ASL. These languages have different histories and social structures, which bear on the issue under investigation. Ten signers from each group, each signing 15 signs, provide the data fo the study

### 3.1. Participants

#### *ABSL*

Ten ABSL signers participated in the study. The subject selection process took into consideration social structure and constraints within the Al-Sayyid community. Since deafness is genetically determined

in the village, and there is a good deal of first cousin marriage, it is common for deafness to be particularly widespread among close relatives, and indeed, the signers included in the study are members of an extended family, six of them members of the same immediate family. The reliance on sign language as the means of communication within the family ensured that the signers chosen are highly proficient in ABSL. A social constraint is imposed on women, who cannot be videotaped if the recording might be watched by men from the village. For those Al-Sayyid women who participated in the study, consented to participate with our reassurance that the recordings would be used for analysis in the lab only. The signers included in the study, then, are people who are comfortable working with investigators and are all highly proficient signers. There was a wide distribution of ages among the subjects: two second generation signers were between 40 and 50 years old at the time of videotaping; one signer was about 28 years old – a young second generation signer; of the third generation participants, fous were between 20 and 30 years od;, anst thres were between 7 and 12 years old. [ASSAF – SAY HOW MANY IN EACH GENERATION AND AGES]

While many hearing people know ABSL well and use it daily within deaf families, all ABSL participants in the study were deaf. The oldest two, Th. and A-B., were born in the second generation of deaf people in the Al-Sayyid village. The rest of the participants represent the third generation of deaf people, all of whom are attending school in a nearby village, where some ISL signs are used by the teachers. At school, children from Al-Sayyid interact with deaf children from other villages in the area. However, neither the majority of second generation deaf people nor the hearing signers in the Al-Sayyid village have direct exposure to ISL or other signs from other areas, and we infer from this that the communication among family members takes place in ABSL. In the study, each signer signed to another ABSL signer while being videotaped.

In order to compare variations across the three sign languages, group sizes were balanced, so that each of the ISL and ASL groups also numbered 10 signers each.

#### *ISL*

All 10 ISL participants were deaf signers. The ISL group was formed in such a way that it would be as analogous as possible to the ABSL group, both linguistically and socially. Thus, all ISL participants

were from the same small geographic area, the city of Haifa. This was intended to result in data that are maximally lexically unified.[4] In addition, of the 10 participants, four were members of a single immediate family (cf. the six same-family members in ABSL), two of them one generation older (the two parents), aged 45 and 50. The ages of the other participants were 40, 38, 37, 32, 21, 21, and 14. All ISL participants have had formal education.

### *ASL*

The group of ASL signers was less homogenous than the other two language groups. All 10 participants were "recruited" while spending leisure time on the University of California, San Diego campus.[5] All, except for a single participant (who acquired ASL from a deaf parent), were deaf, and the only requirement for participation was a perceived high level of ASL proficiency. No information regarding participants' (original) area of residence, educational background, etc. was collected. The ages of the two youngest participants are between 20 and 30 years (the exact ages were not recorded). The other participants were 32, 33, 35, 41, 42, 43 and 54 years old. All the participants started learning to sign by the age of six, with three participants acquiring sign language from deaf parents.

### 3.2. Stimuli and procedure

Citation forms were elicited from participants using pictures of objects presented on a computer screen using Microsoft Powerpoint software. The pictures presented single objects with which participants were undoubtedly familiar, such as common animals, furniture, types of vehicles, fruits, etc.

During the elicitation procedure, each participant was seated opposite another signer of the same language, and next to the computer used for the presentation of pictures. Participants were instructed to look at the computer screen and then to sign to their interlocutors their sign(s) for the presented object. During the entire procedure, the presentation of pictures on the screen was controlled by a researcher, so that one picture was presented at a time, and the next picture was presented after the sign

was produced clearly and to his/her satisfaction by the participant. Since the younger ABSL participants knew some ISL, they were explicitly asked to use only their native (i.e., ABSL) signs. If a participant produced an ISL sign, he or she was asked to sign again, using the local sign.

The total number of elicitation pictures presented to each signer was 35. Of the total number of elicited signs, only 15 were analyzed for variation, for several reasons. First, there were cases in which ABSL signers did not seem to remember or know the sign for the presented object, and instead produced sequences of signs with related meanings, such as KNOBS FLAMES OPEN-DOOR TRAY to refer to STOVE. Some of these combinations were lexicalized as compounds.[6] Lexicalized sequences often consisted of reduced forms of individual signs, which were unsuitable for a valid analysis of sublexical composition of the individual signs. For example, reduction is known to be related to stress pattern, and unstressed syllables in multisyllabic signs are often displaced and become temporally shorter (Sandler & Lillo-Martin, 2006). We have not seen simplex words of more than one syllable in the language, and we make the assumption that when monosyllabic signs are produced in isolation, their surface forms more accurately reflect their underlyingly form. We therefore chose for the analysis only signs that were monosyllabic.[7] A restriction on the choice of signs in the ASL data was imposed by the fact that many responses were fingerspelled.[8] These were treated as phonologically different and excluded from the analysis. Finally, in

---

[4] Naturally, there are regional lexical differences in ISL, and some 'concepts' have different signs representing them in different areas. We attempted to avoid lexical variation by choosing signers from the same area.

[5] We are grateful to Carol Padden and Deniz Ilkbasaran for collecting the ASL data used in this study.

[6] Meir et al. (to appear) use four criteria to distinguish compounds from other sequences of signs. Compounds are sequences that represent a single concept, are identical across at least some signers and have at least two components in common with other sequences produced for the same referent. In addition, their production is natural and flowing (as opposed to the hesitated signing which characterizes the on-line construction of new sequences).

[7] The notion of 'syllable' in sign language has been entertained in several models and shown to be a real phonological entity (for a comprehensive discussion of this issue see Sandler & Lillo-Martin, 2006). The syllable is identified with a single movement event (of any single type or simultaneous combination of movement types – but not a sequence of movements), analyzed as a syllable nucleus in some models (e.g., Sandler, 1989; Perlmutter, 1993; Brentari, 1998).

[8] Fingerspelling is the use of handshapes which represent letters of the alphabet to spell a word borrowed from a spoken language. It is a system which is phonologically distinct from signing, although fingerspelled words may ultimately undergo formational modifications to adhere to the phonological constraints of the system of signs. Lexicalized fingerspelled forms seem to be especially common in ASL.

each data set, and especially in ABSL, there were a few sets of tokens that varied lexically. For example, in ABSL, some participants signed HORSE with a gesture representing the bit part of a bridle (a 🤏 handshape with the thumb and the index finger pressed against each side of the signer's face across an open mouth); other ABSL signers signed HORSE with an upside-down 🖖 handshape "mounted" on a 🤚 to represent a man sitting on a horse. Such lexical variation found in a set of tokens rendered it unsuitable for analysis of sublexical variation, and signs that were lexically different were not included in the comparison.

The list of 15 lexical items represented by the data collected is given in Table 2. The first 11 items are shared by all three language sets, and the remaining 4 items overlap only partly, because of the constraints just mentioned. In any case, a lexical match of the three language sets is of no real methodological import, because of the arbitrariness of the form-meaning relation in language. What matters is sublexical variation for the same form in a given language.

**Table 2** – The lexical items represented in the collected data.

Items 1 – 11 were elicited from signers of all three languages and are listed in the same central column. Since in each language four of the items elicited were not shared by both other languages, these items (12 – 15) are listed in a separate colum).

| Item number | ABSL; ISL; ASL | |
|---|---|---|
| 1 | LEMON | |
| 2 | SCORPION | |
| 3 | TOMATO | |
| 4 | CARROT | |
| 5 | COW | |
| 6 | DONKEY | |
| 7 | FORK | |
| 8 | LEAF | |
| 9 | DOG | |
| 10 | GOAT | |
| 11 | TRAIN | |
| | **ABSL** | **ISL** | **ASL** |
| 12 | WOMAN | TELEVISION | WOMAN |
| 13 | BROOM | BROOM | EGG |
| 14 | STUFFED GRAPE LEAVES | FLOWER | FLOWER |
| 15 | GARLIC | CUCUMBER | CAT |

## 3.3. Measuring variation

Naturally, variation cannot be compared across different lexical items. It makes no sense to look at the difference (i.e., variation) between surface realizations produced for different target representations. If one signer represents whiskers for the concept 'cat' and another represents 'cat' as licking the paws, these are two different lexical items, and not suitable for comparison of sublexical variation. tThe essence of variation is the existence of different variants of the *same* item, which, in our case (i.e., at the sublexical level), is a single lexical item. Therefore, for each language, variatioisshould be measured first for each of the 15 lexical items separately, and only then can we combine these measures to get an indication of the amount of variation at a more global level. This methodology is outlined belo.. [WHAT DOES THIS LAST SENTENCE MEAN ACTUALLY? HOW ELSE WOULD IT BE MEASURED?]

For the analysis, we choose to use two measures which we believe capture the essence of variation in a way that is both transparent and simple. These measures correspond to two important aspects of variation: the range of the distribution and the extent to which the data are concentrated or spread within this range. In Statistics, when measuring the value of a variable along a continuous scale (e.g., from 0 to 100), the range is the difference between the highest and lowest observed values. Recall that in the current analysis, for each token, the hand configuration component is specified in terms of discrete phonetic features which cannot be considered in terms of higher or lower values. This method of coding is comparable to specifying the features [high] [mid] and [low] for vowels, rather than measuring their formant frequencies, since features are discrete whereas frequency is measured along a continuous scale. Therefore, for our purposes we may define the range of variation in hand configuration as the number of different features found across tokens. To make things clear, let us consider a hypothetical situation in which we have two different sets of ten tokens for the sign FORK. For each set of tokens, Figure 8 shows a distribution of features within the subcategory Selected Fingers. We can see that in the first set of tokens (represented by Distribution A) there are two different finger selections: [I+M] (🖐) and [I+M+R] (🖖). In the other set of tokens (represented by Distribution B) there are three different finger selections, [IMR], [IM] and [I] (as in 👆). In other words, there are two different variants of SF in the first set

**Figure 8** – Different amounts of variation indicated by the number of variants.

Distribution A

|  | Signer A | Signer B | Signer C | Signer D | Signer E | Signer F | Signer G | Signer H | Signer I | Signer J |
|---|---|---|---|---|---|---|---|---|---|---|
| Category Selected Fingers | I+M | I+M | I+M+R | I+M | I+M | I+M+R | I+M | I+M | I+M | I+M |

Distribution B:

|  | Signer A | Signer B | Signer C | Signer D | Signer E | Signer F | Signer G | Signer H | Signer I | Signer J |
|---|---|---|---|---|---|---|---|---|---|---|
| Category Selected Fingers | I+M | I+M | I+M | I+M | I+M+R | I+M | I+M | I | I+M | I+M |

of tokens and three variants of SF in the second set. That is, the range of variation in SF is wider in the second distribution. The number of different features found within a set of tokens is therefore an indicator of the range of a distribution. We shall refer to this measure as the *number of variants*.

The other measure we will use provides information about the spread (or dispersion) of a distribution. This is the number of tokens with the most frequent feature. Consider the distributions in Figure 9. Since in each distribution there are two different features realizing the SF category, both distributions have the same range of variation (*number of variants* = 2). However, in Distribution A, eight out of ten tokens have the same feature set [I+M], whereas in Distribution C the two feature sets are distributed more equally across tokens: six tokens have the feature [I+M] and four tokens have the feature [I+M+R]. We may say that in Distribution C tokens are more "spread out" – i.e., they vary more – compared

to tokens in Distribution A. The frequency of the modal feature – i.e., the number of tokens in which the most frequent feature is found – is therefore an important measure of variation. For convenience, we shall refer to this measure as the *mode* (for further discussion of the advantages and disadvantages of this method, see Israel, 2009).

Beyond the single lexical item: a global measure of variation

The ultimate aim of this study is to use the feature by feature assessment of variation described above to arrive at a more global measure of sublexical variation within a language. The first step is to combine the measures of each type calculated for all lexical items by calculating the average mode value and average number of variants for all lexical items within the same language for a given phonological category, as exemplified with hypothetical data in Table 3.

Recall that the first stage in the analysis was to calculate the mode for each lexical item separately.

**Figure 9** – Different amounts of variation idicated by the frequency of the modal feature.

Distribution A:

|  | Signer A | Signer B | Signer C | Signer D | Signer E | Signer F | Signer G | Signer H | Signer I | Signer J |
|---|---|---|---|---|---|---|---|---|---|---|
| Category Selected Fingers | I+M | I+M | I+M+R | I+M | I+M | I+M+R | I+M | I+M | I+M | I+M |

Distribution C:

|  | Signer A | Signer B | Signer C | Signer D | Signer E | Signer F | Signer G | Signer H | Signer I | Signer J |
|---|---|---|---|---|---|---|---|---|---|---|
| Category Selected Fingers | I+M | I+M | I+M | I+M+R | I+M+R | I+M | I+M | I+M+R | I+M | I+M+R |

**Table 3** – Average mode and average number of variants as global measures of variation.

| Category X | Item 1 | Item 2 | Item 3 | Item 4 | Item 5 | Item 6 | Item 7 | Item 8 | **Average** |
|---|---|---|---|---|---|---|---|---|---|
| Mode (%) | 95 | 80 | 100 | 87 | 80 | 93 | 84 | 100 | **89.88 %** |
| Number of variants | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | **1.63** |

In the above table, 95 represents the mode of the set of tokens produced for Item 1, 80 was the mode of all the tokens elicited for Item 2, etc. Once the averages of all the modes and numbers of variants have been calculated, we will already have reached a more global representation of variation, since for each phonological category we are left with two measures per language: (1) *average mode* and (2) *average number of variants*. Now it is possible to compare the values of each of the two measures of variation across languages. For example, if the average mode calculated for Thumb Position is 90 for language A and 95 for language B, we may say that with respect to this measure of variation, language A shows more variation in thumb position than language B. The two languages will also have to be compared with respect to the average number of variants.

Going one step up the phonological hierarchy, the average measures calculated for subcategories may be considered together in order to characterize the degree of variation within each of the three major categories. This, again, may be done by calculating an average. That is, we will calculate an average from the averages of each of the seven HC subcategories.

## 4. Results

Using the methodology outlined in the previous section, the study revealed a consistent ranking across the three language groups with respect to the amount of variation in hand configuration features across tokens. As can be seen in Figure 10, in all subcategories of this component, with the exception of Finger Spreading, mode values were lowest in the ABSL data and highest in the ASL data. That is, as indicated by this measure and the data collected for this study, for each subcomponent of Hand Configuration, the amount of variation is greatest in ABSL and ASL is the least variable.

This picture of the differences across the three languages is made clearer by the second measure of variation – the number of variants. Figure 11 shows that in four of the seven hand configuration subcategories the same relative ranking was found,
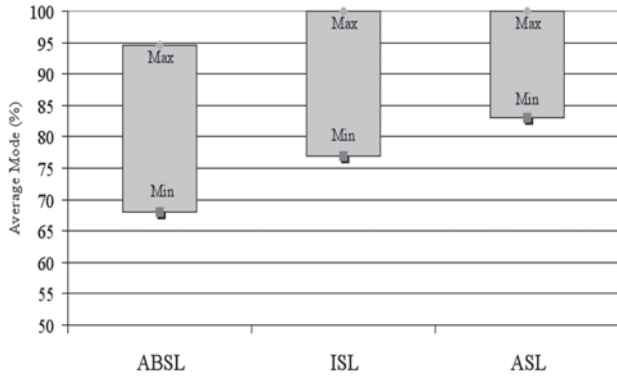
with the number of variants being highest in ABSL and lowest in ASL. Within the Flexion subcategory, the highest amount of variation was also found in ABSL, but no difference was found between ISL and ASL. The highest average number of SF variants was the same in ABSL and ASL. The general ABSL > ISL > ASL pattern was reversed for one category: Spread Fingers. Altogether, ABSL showed more variation than the other two languages on all measures, with one exception, Spreading.

In order to check whether the differences found are statistically significant, A Kruskal-Wallis test was performed on the data. A highly significant difference was found between the degree of variation in thumb position in ABSL and those measured for ISL and ASL. This was found for both the mode measure ($p<0.001$) and the number of variants ($p<0.01$).
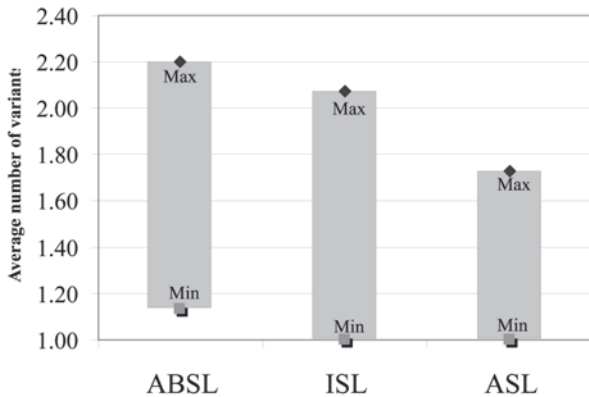
An instructive form of representation of the differences across ABSL, ISL and ASL is given in Figure

**Figure 10** – Average mode values within Hand Configuration subcategories.
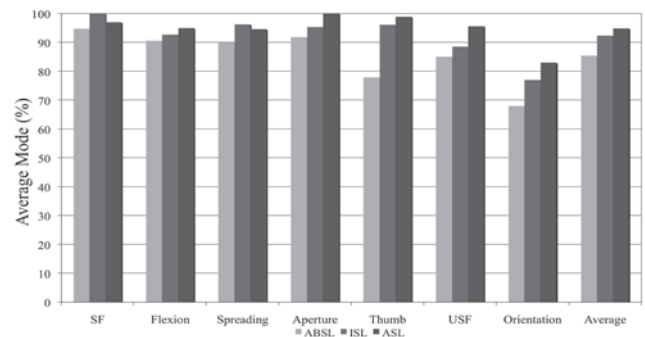


**Figure 11** – Average number of variants within each subcategory of Hand Configuration.
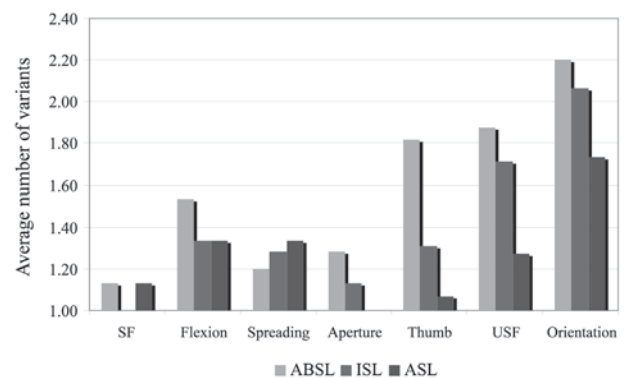
**Figure 12** – Ranges of average mode values.



**Figure 13** – Ranges of average number of variants.



**Figure 14** – Examples of hand configuration variation in ABSL.



[Index]   [Index+Middle]

(a) STUFFED GRAPE LEAVES (variation in finger selection)

[crossed]   [extended]

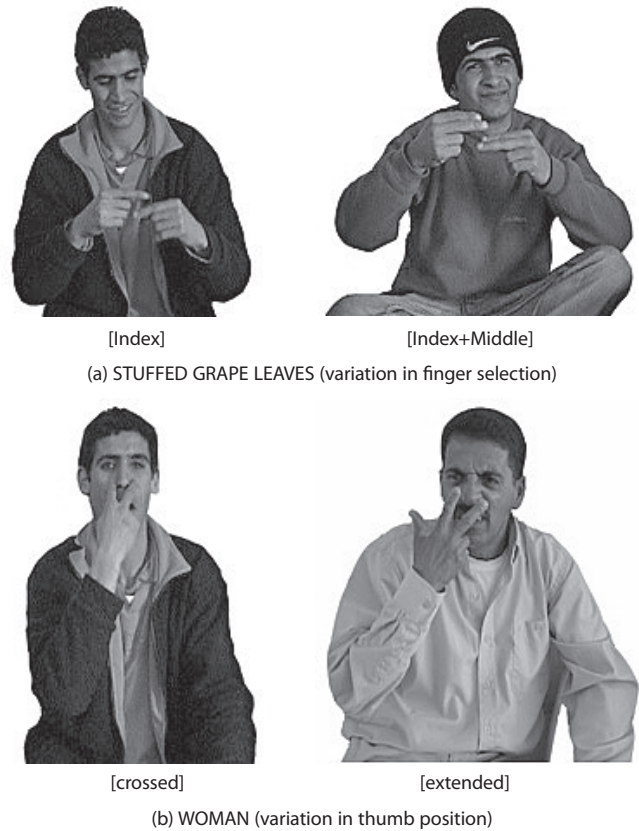(b) WOMAN (variation in thumb position)

12 and Figure 13. This representation shows for each language the range of average mode values and the average number of variants presented in Figure 10 and Figure 11 above.

The range measure clearly shows the differences among the three languages with respect to both the size of the range and its location along the Y-axis. As for the mode, in ASL, its values are distributed within the smallest range, about 17 percent. Like ASL, ISL's maximum value is 100 % (representing a subcategory with zero variation), but its range of average modes is wider – about 23%. Finally, ABSL's average modes spread over about 27 %. Moreover, unlike ASL and ISL, none of the average modes calculated for ABSL reached 100 %. In other words, there was not a single subcategory of Hand Configuration in which there was no variation across ABSL signers. Figure 13 shows similar differences in the range of average numbers of variants. Examples of variation in ABSL are shown in Figure 14.

The analysis of variation shows that, in ABSL, ISL and ASL, different tokens may vary along the sublexical features of hand configuration listed in Table 1. Interestingly, when both measures of variation – the mode and number of variants – are considered, a robust pattern emerges: the amount of sublexical variation is largest in ABSL and smallest in ASL, with ISL in between the two. The fact that this pattern was found in the majority of subparameters of hand configuration suggests that these different amounts of variation reflect some fundamental difference across the three languages. This idea is further supported by results from two additional analyses of variation along features of location and movement – the two other major parameters of sublexical form. Using the same methodology, Israel (2009) found the same cross-linguistic pattern of variation, namely ABSL > ISL > ASL, for both Location and Movement. It is therefore not only the Hand Configuration component which varies to different extents, but the entire form of lexical items.[9]

Assuming that all languages eventually develop lexicons with highly conventionalized forms of items, the results reported here suggest that ABSL, ISL and ASL are currently situated at different points along this conventionalization continuum. In the next section we discuss the possible contributions of four different factors to the development of regularity in new languages.

---

9 In this study we did not include non-manual components, such as facial expressions and mouthing, which in some languages may be part of the lexicalized form.

## 5. Three different sociolinguistic backgrounds

We would like to put forth the hypothesis that, in the early development of a sign language, an aggregate of sociolinguistic factors affects the convergence of signers on a relatively fixed set of forms used as lexical items. Underlying this hypothesis is the assumption that convergence – i.e., transition from more to less variation – is universal and characterizes all cases in which a new language emerges. Intuitively, it does not seem possible for a new language to exhibit the degree of regularity found in well-established languages at the outset. In each case of language emergence, however, the social and linguistic settings, which obviously have an impact on the way language develops, are unique. Our hypothesis incorporates the following factors: a) relation to other languages, b) the language's age, c) the size of the community, and d) the existence of prescriptive norms. In this section we discuss the possible influence of these factors and relate it to the case at hand.

A new language may come to life in one of two settings: within a community whose members have no language at all, and within a community whose members use different languages but none of which is shared by all. The languages that emerge in settings of the latter type are known as Pidgins and, when passed on to children, as Creoles. Even though these languages are fundamentally distinct from any of the languages used natively by the original members of the community, there is no doubt that some grammatical elements are borrowed from native languages into the pidgin/creole (e.g., McWhorter, 1997). This means that, compared to a language developed by people who know no language at all, pidgins and creoles get a head start.

The study of ISL and ASL has shown that both of these languages developed in ways that resemble pidginization and creolization, with contributions from German Sign Language, and other sign languages of Europe, North Africa, and elsewhere in the case of ISL (Meir & Sandler, 2008), and influence from French Sign Language and local American varieties in the case of ASL (Woodward, 1978; Fischer, 1996). Therefore, in both cases, at the outset, there were experienced signers who had been using signs skillfully and consistently. That experience must have been carried over into the new language, and signers presumably did not lose their intuition about the system which underlies sign production, even

when the forms themselves were new to them. In contrast, ABSL has emerged in a relatively isolated community and for many years was developed by deaf people who had no knowledge of any other language. It is reasonable to believe that for such signers it takes longer to converge on a single form for each concept.

If conventionalization is indeed gradual, then we expect forms to be produced more consistently across signers as the language gets older. A language's age may be measured not only in years but also in the number of generations of users that have acquired it. Young children have the capacity to acquire and build upon the language as it is passed on to them from a previous generation, as in the case of Nicaraguan Sign Language mentioned above. It is likely that children play an important role in the process of convergence by taking the language a step closer to fully conventionalized production of lexical items. In our case, ASL is the oldest language, which, according to our hypothesis, explains the fact that it exhibits the lowest amount of sublexical variation. However, since ABSL and ISL are of the same age but vary to different extents, it is clear that this factor by itself cannot predict differences in the amount of variation.

The size of the community in which a language develops may be another factor affecting the amount of variation. Trudgill (1995) suggests that within a small and isolated community there is likely to be a large amount of shared information, and so variation is more easily tolerated. This may well be the case within the community of Al-Sayyid. When much of the background information is shared by interlocutors, it may be sufficient for a signer to produce a token that approximates the overall image which is conventionally associated with the target concept in order for communication to succeed.

Metalinguistic awareness may have a strong impact on language production. One aspect of such awareness is the idea that some forms are "better" or "more appropriate" than others, and that certain forms are "correct" and others are "incorrect". Usually, these concepts are shaped by authoritative sources, such as schools, books, interpreters, and other influential individuals, often associated with formality. On this basis, it is reasonable to distinguish between languages used in formal settings, such as ISL and ASL, and languages whose users are not subject to prescriptive pressure because it is never used formally, such as ABSL. Thus, in both the ISL and ASL communities there are Deaf organizations which

organize formal meetings and sign language courses; members of the community meet in Deaf clubs; there exist dictionaries of both languages; there are Deaf theater and dance groups; and, finally, following linguistic studies on both languages, the status of both languages – mainly within, but also outside the Deaf communities – has improved considerably. The existence of prescriptive norms in ISL and ASL may have affected the way signs are produced. In both communities, dictionaries sign language instruction, and interpreter training programs exist, which may have the effect of establishing norms to some extent. Such norms may in turn considerably reduce the variety of alternate forms, thus pushing towards more consistent signing. In the ASL community, the normative sources just mentioned have longer histories and are therefore more established compared to ISL, which could partly explain the differences in the amount of variation found between the two. In Al-Sayyid, where deaf people are fully integrated into the larger hearing community, none of these sociocultural developments has taken place, and, to the best of our knowledge, the language is only used informally.[10]

We propose that all of the sociolinguistic factors just discussed played a role in the cross linguistic differences found in this study. Table 4 shows that each language has a different aggregate of these factors. According to the discussion in this section, the sum of factors is most conducive to convergence in ASL and least conducive to convergence in ABSL.

The hypothesis developed above is motivated by the amounts of variation measured in this study. In order to test this hypothesis further, it is necessary to measure variation in additional sign languages with different aggregates of sociolinguistic factors. We leave this investigation for future research.

Table 4 – A summary of cross-linguistic differences along sociolinguistic parameters.

|  | ABSL | ISL | ASL |
|---|---|---|---|
| Contribution from other languages | - | + | + |
| Age | ~75 | ~75 | ~200 |
| Population size | ~150 | ~10,000 | ~500,000 |
| Prescriptivism | - | + | + |

---

[10] A dictionary of ABSL signs is being compiled at the Sign Language Research Lab in Haifa. At this point, however, the dictionary is not available to ABSL signers.

## ▬▬ 6. Seeds of phonological form in ABSL

ABSL is a language by any functional measure. Conversations about any topic relevant to the community take place in real time with no apparent effort or hesitation. Humor is conveyed, stories are told. There is a shared vocabulary. Even the variation that we find in the lexicon is apparently well tolerated if ease of communication is any indication, possibly suggesting that the language simply has synonyms.

It is at once fascinating and surprising to discover that a fully functional language appears to have fewer conventionalized grammatical resources than other more familiar and more established sign languages (see Aronoff et al., 2008 for an overview). But a closer look has revealed both a certain amount of grammatical structure to support the system, as well as the kernels of grammar in several areas. At the syntactic level, though sentences are typically short, strict word order within the clause is in place from the beginning, showing that marking grammatical relations between the predicate and its arguments and between nouns and their modifiers is a fundamental ingredient – perhaps the most fundamental ingredient – in human language (Sandler et al., 2005).

Other aspects of grammar are observably in the process of becoming systematic. For example, productive ways of increasing the vocabulary are in place, although much less regular in form than the word order just described. Size and shape compounding or affixation is a widespread word formation strategy, as is compounding in general (Meir et al., to appear). In addition, a prosodic system that demarcates constituents and signals dependencies among clauses is developing, a system that is already much more regular and systematic among young adults of the second generation than among those even twenty years older in the same generation (Sandler et al., to appear).

When it comes to phonology, alongside the kind of indeterminacy indicated by the present study, we also see the seeds of a formal system taking root. Evidence for the formation of phonological categories will come, not only from minimal pairs and sharp production of discrete forms, but also from the participation of such units in processes in the language which are related to form only, and not to meaning. A typical example is assimilation. In established spoken and signed languages, phonological assimilation is a regular process, in which some set of units take on characteristics of neighboring units under specific conditions. Nasal

assimilation in English involves the formal categories nasals and stops, and the direction of assimilation is regressive. All of these are formal properties, unrelated to meaning.

Assimilation has been observed in ABSL under certain conditions, spelled out in Sandler et al. (2009). Although not yet general across the community, these instances suggest the beginning of a formal system. One example is found within a single family. Because we have noticed that vocabulary is less varied within families with several deaf people, we have coined the term **familylect** to describe this sociolinguistic entity. In one familylect, whose members are a deaf mother and five deaf children, we find assimilation in a lexical compound. The compound CHICKEN^OVAL-OBJECT, meaning EGG, is lexicalized across the village, but the assimilation takes place only as signed by this family.

CHICKEN is produced with the index finger in a curved shape, palm oriented downward, and the hand bending at the wrist twice, apparently motivated by the beak of a chicken pecking for food. The sign for SMALL-OVAL-OBJECT is produced with three spread fingers, the palm oriented up. The hands for the basic compound are shown in Figure 15a. In the familylect's assimilated version, the finger selection for the second sign assimilates regressively to the first sign, CHICKEN. Figure 15b shows the hands for the sign, EGG signed in a familylect. The deaf mother and all three of her deaf daughters whom we recorded all signed the 'CHICKEN' part of the compound with the same assimilated form. Since they all signed it the same way, we assume that the assimilated form is lexicalized in this familylect. Crucially, the assimilation is a purely formal process in which the hand configuration of the second member of the compound spreads to the first. Note that the result is less iconic than the basic form, as chicken beaks are pointed and not oval-shaped.

Alongside the presence of indeterminate phonological categories in this new language, we are beginning to see the buds of a system at the sublexical

level. This and other closely observed phenomena show us how ABSL is moving toward phonological organization.

## 7. Summary and conclusion

This study has shown that sign languages differ in terms of the amount of variation in the form of sign production exhibited across a community. The amount of variation in the category of handshape in a new language with little outside influence is shown to be greater for nearly all subcategories of that class than in languages with different social histories. In particular, we find a cline of regularity in form across ABSL, ISL, and ASL, such that ABSL shows the most variation, ISL next, and ASL shows the least amount of sublexical variation. These and other related results (Israel, 2009; Sandler et al., 2009) lead us to suggest first that, while ABSL functions fully as a language and has certain grammatical regularities, it has not yet developed robust phonological categories. Differences in social factors such as language age, size of a community, and formal norms that hold between ABSL, ISL, and ASL, are hypothesized to contribute to convergence in language form.

## Reference

1. Ann, J. (1996). On the Relation between Ease of Articulation and Frequency Occurrence of Handshapes in Two Sign Languages. *Lingua, 98*(1-3), 19-42.

2. Aronoff, M., Meir, I., Padden, C. A., & Sandler, W. (2008). The Roots of Linguistic Organization in a New Language. *Interaction Studies, 9*, 133-153.

3. Barr, D. J. (2004). Establishing Conventional Communication Systems: Is Common Knowledge Necessary? *Cognitive Science: A Multidisciplinary Journal, 28*(6), 937-962.

4. Battison, R. (1978). *Lexical Borrowing in American Sign Language*. Silver Spring: Linstok Press.

5. Battison, R., Markowicz, H., & Woodward, J. (1975). A Good Rule of Thumb: Variable Phonology in American Sign Language. *Analyzing variation in language*, 291-302.

6. Brentari, D. (1998). *A Prosodic Model of Sign Language Phonology*. Cambridge, MA: MIT Press.

7. Corina, D. (1993). To Branch or Not to Branch: Underspecification in Asl Handshape Contours. In G. Coulter (Ed.), *Current Issues in Asl Phonology* (Vol. 3, pp. 63-95). New York, San Francisco, London: Academic Press.

8. Corina, D., & Sagey, E. (1989). *Are Phonological Hierarchies Universal? Evidence from American Sign Language*. Paper presented at the ESCOL.

9. Crasborn, O. (2001). *Phonetic Implementation of Phonological Categories in Sign Language of the Netherlands*. Unpublished PhD dissertation, Leiden University.

10. Crasborn, O., & van der Kooij, E. (1997). `Relative orientation in sign language phonology'. In J. Coerts & H. de Hoop, eds., Linguistics in the Netherlands 1997. John Benjamins, Amsterdam.

11. Fischer, S. D. (1996). By the Numbers: Language-Internal Evidence for Creolization. *International Review of Sign Linguistics, 1*, 1-22.

**Figure 15** – (a). Two handshapes for the compound CHICKEN^OVAL-OBJECT = EGG, standard form. (b). Consistent assimilation of handshape in EGG within a familylect.

12. Frishberg, N. (1975). Arbitrariness and Iconicity: Historical Change in American Sign Language. *Language, 51*, 696-719.

13. Hockett, C. F. (1960). The Origins of Speech. *Scientific American, 203*, 89-96.

14. Hutchins, E., & Hazlehurst, B. (1995). *How to Invent a Lexicon: The Development of Shared Symbols in Interaction*. London: University College Press.

15. Israel, A. (2009). *Sublexical Variation in Three Sign Languages*. Unpublished M.A. thesis, University of Haifa.

16. Kisch, S. (2000). *Deaf Discourse: Social Construction of Deafness in a Bedouin Community in the Negev*. Unpublished MA thesis, Tel-Aviv University.

17. Liddell, S. K., & Johnson, R. E. (1989). American Sign Language: The Phonological Base. *Sign Language Studies, 64*, 195-278.

18. Mandel, M. (1981). *Phonotactics and Morphophonology in American Sign Language*. Unpublished PhD Dissertation, University of California, Berkeley.

19. McWhorter, J. H. (1997). *Towards a New Model of Creole Genesis*. New York: Peter Lang.

20. Meir, I., Sandler, W., Padden, C., & Aronoff, M. (2009). Emerging sign languages. In *Oxford Handbook of Deaf Studies, Language, and Education*, Volume 2. M. Marschark and P. Spencer (Eds.).

21. Meir, I., Aronoff, M., Sandler, W., & Padden, C. (to appear). Sign Languages and Compounding. In S. Scalise & I. Vogel (Eds.), *Compounding*: John Benjamins.

22. Meir, I., & Sandler, W. (2008). *A Language in Space: The Story of Israeli Sign Language*: Lawrence Erlbaum Associates.

23. Perlmutter, D. (1993). Sonority and Syllable Structure in American Sign Language. In G. Coulter (Ed.), *Phonetics and Phonology Vol. 3. Current Issues in ASL Phonology*. San Diego, CA: Academic Press.

24. Sandler, W. (1987). *Sequentiality and Simultaneity in American Sign Language*. Unpublished PhD Dissertation, University of Texas, Austin.

25. --------- (1989). *Phonological Representation of the Sign: Linearity and Non-linearity in American Sign Language*. Dordrecht: Foris.

26. --------- (1995). Markedness in the Handshapes of Signs: A Componential Analysis. In J. v. d. Weijer & H. v. d. Hulst (Eds.), *Leiden in Last: Holland Institute of Linguistics Phonology Papers* (pp. 369-399). The Hague: Holland Academie Graphics.

27. --------- (1996). Representing Handshapes. *International Review of Sign Linguistics, 1*, 115-158.

28. --------- (1999). Cliticization and Prosodic Words in a Sign Language. In T. Hall & U. Kleinhenz (Eds.), *Studies on the Phonological Word* (pp. 223-254). Amsterdam: Benjamins.

29. Sandler, W., Aronoff, M., Meir, I., & Padden, C. (2009). The Gradual Emergence of Phonological Form in a New Language: Ms. University of Haifa, Stony Brook University, and University of California San Diego.

30. Sandler, W., Meir, I., Dachkovsky, S., Aronoff, M., and Padden, C.. to appear. The emergence of complexity in prosody and syntax. Shinichiro Ishihara (ed.), special issue of *Lingua* on prosody and syntax.

31. Sandler, W., & Lillo-Martin, D. (2006). *Sign Language and Linguistic Universals*. Cambridge, UK: Cambridge University Press.

32. Sandler, W., Meir, I., Padden, C., & Aronoff, M. (2005). The Emergence of Grammar: Systematic Structure in a New Language. *Proceedings of the National Academy of Sciences, 102*(7), 2661-2665.

33. Scott, D. A., Carmi, R., Elbedour, K., Duyk, G. M., Stone, E. M., & Sheffield, V. C. (1995). Nonsyndromic Autosomal Recessive Deafness Is Linked to the Dfnb1 Locus in a Large Inbred Bedouin Family from Israel. *American journal of human genetics, 57*(4), 965.

34. Senghas, A. (2003). Intergenerational Influence and Ontogenetic Development in the Emergence of Spatial Grammar in Nicaraguan Sign Language. *Cognitive Development, 18*(4), 511-531.

35. Senghas, A., Coppola, M., Newport, E., & Supalla, T. (1997). Argument Structure in Nicaraguan Sign Language: The Emergence of Grammatical Devices. In E. Hughes, M. Hughes & A. Greenhill (Eds.), *The Proceedings of the Boston University Conference on Language Development* (Vol. 21, pp. 550-561). Boston: Cascadilla Press.

36. Trudgill, P. (1995). Dialect Typology: Isolation, Social Network and Phonological Structure. In G. R. Guy, C. Feagin, D. Schiffrin & J. Baugh (Eds.), *Towards a Social Science of Language: Papers in Honor of William Labov, Volume 1: Variation and Change in Language and Society* (pp. 3-22).

37. van der Hulst, H. (1993). Units in the Analysis of Signs. *Phonology, 10*(2), 209-242.

38. van der Kooij, E. (2002). *Phonological Categories in Sign Language of the Netherlands: The Role of Phonetic Implementation and Iconicity*. Unpublished PhD dissertation, Leiden University.

39. Woodward, J. (1978). Implicational Variation in American Sign Language: Negative Incorporation. *Sign Language Studies, 3*, 20-30.