LANGUAGE ACQUISITION BY EYE

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Chapter 5

Principles for an Emerging Phonological System: A Case Study of Early ASL Acquisition

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Understanding how children acquire phonology is important to our attempt to explain language acquisition. Children who are acquiring a signed language as their first language provide researchers with a distinct observational advantage: We can see the articulators they use to produce words. However, they also provide us with a distinct challenge: discovering the nature and structure of phonological acquisition in languages where the articulators are the entire upper body and the perceptual sense is the eyes. In this chapter, we describe the emerging phonological system of a very young child acquiring American Sign Language (ASL) and propose the principles that guide this early phonological growth. Before we do so, however, we first describe the basic elements of signed language phonology and consider in detail the previous research that has investigated phonological acquisition in signed languages.

WHAT IS PHONOLOGY IN SIGNED LANGUAGE?

The study of phonology is concerned with the smallest parts of a language. These elements do not convey meaning on their own, however, particular combinations of these elements create signs that do convey meaning. The phonological structure of a sign consists of three major components: (a) where the hand is located relative to the body, called *location*—examples of location primes include [head, chin, nose, chest];[1] (b) how the hand moves in space, called *movement*—examples are [circle, arc, straight line, wiggle fingers]; and (c) the form of the hand itself, called *handshape*—examples are all fingers extended, written as [5], or all fingers closed with thumb to the side of the index finger, written as [A]. Other examples of ASL handshapes are shown in Fig. 5.1.

Of course, children have two hands and signs can be formed either with one or both hands. One-handed signs typically use the individual's dominant hand. The relation between the hands in two-handed signs is constrained by symmetry and dominance conditions (Battison, 1978). The symmetry condition states that if both hands move during the production of a sign, then (a) the handshapes must be the same, (b) the locations must be the same or symmetrical about the midline of the body, and (c) the movement must be the same and either simultaneous or alternating in phase (e.g., the hands can move up and down, together or in opposition). The dominance condition states that if both hands do not share the same handshape, then (a) only one hand produces the movement, and (b) the stationary hand is restricted to a small set of handshapes [A, S, 5, B, 1, C, O]. These conditions serve to limit the possible configurations of two-handed signs. Given that the phonological systems of signed languages are complex, but nevertheless rule bound, the question remains as to how very young children acquire these complex, but meaningless, phonological units and rules of signed languages.

PHONOLOGICAL ACQUISITION IN SIGNED LANGUAGE

The signing child must master many different facets of the phonological structure of his or her language over the course of language acquisition. In order to understand phonological acquisition in signed languages, we must know a large number of details. These details include the handshapes, locations, and movements that are produced at the earliest stages of lexical development and the order in which these phonetic elements are acquired. However, knowledge of these details is insufficient. Complete understanding requires that two additional questions be asked. First, at what point in development does a child adhere to the formational constraints on signs, for example, the symmetry and dominance conditions? Second, when does the child show evidence of having a phonological system that guides the production of signs?

[1]Specific ASL primes are listed in square brackets to indicate that they are linguistic units.

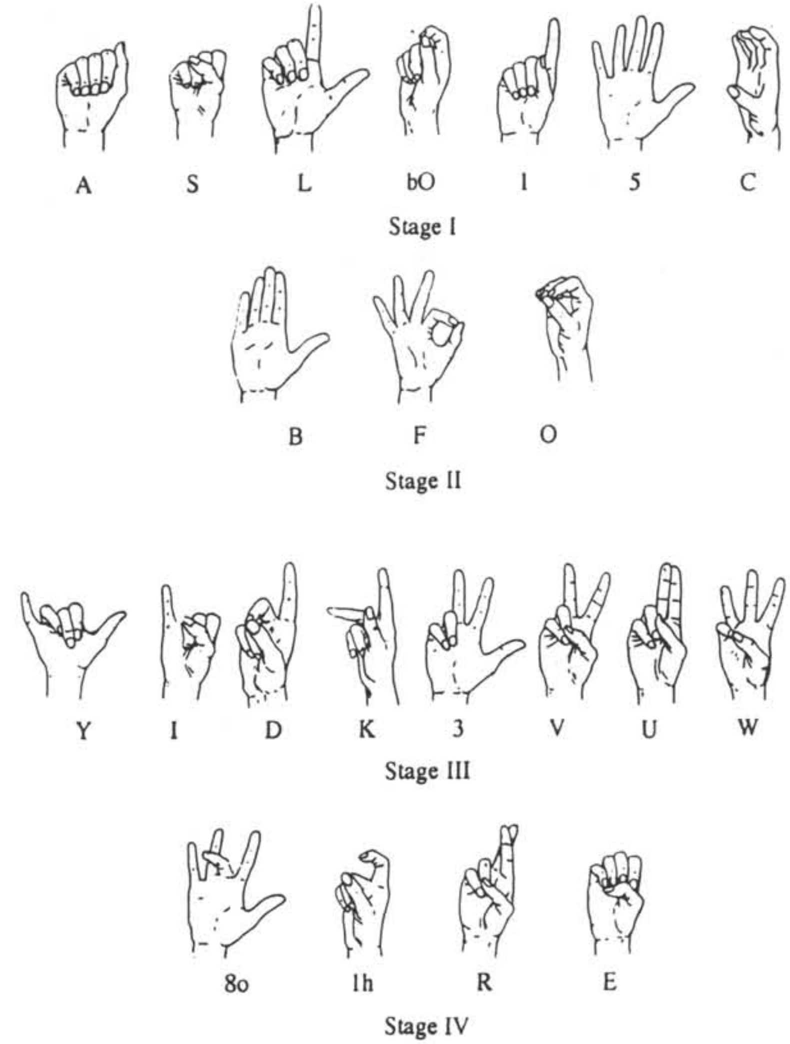

FIG. 5.1. The stages of acquisition for handshape primes according to Boyes Braem's (1990) theory. Handshapes © P. Marentette.

The few studies of ASL phonological acquisition have focused on the question of which primes are acquired and the order in which they appear. There has been relatively little explanation as to why children may be using these particular primes, and acquiring them in the order that they appear. This becomes apparent from a review of the studies of phonological acquisition in ASL. Of the small number of studies that have been conducted on phonological acquisition, the majority focused on handshape. In our present review, we focus on this aspect of ASL phonology in some detail before considering the limited information that is available about the acquisition of location and movement.

The Complex Process of Handshape Acquisition

Boyes Braem (1990) was the first investigator to study phonological acquisition in signing children. She developed a model of the order in which handshapes would be acquired. Using this stage model, Boyes Braem predicted the kinds of substitution errors that would be made by children. An evaluation of Boyes Braem's model must therefore consider both her predictions about the order of acquisition of handshapes and her predictions about the factors that affect handshape substitutions.

Order of Acquisition for Handshape. Boyes Braem hypothesized that the order in which a child learned to produce the handshapes of ASL would be influenced by two primary factors: the anatomical development of the hand and a factor she called *serial finger order*. Boyes Braem (1990) defined serial finger order as "whether the same features are applied to adjacent digits or to digits out of serial order" (p. 107). For example, the handshape [5], which requires all fingers to be extended and spread apart, should be acquired earlier than the handshape [V], which requires the index and middle fingers, but not the ring and pinkie fingers, to be extended and spread apart. Boyes Braem predicted that anatomical constraints on handshape formation would have the greatest influence in the early stages of acquisition, whereas serial finger order would affect the handshapes acquired later in phonological development.

The predicted order of handshape acquisition can be seen in Fig. 5.1. The handshapes of Stage I are those that the prelinguistic infant is capable of producing, for example, in reaching, grasping, and pointing (Fogel, 1981). Stage II handshapes are variants of those already mastered in Stage I. Stage III and IV handshapes are distinguished from those acquired earlier because they require inhibition and extension of the middle, ring, and pinkie fingers (e.g., [Y, K, 3, W]), as well as control of nonadjacent fingers (predicted to be difficult due to the serial finger order factor, e.g., [8o]).

The distinction between Stage I and II handshapes compared to those of Stage III and IV is supported by the work of Ann (1993). Ann examined the ease of production of handshapes in ASL and Taiwan Sign Language based on the anatomical structure of the hand and the physiological principles that guide its movement. According to Ann's (1993) classification, Stage I and II handshapes fall into the "easy" group, whereas Stage III and IV handshapes are classed as "difficult."

A number of studies investigated the order in which children begin to produce handshapes in the earliest stages of signing. Siedlecki and Bonvillian (1997; Siedlecki, 1991) provided data from a study of 9 children (8 hearing, 1 deaf) who were acquiring ASL as their primary language. The children's families were visited monthly between the ages of 0;6 and 1;6. Data analyses were based on the parents' reproduction of the children's sign types. That is, the data consisted of parental report of phonological form. Siedlecki and Bonvillian (1997) analyzed 448 sign types (range 16–139 per child). There is substantial overlap between the earliest handshapes acquired by Siedlecki and Bonvillian's participants and the first two stages of Boyes Braem's (1990) theory. Several handshapes (notably, [5, 1, B, A]) were produced early and frequently in these children's early signs. Earlier research using the same method of parental report with a different group of children also found that these same handshapes were produced with high frequency by young children (Bonvillian, Orlansky, Novack, Folven & Holley-Wilcox, 1985; Orlansky & Bonvillian, 1988).

Similar results were found in a case study of a deaf child of deaf parents (FF) between the ages of 1;1 and 1;9 (McIntire, 1977). Of the target signs that FF attempted to produce, the handshape required for the adult form was likely to be one of the Stage I handshapes (68%). When FF produced a sign, she depended almost exclusively on Stage I handshapes (98%). Of the Stage I handshapes, [5, 1, bO] were successfully produced for more than 80% of the signs in which they were required, and [S, A, C] were successfully produced for less than 50% of the signs in which they were required. Although FF attempted target signs that require Stage III and IV handshapes, she did not successfully produce any Stage III or IV handshapes during this time period.

Boyes Braem's (1990) own data provided further support of the primacy of Stage I handshapes. She studied an older child, Pola, age 2;7. Half of the target signs Pola produced required Stage I handshapes. With the exception of [S], the Stage I handshapes were correctly produced for 87% of the target signs in which they were required. Stage II handshapes were used with mixed success: [B] was produced correctly 95% of the time, but [O] was only correct 33% of the time. The handshape [F] was never required. Similarly mixed results occurred with Stage III handshapes. The handshapes [D, 3] were produced with complete accuracy, and handshapes [H, K] were used with moderate accuracy (66%, 50%), whereas handshapes [Y, V] were never accurately produced, and the others were not attempted. Boyes Braem concluded that Pola was at Stage III in her handshape development. Because these data were derived from a single session, however, it is impossible to assess the order in which Pola acquired these handshapes.

Finally, it is worth noting that Clibbens and Harris (1993) briefly reported on the acquisition of handshape between the ages of 1;2 and 2;4

in a deaf girl of deaf parents learning British Sign Language. The participant (Anne) depended heavily on the primes [5, A, 1] in her initial signs.

These studies provide supporting evidence for the primacy of a subset of Boyes Braem's (1990) Stage I handshapes (perhaps [5, A, 1, B, bO]). However, there is limited evidence to support the arrangement of handshapes among the other three proposed stages. None of the studies followed a child for a long enough period of time to observe the acquisition of handshapes from several different proposed stages. This makes it difficult to assess the stage aspect of the model.

Substitution Data. Boyes Braem (1990) also predicted the kinds of substitution errors that children would make. When a child produced the wrong handshape in a sign, Boyes Braem predicted that the handshape substituted for the target handshape would be one from the current stage or earlier stage of acquisition. That is, a child might substitute a [5] hand of Stage I for a [B] hand of Stage II, but she would not substitute a [U] hand of Stage III for a [B] hand. Boyes Braem identified six additional factors that she hypothesized to influence the particular handshape that replaced the target handshape. These were (a) a preference for fingertip contact, (b) the sympathetic extension of the thumb when the index finger is extended, (c) anticipation and retention of handshapes in other signs (or coarticulation), (d) the nature of the sensory feedback available to the child (i.e., can they see their own hands?), (e) the nature of the movement required by the sign (this suggests a limit to the level of linguistic complexity permitted in a sign, e.g., a more complex movement may be possible if the child simplifies a handshape), and (f) the use of handshapes as classifiers.

Bonvillian et al. (1985; Orlansky & Bonvillian, 1988) reported many handshape errors in their group of 13 children (12 hearing and 1 deaf) between 0;6 and 3;0. Five handshapes [B, 5, 1, A, C] accounted for 73% of the targets and 84% of the handshapes produced. These are all Stage I and II handshapes in Boyes Braem's model. Orlansky and Bonvillian (1988) reported three frequent errors: the primes [5] and [B] were frequently interchanged; the handshape [5] was often substituted for other Stage 1 handshapes such as [C, A, 1]; and the handshape [1] was often substituted for target primes from both Stages I and III [5, U, V, W, A]. However, these data were collapsed across all 13 children, making it impossible to know what an individual child's substitutions looked like. Nevertheless, these error data are largely consistent with the predictions made by Boyes Braem in that handshapes from earlier stages replace handshapes from later stages.[2]

[2]The prime [B] replacing [5] is not predicted from Boyes Braem's theory, as [B] is a Stage II handshape and [5] is a Stage I handshape.

Siedlecki (1991) reported a number of handshape substitutions for target signs in his group of children. The frequently produced handshapes [5, 1, A, B, bO] were also the most frequent substitutes in these children's signs. The handshape [5] was used to replace target handshapes [A, B, C, O] and the handshape [1] replaced [5, B, C, O]. One pattern of substitution that Siedlecki and Bonvillian (1997) noticed was that a [5] handshape was chosen if the target sign required contact between the heel of the hand and a location, and a [1] handshape was chosen if the target sign required contact between the fingertips and a location. Because these substitutions were collapsed across children, it is impossible to know if individual children showed distinct patterns of substitution.

Siedlecki and Bonvillian (1997) acknowledged the contribution of "ease of fine motor control" to handshape acquisition but found this factor to be inadequate to fully explain the children's handshape use. They found that several of Boyes Braem's (1990) secondary factors were influential. For example, they found that handshape production was influenced by the type of contact required with a location. In addition, having to produce a handshape in the context of a sign (i.e., simultaneously with a location and movement) reduced the accuracy of handshape production, as did the presence of differing handshapes in preceding and following signs.

In McIntire's (1977) case study of FF, she found that of the 186 substitutions made by FF, 182 (98%) were handshapes from Stage I. The prime [5] accounted for 54% of all substitutions. These data also support the primacy of Stage I handshapes in Boyes Braem's (1990) model. McIntire (1977) posited phonological rules to explain several of FF's substitutions. However, she further hypothesized that many of the secondary factors suggested by Boyes Braem would override these phonological rules. For example, there was a clear preference for fingertip contact in some signs that do not require that type of contact (i.e., SHOE, BIRD, GOAT, and WATERMELON). McIntire agreed with Boyes Braem's speculation that other secondary factors would also have a strong influence on the accuracy of handshape production. Due to the difficulty of assessing these factors, however, she did not provide data to evaluate this claim.

A study of the bilingual acquisition of ASL and English in a hearing child (Anya) with a deaf mother and a hearing father provides a few additional observations about phonological acquisition. Prinz and Prinz (1979) reported that phonological errors between the ages of 0;7 and 1;7 included handshape substitutions of [A] for the target [1h] in APPLE and [A] for the target [Y] in TELEPHONE. The prime [A] is a Stage I handshape, so its substitution for the later primes [Y, 1h] conforms to Boyes Braem's model.

Collectively, these studies provide supporting evidence for the early acquisition of Stage I handshapes. Boyes Braem hypothesized that these early handshapes are anatomically easy configurations for very young children to produce. In addition to frequent production, these same handshapes are often used as substitutions, in place of the target handshape. Although both Boyes Braem (1990) and McIntire (1977) posited phonological rules to govern these substitutions, they were working during a time when our theoretical understanding of ASL phonology was quite limited. The linguistic theories they used are no longer held. Current phonological theories may provide better explanations of some handshape substitutions. In addition, Boyes Braem proposed a number of other factors that may guide a child's substitutions. These include a mix of anatomical (sympathetic thumb extension), perceptual (fingertip contact, sensory feedback), phonetic (coarticulation, complexity of other parameters), and linguistic (classifier use) influences. These are all reasonable avenues of exploration. Few other attempts have been made to explain the particular handshape substitutions that children make in their early signs.

Location, Location, Location

In contrast with the study of handshape, there are few studies of the acquisition of location by signing children. Perhaps location has been the subject of less work because researchers have informally observed that children do not show much problem with its acquisition. Of the three major sign parameters, Siedlecki and Bonvillian (1993) found that location was the most accurately produced (overall accuracy calculated across children and ages was 83% compared to 50% for handshape and 61% for movement). Meier, Mauk, Mirus, and Conlin (1998) also found high accuracy for the production of location relative to the other parameters of a sign.

Bonvillian and Siedlecki (1996) proposed a model for the order of acquisition of location primes. The proposal is based on several characteristics of their data: accuracy of production of location primes, order of acquisition of primes across children, and frequency of appearance of primes in the children's lexicons. The earliest acquired primes in their study were [neutral space, trunk, chin, forehead]. Bonvillian and Siedlecki noted that these early primes are frequently used in the adult lexicon and suggested that they are easy to produce (although there is no explanation of how ease is measured). In addition, these primes were maximally contrastive, requiring much broader distinctions compared to those required among the location primes of later levels. Finally, Bonvillian and Siedlecki (1996) noted that many of the children's signs involved locations that contacted the body.

The accuracy difference between location and the other parameters, was explained by both Meier et al. (1998) and Bonvillian and Siedlecki (1996) as resulting from the level of motor control required. The production of a location prime requires a relatively gross level of control compared to the finer manipulations of the fingers needed to produce particular handshapes.

The Movement Puzzle

As with location, few studies have investigated the acquisition of movement primes. Bonvillian et al. (1985) reported the coding of movement primes to be particularly difficult. This is because children sometimes produced different movements with each hand, thus violating the symmetry and dominance conditions of ASL. The most frequently produced movement primes were [contact, in, pronate, out, down, and supinate].[3] Participants made frequent errors for movement primes.

The principal observation made by Siedlecki (1991; Siedlecki & Bonvillian, 1993) about the acquisition of movement primes was the children's reliance on the prime [contact]. Aside from the frequent and accurate production of this prime, and its dominant use as a substitute, few other patterns were noteworthy. The prime [contact] was the only movement prime produced by all of the children in the study. As a result, in his model of the order of acquisition of movement primes, Siedlecki (1991) placed [contact] alone in the first level. He hypothesized that this prime is mastered by the children, in part, because its production highlights location, a sign parameter that the children produced with greater accuracy.

Meier et al. (1998; see also Conlin, Mirus, Mauk & Meier, chap. 4, this volume) analyzed ASL acquisition in 3 deaf girls ranging in age from 0;7 to 1;5. They investigated the effect that the development of motor control may have on the production of early signs. Their results suggest that children may alter the movement of a sign by replacing a more distal articulator with a more proximal articulator (e.g., the elbow rather than the wrist), by deleting the movements made by more distal articulators, or both. The reduction of many of the movement primes to a movement of the shoulder or elbow often resulted in a simple contact to the target location. This fits well with Siedlecki and Bonvillian's (1993) finding of children's early reliance on the prime [contact].

The Early Phonological Repertoire in ASL

We can draw several generalizations about the early phonological repertoire of children acquiring ASL from our analysis of the available studies. First,

[3]The movement prime [pronate] refers to twisting the lower arm so that the palm of the hand faces down; the prime [supinate] refers to twisting the lower arm so that the palm faces up.

children produce a variety of location primes and do so with high levels of accuracy. Second, children tend to make heavy use of the movement prime [contact] but despite this, they manage to achieve a fair degree of accuracy in the production of movement. Third, most children produce a small set of common handshapes (i.e., [5, 1, A, B]) and achieve relatively low overall accuracy in handshape production. These observations describe aspects of the phonological repertoire of young signing children, including the phonetic elements they produce in the earliest signs as well as the order in which they produce various handshapes, locations, and movements.

Despite the accumulation of details regarding children's early ASL phonological acquisition, there has been little theoretical development in this field. Just as the phonological errors made by adults reveal something of their phonological system (Mayberry, 1995), phonological errors produced by children can reveal something about the child's emerging phonological system. In the following section, we investigate the phonological acquisition of a single child in the earliest stages of phonological acquisition. We then analyze her phonological errors and propose of a set of principles to account for her errors.

THE EMERGENT PHONOLOGICAL SYSTEM

The present study describes the emerging phonological system of 1 child through the identification of the principles that structure the form of her signs. A longitudinal case study was chosen to determine if principled relations existed between target signs and actual sign productions. This type of analysis can only be conducted within a single child's data because of the degree of individual variation in children's phonological repertoires and in the strategies used to reduce a target sign to a sign that the child can produce (Ferguson & Farwell, 1975; Vihman, 1993). Our analyses focus on the patterns that were evident during the first year of signing and we describe the principles that may underlie this child's developing phonological system.

The Child

The participant, SJ, was a female hearing child of deaf parents. ASL was the exclusive language used in her home and was SJ's primary language for the duration of the study. SJ was videotaped in her home, for about 1 hour, once every 2 months. The observations included in the present analysis begin with her first signs on tape at 1;0 and continue until 2;1. Table 5.1 shows SJ's age at each session included in the study. During the taping sessions SJ, her mother, and occasionally her father played with various toys, books, and household items.

TABLE 5.1
Sign Types and Sign Tokens by Age

Age (year, Month, Day)	*Sign Types*	*Sign Tokens*
1;00.07	5	10
1;02.24	11	32
1;04.26	18	50
1;06.13	42	136
1;08.18	63	162
1;10.27	49	154
2;00.26	70	145

Coding and Analysis

Each session was coded twice: first to isolate the signs produced on each tape, then to determine the phonetic form of each of the signs. An important part of the first coding involved the assessment of whether a given manual action was a sign or not. This meant that nonlinguistic actions such as pointing and communicative gestures, and prelinguistic actions such as manual babbling, were excluded from the phonetic analysis.

A sign was defined as a manual action with an interpretable meaning and a phonetic form based on an adult sign. A form observed more than once had to have a consistent referent for it to be considered a sign. The majority of signs produced by SJ were easily recognized as an attempt at the form of an adult sign. The requirement that the form of the child's signs be based on the form of the adult sign was helpful in separating gestures from signs (Meier & Willerman, 1995). The requirement that the child's signs have a consistent meaning was helpful in separating manual babbling from signs. In this way, the definition of sign used in this study permitted the isolation of signs from the variety of manual actions that SJ produced. Reliability of sign identification was checked by a deaf research assistant for portions of the videotapes and found to be 86% (275 signs agreed on/321 signs observed by either coder).

The second coding involved recording the phonetic form of each sign. The following phonetic aspects of each sign were coded: handshape (right and left hand), palm orientation (right and left hand), location (vertical place of articulation and horizontal place of articulation, following Brentari, 1990), movement (path, hand internal), and contact (contact of hand to body, contact within hand). This yielded 10 bits of information for each sign. Handshapes that differed only by thumb location were not reliably distinguished in this study. A list of 105 randomly selected signs was coded to check for reliability. Reliability was calculated as the number of bits of phonetic information agreed on divided by the total number of bits of phonetic information: Intercoder reliability was 86% for phonetic form.

The data analysis was designed to discover any patterns in the form of SJ's early sign production. An important element of this analysis was to determine which primes SJ substituted for the target prime when she produced an error. To this end, two types of frequency data were collected: target frequency (how often she attempted signs that required a prime) and production frequency (how often she produced a prime). These counts provided information about the frequency of various substitutions (e.g., SJ substituted a handshape prime [5] when she was attempting to produce [B] on 16 occasions at the 1;11 session).

The Acquisition of Sign Parameters

A total of 1,699 data points were coded from the seven videotaped sessions. Signs represent 48% of these data points (689 spontaneous signs, 115 imitated signs). The distribution of sign types and spontaneous sign tokens across sessions is shown in Table 5.1. SJ produced a range of other empty-handed manual activities including points, empty-handed gestures, manual babbling, attention-seeking actions, and a few uninterpretable actions.

The results of this study show that development was not uniform across all aspects of ASL phonology. Instead, this child demonstrated a distinct acquisition process for each aspect of ASL phonology. The systematicity of SJ's phonological acquisition is most clearly demonstrated by an analysis of the location and handshape parameters. Movement is mentioned only briefly as it provides an excellent contrast to the patterns observed in the acquisition of location and handshape. The full analyses can be found in Marentette (1995).

Location. SJ produced location primes with a high degree of accuracy throughout the study. Horizontal place of articulation, which encodes how far away from the body a sign is produced (either in contact, slightly away from the body, or with extended arms), was produced with an overall accuracy of 89%. The few errors that she did produce primarily involved substituting a fully extended arm for one that should have been positioned close to but not touching the body.

Vertical place of articulation (VPOA) was encoded with respect to the body part near which a sign is produced. The overall accuracy of locations SJ produced in the vertical plane was also quite high at 74%. SJ produced

the primes [trunk, cheek, hand, chin, head] most frequently. These five primes accounted for 75% of VPOA primes produced.

The three primes that SJ used as substitutes most often were [trunk, head, mouth]. She did not make substitutions randomly. SJ used anatomy as an organizing principle for VPOA production. Of the errors produced, 91% involved anatomical neighbors. Consider the most frequent substitutions made by SJ:

[temple] replaced by [head]
[chin] replaced by [mouth]
[shoulder] replaced by [trunk]
[cheek] replaced by [ear]
[trunk][4] replaced by [hand]
[hand] replaced by [trunk]

The first four substitutions show a less salient anatomical part being replaced with a more salient location. These errors may have occurred because the target body parts (e.g., temple, chin, shoulder, cheek) were not as well represented in her body schema as other body parts such as mouth and head and chest. Examples of these errors include COW (produced at [head] not [temple]) as shown in Fig. 5.2, DUCK (produced at [mouth], not [chin]), COP (produced at [trunk] not [shoulder]), and TELEPHONE produced at [ear] not [cheek].

These last two types of substitution do not seem to fit with an explanation based on anatomical representation. Instead, they involve errors in the dominance and symmetry conditions that apply to two-handed sign production (Battison, 1978). Examples include SHOE and BOOK, two-handed signs that require both hands to move. SJ occasionally produced these with one stationary hand, while the other moved to contact it (replacing [trunk] with [hand]). The opposite error also happened, in which SJ would replace a [hand] location with [trunk], that is, when one hand should have been stationary, but both hands produced the movement. Examples of this type of error are the signs COOKIE, and SCHOOL. These violations of dominance and symmetry are distributed throughout the data with a peak occurring at the 1;11 session.

Handshape. In contrast to location primes, handshape primes were the least accurately produced by SJ. Accuracy did not improve over the course

[4]Note that [trunk] does not mean the sign was made in contact with the body as it could be produced at differing horizontal places of articulation. All of the signs involved in this error type were produced in neutral space.

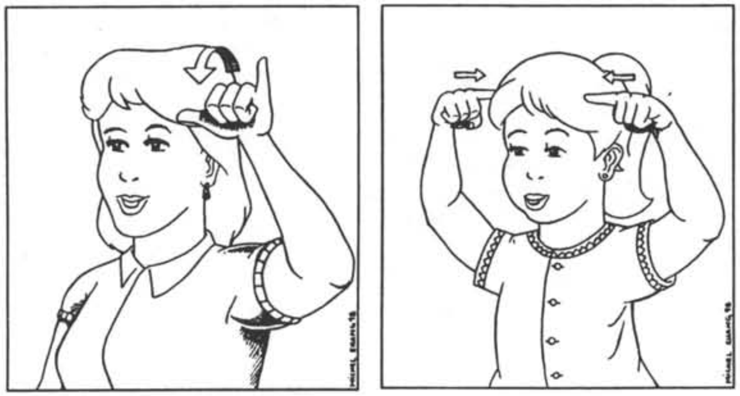

FIG. 5.2. The child's sign COW (in comparison with the mother's target sign) shows several noteworthy errors; she replaced the handshape [Y] with [1] and added a second hand (a tendency for signs made outside SJ's visual field); she also replaced the location [temple] with [head]. Illustration by Michel Shang, © R. Mayberry & P. Marentette.

of the year of observation. The overall accuracy of handshape production with the dominant hand was 27%. Even though SJ used a restricted range of handshapes on the nondominant hand, these were no more accurate, showing an overall accuracy of 26%.

SJ produced a wide variety of handshapes, but the central trio were [5, 1, A]. These primary handshapes represent a particular set of relations: (a) they are a subset of easy to produce handshapes (Ann, 1993); (b) they are produced with high frequency in the adult language (Klima & Bellugi, 1979); and (c) they are perceptually distinctive (i.e., fully open fingers, fully closed fingers, extended single digit). These handshapes were also the earliest to appear, with [5] appearing first, followed by [1], and then [A].

SJ's handshape substitutions provide clear evidence of a phonological system influenced by anatomical, linguistic, and possibly perceptual factors. The most frequent substitutions are listed below:

[B 5h C Bb][5] replaced by [5]
[1b 1h Y]replaced by [1]
[S bO]replaced by [A]
[F]replaced by [bO]

[5]The handshape [5h] is produced by bending the fingers of the [5] hand at the distal joints, or by spreading the [C] hand. The handshape [Bb] is produced by bending the fingers of the [B] hand at the proximal knuckle, so that all fingers are straight but perpendicular to the palm of the hand.

FIG. 5.3. The child's sign APPLE replaced the handshape [1] for [1h] and the movement [twist] with [contact] in comparison to the mother's target sign. Illustration by Michel Shang, © R. Mayberry & P. Marentette.

These substitutions are patterned and do not represent the random use of any prime for any other prime. This pattern is demonstrated in part by their independence. First, SJ rarely substituted frequent handshapes for each other. This pattern is true for the three frequent substitutes [5, 1, A]. For example, consider the handshape pair [5] and [A]. The prime [5] was never produced in place of [A] and [A] never produced in place of [5]. Second, there was a unidirectional relation between the substitute and the intended target. For example, the prime [5] replaced [C], but [C] did not replace [5]. Third, each handshape was used as a substitute for a different set of handshapes: [A] substituted for [bO] but [5] did not substitute for [bO]. Because SJ's error patterns demonstrate an internal structure, this provides strong evidence of a phonological system at work.

Examples of signs involving these errors include DRINK (with [C] replaced by [5]), SHOE (with [S] replaced by [A]), and APPLE (with [1h] replaced by [1]), as seen in Fig. 5.3. The sign COW, depicted in Fig. 5.2 shows two noteworthy errors. First, the handshape error, where SJ replaced a [Y] with a [1], and second, the addition of the second hand. Unlike Siedlecki and Bonvillian (1993), who reported that their participants often deleted a required second hand, SJ was more likely to add a second hand, particularly to signs produced out of her field of vision.

Movement. Movement primes were produced with moderate accuracy across all sessions. For path primes (involving the movement of the arm through space), accuracy was 57%. The most frequently produced path primes were [contact] (e.g., MOMMY) and a brushing movement (e.g., HAPPY). These two primes accounted for 59% of path primes in the database. Hand-internal primes (movements within the hand and fingers) were produced with an overall accuracy of 48%. The most frequent hand-internal movement primes were bending the proximal finger joints (e.g., DUCK) and rotation of the lower arm (e.g., BOOK), accounting for 58% of hand-internal primes produced. SJ often replaced a target hand-internal prime with a path prime (44 of 329 required primes, 13%), suggesting that she did not distinguish the two types of movement. SJ produced those primes that were most frequently required in the target signs she attempted. No pattern accurately describes her substitutions.

There are (at least) two possible explanations for the rudimentary nature of the system observed in SJ's production of movement. First, movement is complex and it may develop later in the child's acquisition process. During the early period covered in this study, it may be that SJ relied on frequency, producing movement primes with the same frequency that she observed them. Perhaps later in her development SJ began to make substitutions for movement primes based on some other principle, as she did with handshape and location. A second possibility is that the coding scheme used in this analysis does not capture the important factors relevant to the acquisition of movement. Unlike handshape primes, movement primes are not all articulator based and this fact may obscure any systematicity that exists in SJ's data. However, the hand-internal movement primes are primarily articulator based and they do not exhibit any systematicity in SJ's data. The absence of systematicity of hand-internal movements may be accounted for by the Meier et al. (1998) hypothesis that hand-internal movements are distal and therefore less likely to be used by the child.

In summary, SJ showed different levels of accuracy in the production of location, handshape, and movement. Her production of location was most accurate, followed by movement, and then handshape, just as has been observed in other children. SJ also relied on many of the same primes that have been observed in other children's early signs. What is particularly revealing about SJ's early signs, however, is the distinct nature of the paths that she followed in acquiring each of the parameters of ASL over her first year of signing. We next propose the principles that guided this child's emerging phonological system.

Principles Guiding Phonological Acquisition

Location was produced with high accuracy from the very earliest of SJ's signs. This finding replicates that of Bonvillian and Siedlecki (1996) and Meier et al. (1998). Although the earlier mastery of gross motor control is undoubtedly a significant factor in the acquisition of location, this does not provide an explanation for the errors that children make. SJ's accuracy in producing location primes, along with the anatomical organization of

her errors, suggests that she used a body schema as an initial representation of this parameter.

Throughout the first year of life, children develop a sense of how their body is organized and how it functions in the world (Butterworth, 1992; Neisser, 1991). Using a body schema would permit SJ to connect locations that are visually identified on another person's body with locations on her own body that she must identify through tactile and kinesthetic feedback. The capacity to link information that is received by visual and tactile means is crucial to the infant's capacity to imitate facial expressions (Meltzoff & Moore, 1993). This cross-modal link, connected to a well-developed body schema, may also subserve the child's capacity to acquire the location aspect of sign phonology.

With respect to handshape, the first primes to be acquired are those that are (a) easy to produce, (b) perceptually salient, and (c) frequent in the target language. For SJ (and many other children reported in the literature), these first handshapes include [5, 1, A, B]. Once SJ mastered these handshapes, she systematically substituted them for other handshapes. Three principles explain her handshape substitutions. First, SJ showed a preference for spread handshapes. Boyes Braem (1990) argued that it is more natural for fingers to spread than for fingers to be held tightly together and predicted that children would prefer [5] over [B] as a result. This is clearly true for SJ, as the substitution of [5] for [B] is her most frequent error.

The second principle is a preference is for unmarked primes. It is not surprising that unmarked primes appear early in a child's phonological repertoire. What is noteworthy, however, is the relation between the target primes that SJ attempted and the unmarked primes with which she replaced them. For example, SJ never produced the prime [Y] correctly. Instead, she frequently replaced it with [1]. Although this is certainly an example of anatomic ease, ([1] is easier than [Y] for the young child), the use of [1] as opposed to [5] or [A] as a substitute appears to be motivated by the phonological structure of ASL. In several current theories of ASL phonology, the prime [Y] is most closely related to [1] in structure (Brentari, 1990; Brentari, van der Hulst, van der Kooij, & Sandler, 1996; Sandler, 1995). The substitution of [bO] for [F] is also explained by this phonological principle.

The third principle underlying the substitution of handshape primes is a preference for open finger position. For example, SJ substituted [5h, C, Bb], all handshapes in which either the proximal or distal knuckle is bent, with the handshape [5]. This could be an anatomical preference for fully extended fingers, although Ann (1993) argued against this. It could also be a perceptual preference for fully open handshapes. In Brentari's (1990) phonological analysis of ASL, fully open or fully closed handshapes are more perceptually salient and therefore are preferred over handshapes with partially extended fingers.

To summarize, the structure of SJ's emerging phonological system is complex and varied. She relies on a body schema for location and a set of anatomically and linguistically influenced principles for handshape. It appears that she has not developed beyond a rudimentary system for movement within the time frame studied, although it may also be that better explanation of movement primes in ASL is required to explain the aspect of phonological acquisition in very young children.

One generalization describes all of the children studied to date. Location and handshape are acquired differently by children. Previous studies have established that location is easier for children; young children produce location primes with a greater degree of accuracy relative to other sign parameters. This study provides one possible explanation for this result. We propose that location is easier because children can rely on an emerging cognitive representation of their body to anchor their acquisition of the location primes of signs. For handshape acquisition, by contrast, the child has no preexisting mental representation or schema to provide an easy entry into the phonological system. Instead, factors such as ease of production, frequency in the input, and perceptual salience highlight a small set of primes for the child. The young child's substitutions of handshape primes reveal structured relations rather than random replacements.

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Chapter 6

Early Sign Combinations in the Acquisition of Sign Language of the Netherlands: Evidence for Language-Specific Features

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In this chapter, I demonstrate that children can acquire language-specific features at an early age. This will become clear from research on the acquisition of basic order in Sign Language of the Netherlands (SLN) in relation to the acquisition of another language-specific feature, namely, subject pronoun copy.

To explain the acquisition of language-specific features, the theory of parameter setting was proposed within a generative syntactic framework (Chomsky, 1981). Within this theory, children find out how the values of a restricted set of parameters are set in the language they are acquiring. The choice for a particular parameter value is made on the basis of information available in the input.

The description of the possible set of parameters is far from complete, but it is generally assumed by researchers working within a parametric framework that there is a parameter for basic order and a so-called pro-drop parameter. The description of the initial states of parameters is another area that needs more attention. Is there an initial default value (as suggested by Hyams, 1986, for the pro-drop parameter)? Or are the parameters initially not set, that is, are the various options, for a limited time, simultaneously present in the developing grammar (cf. Meisel, 1995)? The third area that needs further investigation relates to the moment at which children are able to definitely link the correct value to a specific parameter. The parameter for basic order is assumed to be acquired early (Clahsen & Muysken, 1986; Weissenborn, 1990).

Within the acquisition context, pro-drop and basic order have been investigated most extensively from a parametric point of view. The acqui-