Babbling in Sign Language: Implications for Maturational Processes of Language in the Developing Brain

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Sign Babbling: Implications for Maturational Processes of Language

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Key to Notational Conventions

SIGN	The English gloss for ASL signs is written in capital letters.
SIGN-SIGN	Single signs that require multi-word glosses in English are written using hyphens.
___Q SIGN	The Q indicates that the "question" facial expression was produced simultaneously with the sign. This facial expression involves raising the eyebrows for the duration of the sign.
___N SIGN	The N indicates that the "negative" marker was produced simultaneously with the sign. This marker involves a negative head shake.
word	Spoken words are written in italics.
"gesture"	Types of gestures are indicated with double quotes.
/d/	The slashes around a letter indicate that this is a phoneme from a spoken language.
5 2	Phonetic primes of sign language are indicate in bold face.

Abstract

The phenomenon of babbling has been a focus of intensive research because it represents the child's "first step" into the language acquisition process. Traditionally, babbling has been viewed as a stage in the development of the articulatory mechanisms of speech. This paper presents first-time evidence that challenges the traditional view of babbling. The study was conducted with two deaf children acquiring sign language from their deaf parents, and three hearing children acquiring spoken language from their hearing parents. The children were studied from 10 to 14 months of age. The results indicate that the deaf children produce canonical sign babbling. In contrast, hearing children with no exposure to sign language do not produce canonical sign babbling. Canonical sign babbling occurs when a child consistently produces well-formed syllables. The implications of this finding are clear; babbling is an a-modal phenomenon, related to the development of language *per se*. Canonical sign babbling provides evidence of the equi-potentiality of the signed and vocal modalities to serve as reception and transmission channels for language.

Resumé

Le babillage représente les premiers pas de l'enfant dans le processus d'acquisition du langage Pour cette raison, ce phénomène a été l'objet de recherches intensives. Traditionnellement, le babillage était considéré comme une étape dans le développement des mécanismes articulatoires relatifs à la parole. Cette recherche présente des évidences originales qui défient le point de vue traditionnel concernant le babillage. Les sujets de cette étude sont deux enfants sourds faisant l'acquisition d'une langue signée suivant le modèle de leurs parents sourds, et trois enfants entendants faisant l'acquisition d'une langue orale suivant le modèle de leurs parents entendants. Ces enfants ont été filmés de l'âge de 10 à 14 mois. Les résultats démontrent que les enfants sourds produisent un babillage signé authentique (canonical sign babbling). Contrairement, les enfants entendants qui ne reçoivent pas de modèle d'une langue signée ne produisent pas ce même type de babillage signé authentique. Seulement le babillage de l'enfant qui produit de façon continue des syllables bien formées est qualifié de "babillage signé authentique". Les implications de cette découverte sont implicites; le babillage est un phénomène qui requière un modèle linguistique. Le babillage signé authentique nous fournit l'évidence de l'équipotentialité des modalités visuo-gestuelle et audio-orale en tant que canal de réception et de production du langage.

Introduction

Towards the end of the first year of life infants vocalize extensively, producing language-like sounds that are apparently meaningless. This phenomenon, called babbling, has been the focus of intensive research because it represents the child's entry into the most distinctive of human capabilities, language. In order to truly understand language, scientists have looked to babbling: Babbling is universally acknowledged by parents and researchers alike as the "first step" in the language acquisition process.

Babbling is a universal phenomenon. It is cross-linguistic, having been noted in many of the world's languages. Babbling is also cross-modal. Children exposed to sign language babble in sign language. The goal of this thesis is to provide evidence for the existence of babbling in sign language or "sign babbling". Contrary to current belief, babbling is not the exclusive domain of the oral/aural channel. Evidence is provided which demonstrates that sign and vocal babbling share fundamental properties and differ only in their modality of expression; thus, babbling is a modality-free phenomenon.

To pursue the above goal, the sign babbling of two deaf children acquiring American Sign Language (ASL) as a first and native language is examined (ASL is the natural sign language used in parts of Canada and in the United States). Several analyses are conducted: (a) the phonetic and syllabic structure of the deaf child's earliest linguistic productions are examined in detail, (b) the extent to which the phonetic and syllabic structures of sign babbling and early signs are continuous is considered, and (c) a comparison between the pre-linguistic communicative gestures of the deaf

children and the pre-linguistic communicative gestures of the hearing children with no exposure to sign language is also provided.

The examination of sign babbling provides powerful evidence for a link between babbling and language (*qua* language) which extends beyond the currently postulated link between babbling and speech. The existence of such a link provides new evidence in support of theories of the biological foundations of language.

Why Study Vocal Babbling?

Research on vocal babbling has centered around two key issues. The first issue concerns the relationship between babbling and later language acquisition. Does babbling bear any unique relationship to the development of speech? Is babbling an opportunity for the child to master the sound patterns of her language? The second issue uses babbling as a way of gleaning information about language, *per se*. Whether language is "innate" or "learned" has been debated for centuries. As the first step in the language acquisition process, babbling has been examined in the hopes that it would provide telling evidence of its origin. This question was most notably pursued by Eric Lenneberg in the 1960's. Thus, babbling is of interest to scientists because it offers an opportunity to test hypotheses concerning the nature of language acquisition and the nature of language itself.

Babbling as Evidence for the Biological Foundations of Language

In the early 1960's, Eric Lenneberg examined the maturation of the brain in relation to speech and language. Lenneberg proposed that language was part of the biological makeup of human beings, and that it developed along a maturational timetable (Lenneberg, 1967). He identified key periods in development that were thought to be intimately tied to the biological foundations of language. One

major developmental milestone that he noted was the universal and regular onset of vocal babbling that preceded speech/language. His observations about the onset and development of babbling were used to support the maturational status of language in the brain.

The role of auditory input in vocal babbling. Lenneberg was so convinced that language was part of our biological endowment that he claimed that there would be evidence of the maturation of language in the absence of auditory input. In order to substantiate this claim, Lenneberg, Rebelsky and Nichols (1965) investigated whether vocal babbling would occur in the absence of speech input. They examined hearing children of deaf parents, ages two weeks through three months. Because the parents in this study were deaf, they did not provide auditory linguistic stimulation for their children. The results of the study indicate that no significant differences between children of hearing and deaf parents were found in the development of crying or cooing. One of the children was later found to be deaf himself, yet this child did not display any unusual developmental patterns throughout the duration of the study. Lenneberg et al. (1965) concluded that cooing (which occurs prior to true babbling) was not contingent upon linguistic auditory input, and that the maturation of language seemed to follow the expected course of development despite environmental differences. This study was seen as support for the claim that language is part of a maturational process, that is biologically endowed.

After further observations of the deaf child and one other deaf child of deaf parents, Lenneberg (1967) noted that these children began to babble vocally at six months, the same time as the hearing children he had observed. Although the deaf children did not produce as great a variety of sounds as their hearing contemporaries, they

were noted to utter "well articulated speech sounds". Lenneberg concluded that auditory input was not necessary for the occurrence of vocal babbling.

There are several problems with Lenneberg's data on babbling. The study he conducted followed infants from birth to three months of age. Recall that these children did not show any differences in cooing or crying from their peers with hearing parents. We now have reason to believe that cooing and crying behaviours are distinct from true babbling (to be discussed further below, p. 16). It is not remarkable, then, that children would be similar along the cooing and crying dimensions; these may be primitive signalling behaviours that are unrelated to babbling and language development. Another concern is that, with one exception, the children themselves were hearing and it is impossible to determine how much exposure to speech (e.g., from grandparents) they actually received.

Clearly, the ideal test case for Lenneberg's position is to determine whether profoundly deaf children babble vocally in a manner similar to hearing children. Lenneberg's conclusions were based solely on his observations of two deaf children. There was no mention of, or reference to, a study that was conducted to examine the characteristics of deaf children's babbling (Gilbert, 1982). Recent research does not support the conclusions Lenneberg made about the role of auditory input in the development of vocal babbling.

Strong support for the importance of auditory input in the development of vocal babbling is provided by several recent studies of deaf children. A detailed analysis of the acoustic properties of one deaf infant's vocalizations (ages 8 through 13 months), indicated that she never reached the canonical babbling stage (Oller, Eilers,

Bull & Carney, 1985). Canonical vocal babbling is the production of syllabic units which exhibit adult timing and production characteristics such as fully resonant vowels and fully closed consonants. The average age of onset of canonical babbling in hearing infants is 7 to 10 months. It is the production of canonical babbling that is continuous with children's language acquisition and judged by most to be "true" babbling. This deaf child did not produce the canonical vocal babbling forms typical of hearing infants at these ages. Instead, she produced vocalizations similar to those of hearing children aged 4 to 6 months; such vocalizations do not exhibit the adult syllabic properties required for canonical babbling. Thus, while the child did vocalize, she did not produce the canonical vocal babbling whose form is continuous with speech/language.

The above results are confirmed by three studies involving larger numbers of deaf children. In a study following the vocalizations of 11 deaf children ranging in age from 4 through 28 months, Stoel-Gammon and Otomo (1986) found both qualitative and quantitative differences in the babbling forms of the deaf children. They produced fewer multisyllabic utterances and displayed a much smaller repertoire of consonantal sounds. Some deaf children also produced a greater percentage of glottal stops (a sound made by opening and closing the glottis in the throat) than did the hearing children. Holmgren, Lindblom, Aurelius, Jalling, and Zetterstrom (1986) found a decrease in the production of glottal stops to be coincident with the onset of canonical vocal babbling so it is not surprising that some deaf children continued to produce a greater number of glottal utterances.

Stoel-Gammon (1988) reported the consonantal inventories of 14 deaf children. The children were followed from 4 months of age

through the early word stage. These data provide further support for the results published in her earlier paper (Stoel-Gammon & Otomo, 1986). The babbling of the deaf children was produced from a much smaller consonantal inventory than that of the hearing children (an average of 3.2 consonants by 15 months of age compared with 8.7 consonants for hearing children at the same age). Very little change was observed in the phonetic inventory of the deaf children until about 20 months of age, a time well after a change in phonetic inventory had been observed in the hearing children.

A third study observed nine deaf children throughout the expected babbling period (Oller & Eilers, 1988). All of the children were involved in speech training programs and wore hearing aids. Despite the amplification and training none of the children reached the canonical babbling stage before 12 months, approximately five months later than the hearing children. Even after the deaf children began canonical babbling, the quantity and developmental pattern of their utterances deviated markedly from those of the hearing children. The vocalizations produced by the deaf infants seem to be similar to those produced by hearing infants aged 4 to 6 months.

Clearly auditory input does play an important role in the development of canonical vocal babbling. With this evidence in hand it is necessary to re-examine some of Lenneberg's conclusions. It appears that vocalizations of both deaf and hearing children develop in a similar fashion until approximately 7 months of age. At this time, contrary to Lenneberg's prediction, the presence of auditory linguistic input is necessary for the development of canonical vocal babbling. Do these findings contradict the theory that language development is under maturational control?

Lenneberg revisited. At first glance it appears that Lenneberg was wrong. Children who did not receive auditory input did not produce canonical vocal babbling. This contradicts Lenneberg's prediction that there would be maturational indices of language development even in the absence of input. Lenneberg's prediction was limited to the occurrence of vocal babbling itself. At the same time, he clearly stated that input was necessary for a child to learn language. Why might he have predicted that vocal babbling would occur without input? Lenneberg's views on exactly what babbling was may help answer this question.

Lenneberg believed that babbling was controlled by the maturation of the language faculty; babbling was not the result of motor or articulatory development. At the same time, he believed that babbling was essentially discontinuous with later language development. Lenneberg did not think babbling was practice for speech. Nor did he observe a continuity of form between babbling and speech. Examples of this sort of discontinuity can be found in biology as well. Perhaps Lenneberg thought the relationship between babbling and speech was similar to the relationship between a tadpole and a frog. The two stages are morphologically different, yet the second stage (the frog, or speech) clearly evolved from the first (the tadpole or babbling).

Lenneberg noted that the exact mechanism responsible for babbling could not be determined at the time of his writing due to limitations of both the knowledge and technology needed for studying mechanisms of the brain. Nonetheless, he was quite clear about what was not responsible for babbling. Given his view on the discontinuity of babbling and speech, it is easier to understand why

Lenneberg had predicted that input was not necessary for babbling to occur, but was necessary for language to develop. The evidence shows that his prediction is wrong, canonical vocal babbling does not occur in the absence of auditory input (Oller et al., 1985; Oller & Eilers, 1988; Stoel-Gammon & Otomo, 1986; Stoel-Gammon, 1988). But this prediction was not central to his theory of the maturational control of language.

Do the above findings undermine Lenneberg's theory of the maturational control of language? Had Lenneberg been aware of the above studies, he might have thought they did. Twenty years later, it seems that Lenneberg may have been more right than he ever could have guessed. The reason for this apparent contradiction could be due to Lenneberg's views regarding the relationship between speech and language. Lenneberg clearly makes a distinction between the language faculty and speech, "having knowledge of a language is not identical with speaking" (Lenneberg, 1967, p. 308-309). Despite this, it seems that he believed speech was the only production mechanism available for language. This was not an unreasonable belief to hold in the 1960's. However, we now know that languages exist in two modalities, both spoken and signed (see Fromkin, 1988 for a clear discussion of the relationship between speech, sign, and language).

Current data about the vocal babbling of deaf children do not support Lenneberg's theory of maturational control because they tell only half the story. The definition of language must be extended to include sign languages. If babbling is the result of a maturing language faculty *per se,* as Lenneberg predicted, then we should expect to see the development of sign babbling in children acquiring signed language. To be a true indicator of maturational development,

sign babbling would have to appear between 7-10 months of age, the precise time when vocal babbling begins in hearing children acquiring spoken language.

This paper provides evidence for the existence of sign babbling which support Lenneberg's theory of the maturational control of language In the absence of language input -- spoken or signed -- children do not develop canonical vocal or canonical sign babbling, respectively. The existence of sign babbling supports the notion that babbling is a language-related, rather than a speech-related phenomenon; it is a modality-free expression of the language capacity. In this way, sign babbling may present the very evidence Lenneberg was looking for in support of his theory of the biological foundations of language.

Why Study Sign Babbling?

The study of vocal babbling has promised to inform scientists about the nature of language and the nature of language acquisition. To date, the focus of research has been on vocal babbling and its relationship to the development of speech. As a result, it is difficult to determine the specific relationship between babbling and language *per se*. The study of sign babbling presents a unique methodological advantage for addressing this issue. Is babbling modality-specific, that is, specific to the development of speech? Or, is babbling a cross-modal stage in the acquisition of language? If both vocal and sign babbling occur, this provides evidence that babbling is the result of a language-specific property, rather than a function of speech.

Furthermore, the study of sign babbling provides an opportunity to examine the phonetic and syllabic form of the signing child's earliest linguistic productions. Sign babbling itself has not

been studied before. There are anecdotal accounts of "manual babbling" or "finger babbling" occurring in hearing children learning sign language from their deaf parents (Maesta y Moores, 1980; Prinz & Prinz, 1979, 1981; Wilbur & Jones, 1974). These are all short passages that mention the existence of such a stage in the acquisition of sign language, however, no analyses are presented in any of these papers. The existence of sign babbling in deaf children, and the implications of this finding, have been noted and discussed by Petitto (1985, 1987a, 1987b, 1988; Petitto & Marentette, 1989). This thesis represents the first full analysis of sign babbling.

Analyses of the acquisition of ASL phonetic structure have been presented in two papers (Boyes-Braem, 1973; McIntire, 1977). These analyses are limited to the study of handshape, and will be discussed below (see p. 39). These studies did not evaluate the role of the three other parameters of location, movement, and palm orientation in the acquisition of ASL. There have been no analyses conducted of the syllabic structure of deaf children's signing or sign babbling. The present study provides the first analyses of the phonetic and syllabic structures of deaf children's early linguistic productions. It is further expected that the results of such an analysis may influence our understanding of the phonetic and syllabic structures of adult sign languages

Finally, the existence of sign babbling provides further support for the distinction between communicative gesture and language. Although both gestural and linguistic forms share the manual modality for deaf children, these two types of communication are treated differently by deaf children from the beginnings of language acquisition (Petitto, 1986, 1987, 1988). If the deaf children in this

study also distinguish gesture from sign babbling, these data will provide further support for the claim that children distinguish linguistic from non-linguistic forms, from the very onset of language.

As was noted above in the discussion of Lenneberg's theory of the biological foundations of language, the study of sign babbling provides a unique opportunity to re-examine the nature of language at the biological level. Through the study of sign babbling it is possible to determine the universal characteristics of babbling. The study of vocal babbling in itself does not provide this opportunity as it is impossible to determine which characteristics are a result of the speech modality and which characteristics are truly universal. The study of sign babbling, because it occurs in a different modality, provides a unique method of determining the essential characteristics of babbling. Thus, we can deepen our understanding of the nature of language itself.

The Function of Babbling

There are many differing accounts of the possible role of babbling in the development of the child. Indeed, it is possible that babbling could serve more than one function. If this is the case, a number of the following factors may jointly contribute to the causes and functions of babbling.

Jakobson (1941/1968) suggested that the function of babbling was related to motor development of the speech apparatus and was specifically unrelated to the later development of language. A similar view has been put forth by Studdert-Kennedy (1986). He argued that babbling was a process of articulatory development that was constrained by both physical and anatomical mechanisms in the developing infant. In this account, babbling was not a result of the

language acquisition process. Locke (1983) provided data in support of this view with an analysis of the phonetic repertoire of the infants' babbling from many languages and cultures. There was an astounding similarity among the consonantal forms produced by children all over the world during the babbling period. In addition, there was little evidence that the consonantal repertoire of any individual child developed to include more of the sounds of that child's environmental language during the babbling period.[1]

Locke (1983, 1984) and Studdert-Kennedy (1986) interpreted these data as support for an account of babbling as a function of articulatory development. Note that both Locke and Studdert-Kennedy stated that babbling was a property of the articulatory system responsible for speech, not language. This was not an oversight on their part concerning the distinction between speech and language. Each of these researchers made specific statements to this effect. To reiterate, their claim is that babbling is driven by motor and physical development, not language.

In contrast, Lenneberg (1967) stated that the function of babbling was not related to the development of the articulatory system at all, nor was it under motor control. Instead, he attributed the presence of babbling to the maturing language faculty. Babbling was simply seen as a stage in the maturation of language. However, at the time he was writing Lenneberg did not feel that it was possible to be more specific about the particular mechanism that might control babbling.

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[1] To my knowledge, there is only one paper which presents contradictory data. The results from this study suggest that in one child's late babbling it is possible to detect language-specific variation in the phonetic inventory (de Boysson-Bardies, Sagart & Bacri, 1981). It must be noted that this is very late babbling indeed, as the child was followed from ages 18 through 20 months. The data Locke (1983) presents are from a much younger group of infants aged 7 - 15 months.

A third account focused specifically on the relationship between babbling and language development. The role of babbling was to help the child in the acquisition of phonology (Ferguson & Macken, 1983). Phonology consists of a set of sounds, and the rules for combining those sounds. Each world language is made up of a unique combination of sounds and rules. Ferguson and Macken (1983) suggested that babbling provided a mechanism for learning about the sounds and phonological rules of language. This mechanism was thought to be crucial for sorting out the phonological rules that govern acceptable combinations of sounds that come with the acquisition of words. Jusczyk (1989, p.11) supported this theory with the statement that the role of babbling "is an attempt to match [the infants] vocal output with that of adults", that is, to work towards mastery of the adult phonology. This account focused on the actual manipulation of the language form in its own right. Babbling is playing with the sounds of language (Ferguson & Macken, 1983). Through this activity the child has the opportunity to concentrate on the raw form of language without any interference from meaning.

The study of sign babbling directly addresses these accounts of the function of babbling. If babbling is found to occur in both spoken and signed languages it is clearly not adequate to attribute its function to the development of the articulatory system responsible for speech. Rather, it is more probable that babbling is the result of a maturing language faculty as Lenneberg suggested.

The data presented by Locke can be explained within this theory. The framework of interpretation must be extended to include the language faculty itself, not just speech. As Locke and Studdert-Kennedy suggest, it is quite likely that there are articulatory and motoric constraints on the form of vocal babbling.

Nevertheless, these constraints are secondary to the primary purpose of babbling which is controlled by the language faculty. One would expect to see that the sign babbling of deaf children is also constrained by articulatory and motoric limitations on the developing hands.

Finally, a theory which predicts that babbling is the result of the maturation of the language faculty is commensurate with the idea that babbling is the child's tacit attempt to master the basic set of units that will be relevant in her language, i.e., the phonological system of language. This idea is supported by the work of Oller, Wieman, Doyle, and Ross (1976) and Vihman, Macken, Miller, Simmons, and Miller (1985), among others, whose work demonstrates the continuity of form in vocal babbling and speech. The research on the continuity of vocal babbling and early speech is reviewed below.

The Form of Babbling: Continuous or Discontinuous with Language?

Early researchers proposed a discontinuity between babbling and first words (Jakobson, 1941/1968; Jakobson & Waugh, 1979; McNeil, 1970). Most notably, Jakobson (1941/1968) described infants' vocal productions as consisting of a widely varying range of sounds, a range much greater than that found in any one language. The occurrence of such vocalizations was viewed as constituting a distinct developmental stage, and was the behaviour that Jakobson referred to as "babbling". According to Jakobson, the transition from babbling to language was marked by a change in form of the phonetic repertoire of the child. During this transition the "variety and opulence of the babbled sounds yield to a rigorous sparseness of speech sounds" (Jakobson & Waugh, 1979, p. 62). Occasionally this transition was said to result in a silent period during which the

child did not produce any speech related sounds (see also Carroll, 1961; Velten, 1943).

Not all researchers believed the relationship between babbling and speech to be discontinuous. In his now classic book Words and Things, Roger Brown noted that the important thing about babbling was its continuity with language, that children's inventory of vocalizations (or phonetic repertoire) drifted "according to the prevailing linguistic winds" (1958, p. 199). Brown did not commit himself to a description of the phonetic repertoire exhibited by the child in the early babbling period. As time passed, however, he predicted that this repertoire would come to resemble more closely the adult phonetic inventory of the environmental language

To date, there is little support for Jakobson's claim that babbling and language are fundamentally discontinuous Structural similarities between babbling and first word forms appear to be continuous, and are observed across children (Oller et al., 1976). Acoustical analyses of babbling have shown that canonical babbling was much more "speech-like" than the infants' earlier vocalizations (Holmgren et al., 1986; Oller, 1980, 1986). This increase in the "speech-like" qualities of infants' canonical babbling, lent further support to the continuity hypothesis. Vihman et al. (1985) found that the babbling repertoire played a significant role in determining the composition of a child's first words. This continuity occurred in the dimensions of syllabic structure, vocalization length, and consonantal repertoire. These data corroborate the findings of Elbers (1982) who argued that her evidence supported the influence of babbling on the form of early words. In summarizing the results

of many researchers, Locke (1983) concluded that the continuity between babbling and early words was clear.

The continuity between babbling and early words is more particularly a continuity between canonical vocal babbling and early words. What is the distinction between babbling and canonical babbling? What is canonical babbling?

The Definition of Babbling

A clear definition of babbling is crucial, as it influences the design of studies in three fundamental ways: the age of the infant studied, the types of vocalizations studied, and the methods used to collect data. Despite the overwhelming agreement that babbling does occur, there is no widely accepted definition of babbling. It is important to establish a clear operational definition of vocal babbling in hearing children in order to allow adequate comparisons with the manual behaviour of deaf children at similar ages. In the following sections, a number of examples demonstrating the range of behaviours that have been studied under the term babbling are presented. Some conclusions regarding what a complete definition of babbling should entail are also provided.

Onset of babbling. Babbling is most commonly defined as meaningless vocalizations (Jakobson, 1941/1968; Leopold, 1947; Oller et al., 1976; Winitz, 1969). This feature of babbling plays an important role in distinguishing babbling from early words; however, it does not resolve questions concerning the onset of babbling.

A frequently noted form of early infant vocalization is cooing, a form which demonstrates a high percentage of back vowels [u, o, a] and consonants [k,g]. Some researchers (Leopold, 1947; Winitz, 1969) included cooing in their studies as a special, early phase of babbling. Other researchers, however, have found reason to divide

these two types of vocalizations (cooing and babbling) and consider them separately. Cruttenden (1970, 1979) suggested that true babbling begins when the following two criteria have been reached: first, the discovery of pleasure in the production of sounds, implying that babbling is intentional; and second, the onset of supraglottal articulations. This placed the onset of babbling at an approximate age of three or four months for his subjects. Due to the difficulty of making objective judgments about the intentionality of infants' utterances, Cruttenden chose to use a purely phonetic criterion. He defined babbling as beginning at the changeover from predominantly back and glottal articulations to those containing supraglottal consonants. With this criterion he established that babbling begins at the end of the cooing period. The separation of cooing and babbling is readily accepted in the current literature. Current researchers rarely consider the period previous to 6 months of age in a study of babbling. This separation of cooing and babbling is further supported by the work of Oller.

Oller (1980, 1986; Oller & Eilers, 1988; Oller et al., 1985) directly addressed the issue of the onset time of babbling in his proposal for a "metaphonological approach" to the definition of babbling. This approach presents the clearest and most explicit definition of babbling in the literature as it combines both acoustical and phonetic criteria to establish the onset of babbling. Oller argued that the acoustical properties of infant vocalizations must be examined previous to the application of a phonetic transcription. Once it is clear that a vocalization is acoustically similar to adult utterances, then a phonetic transcription system, such as the International Phonetic Alphabet (IPA), may be applied (see also Lynip, 1951).

Oller's reticence concerning the use of phonetic transcription results from an assumption that underlies its use. This assumption holds that the oral cavity of the infant has the capacity to produce exactly the same sounds as the adult. Because the capacity of the infant is considered to be the same as that of the adult, it is deemed appropriate to use an adult phonetic system to transcribe the infants' vocalizations. Oller (1980, 1986) and Studdert-Kennedy (1986) have suggested that this assumption is unfounded and premature.

With acoustic analyses it is possible to compare infant utterances to a standard set of acoustic properties of adult utterances and determine at what point infant utterances become speech-like. This changeover typically occurred between 7 and 10 months, with the onset of canonical babbling (Holmgren et al., 1986; Oller, 1986). Canonical babbling is characterized by full closure stops, and reduplicated (CVCV) syllable structure, e.g., "gagaga" or "mamama". The onset of canonical babbling was so dramatic that parents readily, and accurately, indicated its occurrence (Oller & Eilers, 1988). It is canonical babbling which parents and scientists all agree is true babbling.

Canonical babbling. A more precise definition for canonical vocal babbling is presented here as this will form the basis of the definition of canonical sign babbling. Oller (1986) defined canonical vocal babbling using the acoustic criteria that define the presence of a syllable. These criteria were not exhaustive in that they would not include all possible syllables in all languages. Instead, the criteria were intended to define the "canonical" syllable and thereby be appropriate for the majority of syllables produced by the child.

The physical criteria used to define canonical vocal babbling included the duration, resonance, transition time, intensity, and formant range of each utterance. In addition, a comparison of the number of canonical utterances to the total number of utterances produced must have yielded a ratio of at least 0.2. This minimum "canonical babbling ratio" must be achieved by each child before it could be said that she had reached the canonical babbling stage. This stage was typically reached between 7 and 10 months of age in hearing children. Once this stage was achieved there was a great deal of consistency in the child's production of canonical babbling (Oller, 1986; Oller & Eilers, 1988).

Transition from babbling to early words. Having established a method of determining the onset of canonical babbling, the next reasonable question is: When does babbling end? At first glance this appears simple enough: At some point the babbling form must drop out. There are a number of problems with this assumption, however, that entail distinguishing babbling from first words. At the beginning of this discussion it was suggested that the feature "meaningful" would play a crucial role in determining the difference between babble and words. Problems arise in applying this feature to distinguish babbling from first words. A wide variety of definitions of a word are used by researchers in the field of child language. Two differing approaches to the definition of a word are presented here. These two definitions were chosen because both of these authors also addressed the issue of babbling in their research. The implications of this work for the definition of babbling are discussed.

The definition of a word has clear implications for the classification of utterances into words and babbling. Menn (1978,

1983) defined a word as any form which demonstrated a consistent sound-meaning relationship and was used in a symbolic manner. These forms did not need to be based on forms in the adult language. Menn also posited an intermediate form between babbling and words which she called proto-words. Proto-words did not exhibit all the necessary elements of a word but were used repeatedly in a meaningful way, and therefore were not babbling Proto-words were not fully symbolic as they were often used in only one particular context. In addition, the child usually used a proto-word for just one communicative function. Although Menn didn't define babbling *per se*, given her definitions for word and proto-word, babbling must consist of meaningless, non-referential vocalizations.

In contrast, Vihman et al. (1985) proposed that "intent to express meaning" was not a sufficient criterion to define a word. Instead, they chose to define words as "adult-based vocalizations". In practice this definition was extended to include imitations of adult words, ill-formed attempts at adult words, and any "apparent renditions" of a previously uttered word in the child's lexicon. These vocalizations were included regardless of the context in which they were produced. This definition of a word did not include any reference to its communicative function. As a result, for Vihman et al. babbling was defined as anything that did not constitute (by their definition) a word.

Vihman et al.'s definition of a word, however, was both over and under inclusive. Forms that the child used consistently in a referential manner were excluded as words because the form was not based on the adult word used to convey that meaning. Also, vocalizations which had no referential properties, and therefore no meaning, were included as words if there was a phonological

similarity between the child's utterance and an adult word. The problems inherent with this definition of a word underline the importance of considering the referential properties and communicative function of the child's vocalizations. Vihman, Ferguson, and Elbert (1986) recognized these problems and changed their definition of a word. Their definition now includes appropriate contextual and referential use. Vihman et al. (1986) maintain, however, that words must be adult-based in form.

These two examples demonstrate the difficulties inherent in trying to determine when babbling ends. It is important to note that these difficulties centre around the transition period between babbling and early words. The problem lies in classifying these borderline utterances. These difficulties do not call into question the existence of babbling. Babbling is a clear and robust phenomenon. This is supported not only by the hundreds of research articles published on the topic, but also by the absence of articles which deny or explain away its existence. The difficulty in classifying borderline utterances is raised in anticipation of similar methodological difficulties regarding the distinction between signs and sign babbling.

The definition. From this research it is clear that babbling minimally entails the following features.

Babbling must be:

(a) meaningless, and
(b) canonical, that is, it must exhibit well-formed syllables.

These features define the core of the babbling phenomenon. In addition, a set of criteria for distinguishing the transition periods of babbling must be provided. In the transition period that marks the onset of babbling it is important to distingu'sh cooing and babbling. The requirement that babbling must be canonical allows this distinction to be made, because cooing does not involve the production of well-formed syllables. The transition from babbling to early words presents a knottier problem. The evaluation of a form's referential scope, communicative context, and communicative function must be conducted to allow the distinction between babbling and early words to be made.

An adequate comparison of sign and vocal babbling does not rely solely on defining a similar behaviour in the two modalities. The developmental sequence in which vocal babbling appears must also be compared to the sequence of manual behaviours exhibited by deaf children.

Stages of Infant Vocalizations

The development of the infant's vocalizations can be followed from birth, when crying and vegetative sounds predominate, through to the early word stage. The following stages give a general idea of the behaviours that occur throughout this development as well as a range of ages when these behaviours typically occur.

Vegetative Sounds. The earliest stage of vocalizing in infants occurs from birth to two months. During this period very few sounds are identifiable as being similar to elements of the adult language. Most comfort sounds (i.e., non-distress, non-vegetative) tend to be quasi-resonant nuclei (Oller, 1980), an acoustic term meaning vowel-like but lacking the use of full resonance capacities of the oral cavity.

Cooing: Cooing commences at about two months and lasts until approximately four months of age. This stage is characterized by a predominance of back vowels and consonant approximants (similar to [k, g]) as well as glottals [h,ʔ]. (Cruttenden, 1970; Holmgren et al., 1986; Irwin, 1947; Leopold, 1947; Oller, 1986)

Expansion Stage: This stage is explicitly mentioned by only a few researchers and typically occurs between 4 and 6 months of age (Oller, 1980; Stark, 1980). At this stage, infants seem to be experimenting with the production of a wide variety of unusual sounds. These are described by Oller with such terms as raspberries, squeals, and growls and by Stark as vocal fry, affricate clicks, and ingressive voicing. Other researchers (Cruttenden,1970; Lenneberg, 1967; Leopold, 1947; Vihman, Macken, Miller, & Simmons, 1981) note the presence of various "wild sounds" (Jakobson, 1941/1968) such as bilabial trills, labial fricatives, and spirants, which are not phonemic in the environmental language.

Canonical Babbling: This stage is typically identified as true babbling. Canonical babbling begins between 7 and 10 months. This seems to be a very marked phenomenon as the majority of authors report its existence. Holmgren et al. (1986) note a dramatic shift between glottal [h,ʔ] and supraglottal consonants (e.g., [p,b,t,d,k,g]) at 30 weeks. They also remark that the first full closure stops are produced during the same period. Oller (1980, 1986; Oller & Eilers, 1988; Oller et al., 1985) also marks this as an extremely crucial transition; the first fully syllabic vocalizations which are acoustically similar to adult speech are produced when canonical babbling begins. This stage is marked by reduplicated utterances (CVCV syllable structure), a fact noted by many researchers (Cruttenden, 1970; Elbers, 1982; Oller, 1980; Stark, 1980;

Holmgren et al., 1986). A number of other preferences of form are common at this stage of development; these include single consonants over consonant clusters, consonant initial over consonant final, glides over liquids, unaspirated consonants over aspirated consonants, voiced over voiceless consonants, and apical or front sounds over dorsal or back sounds (Oller et al., 1976).

The phonetic and syllabic forms produced in the canonical vocal babbling of hearing children are continuous with the phonetic and syllabic forms produced in their early words (Locke, 1987; Oller et al., 1976; Vihman, 1986; Vihman et al., 1985; Vihman et al., 1986). It must be noted, however, that the continuity observed here is strongest within individual children. Individual differences in the phonetic and syllabic structures used by children in their vocal babbling and early words have been noted by many researchers (Locke, 1987; Oller et al., 1985; Vihman, 1986; Vihman et al., 1985; Vihman et al., 1986). The individual preferences demonstrated in the phonetic and syllabic structure of a child's vocal babbling are often found in the phonetic and syllabic structure of the same child's words (Vihman, 1986; Vihman et al., 1985; Vihman et al., 1986).

Jargon Babbling: By twelve months of age the child begins to produce sentence-like structures with strings of babbling instead of words (de Boysson-Bardies, Sagart & Bacri, 1981; Elbers, 1982; Lenneberg, 1967; Sachs, 1976). An example of jargon babbling would be the production of a lengthy string of babbling with the rising prosodic pattern of a question. To the listener it seems as if the child has every intention of telling you something that is unintelligible because she is speaking a different language! At this time children also begin to combine different consonants in single

utterances, something generally called variegated or mixed babbling (Holmgren et al., 1986; Oller, 1980). Children also begin to produce their first words at this time; however, babbling is noted to continue well into the early word stage of language (Cruttenden, 1979; Leopold, 1947; Vihman et al., 1985; Winitz, 1969).

Summary

In the past, research on babbling has focused on the vocal babbling of both hearing and deaf children. This research indicates that many researchers view babbling as a speech-specific, rather than a language-specific phenomenon. Oller's metaphonological approach to the definition of babbling is a great step forward for this field because it provides an objective way of identifying the transition from cooing to canonical vocal babbling. Canonical babbling is the production of well-formed syllabic units. Studies involving deaf infants provide evidence that linguistic auditory input is necessary for canonical vocal babbling to develop. It is canonical vocal babbling that is continuous in both phonetic and syllabic form with early speech.

In this thesis, the sign babbling of deaf infants acquiring a sign language as their native language is examined. In particular, three questions are addressed. First, does sign babbling exhibit the characteristics noted in the canonical vocal babbling of hearing infants? That is, is sign babbling canonical? Does it share the properties of canonical vocal babbling in all respects, save modality? Second, what are the phonetic and syllabic properties of sign languages that emerge in sign babbling? Third, is canonical sign babbling continuous with the phonetic and syllabic form of early signs?

Background

ASL Phonology

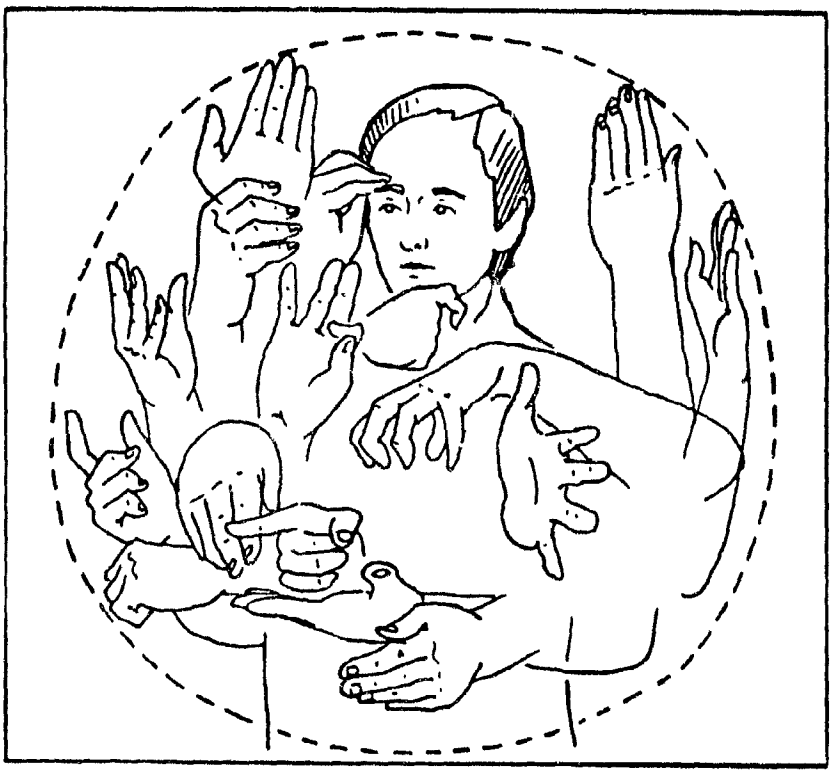
A fundamental assumption made in conducting this research is that sign languages are "real" languages. They share highly similar structural organization with spoken languages on the phonological, morphological, syntactic, and discourse levels (Fromkin, 1988; Klima & Bellugi, 1979; Newport & Meier, 1985; Padden, 1988; Stokoe, 1978; Wilbur, 1987; Wilbur & Petitto, 1983). The discussion of the linguistic structure of ASL in this paper focuses on the level of language that is directly relevant to babbling, namely phonology. Evidence is presented below which supports the claim that there exists similar organization at the phonological level of both signed and spoken languages.

Spoken language phonology consists of articulatory features (e.g., +/- voice, +/- nasal) which combine to create a finite set of sounds. The sounds used for language represent a subset of the possible vocal sounds that humans are capable of producing. Each language utilizes an even smaller subset of the possible sounds for language to produce the words in its lexicon. The combination of sounds used to create words is constrained by the phonological rules of each language. These phonological rules are unique to each language; what is an acceptable combination of sounds in one language may not be acceptable in another (Fromkin & Rodman, 1983). An example of this is the combination /mb/. This combination of sounds is not accepted at the beginning of English words. In other languages, such as Swahili, this combination of sounds is perfectly acceptable at the beginning of a word.

Sign language phonology exhibits the same levels of organization, differing only in the actual form of the units used (Coulter, 1986a, 1986b; Klima & Bellugi, 1979; Newport & Meier, 1985; Padden, 1988; Padden & Perlmutter, 1987; Stokoe, 1978; Wilbur, 1982, 1987; Wilbur & Nolen, 1986). A finite set of manual primes are manipulated to produce each sign. This finite set of manual primes for language represents a restricted set of all the possible primes which could be produced by the human hand (Fromkin, 1988; Wilbur, 1987). Each sign language utilizes an even smaller subset of these manual primes for language to produce the signs in its lexicon. The combination of primes used to create signs is constrained by the phonological rules of each sign language. These phonological rules are unique to each sign language; what is an acceptable combination of primes in one sign language may not be acceptable in another.

The manual primes of sign languages are separated into four types, called parameters. The four basic parameters of signs are handshape, location, movement, and palm orientation. Handshape refers to the configuration of the hand used for a particular sign. There are approximately 40 hand primes in ASL (Klima & Bellugi, 1979; see Figure 4, p. 41 for examples of handshapes). Location is the place where the sign is made. There are 12 possible locations in ASL (Stokoe et al, 1976). Signs can be made only in this restricted space in front of the signer's body. Figure 1 illustrates the permissible locations within which all ASL signs must fall. The third parameter is movement; every sign contains at least one movement. There are 24 different types of movement in ASL (Stokoe et al, 1976). The last parameter is palm orientation. This parameter indicates whether the palm of the hand is facing in, out,

Figure 1. The Constrained Signing Space of ASL



Note: This figure is from The Signs of Language (p. 51) by E. Klima & U. Bellugi, 1979, Cambridge, MA: Harvard University Press. Reprinted by permission.

up, down or to either side (Klima & Bellugi, 1979) The primes of these four parameters, handshape, movement, location, and orientation are analogous to the articulatory features of spoken languages. Thus, like words in spoken languages which produce words from a finite set of features, signs are produced from a finite set of units called primes

Also like spoken languages, there are phonological rules which govern the way manual primes may be combined In other words, certain handshapes may be used with certain locations, movements, or palm orientations but not with others (Battison, 1974, Mandel, 1979, Siple, 1978, Wilbur, 1987). The set of primes from which signs are produced, as well as the phonological rules which govern allowable combinations of primes, differs for every sign language (see Klima & Bellugi, 1979, for Chinese Sign Language; Petitto, Charron & Brière, in preparation, for Langue des Signes Québécoise; Kyle & Woll, 1985, for British Sign Language). In this way the phonology of sign languages is highly similar to the phonology of spoken languages.

Reality of sign language phonology. We now have several lines of evidence that support the linguistic and psychological reality of the sign language phonology described above. One compelling source of evidence is the presence of minimal pairs for each parameter A minimal pair is a set of words differing along only one feature An English example is the set *bin-pin*. These words show that the voicing feature is phonemic in English (the sole difference between /b/ and /p/ is voice onset time) This means that a change in voicing can signal a difference in meaning in English Minimal pairs can be found for each of the four parameters in ASL, there are pairs

of signs which differ in only one parameter, that is, handshape, or location, or movement, or orientation. Examples of minimal pairs in ASL can be seen in the signs SUMMER, UGLY, and DRY (really a minimal triplet!), which are presented in Figure 2a. These signs share the same handshape, movement, and orientation. They differ only in the location in which each sign is made. Another minimal pair which differs along the orientation parameter are the signs CHILD and THING, presented in Figure 2b. These signs share handshape, movement, and location parameters but differ on the orientation parameter. There are also minimal pairs involving handshape and movement (see Klima & Bellugi, 1979). That a change of one prime of a sign (when all the other primes are held constant) changes the meaning of that sign suggests that the proposed phonological structure is required to fully describe the linguistic structure of these languages.

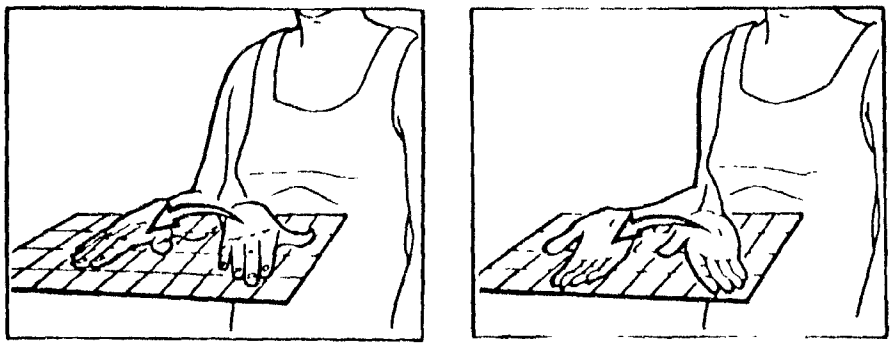
Evidence for the psychological reality of the phonological level comes from memory experiments done by Klima & Bellugi (1979). Sign recall experiments were performed and the intrusion errors of native ASL signers were examined. In spoken languages, intrusion errors in recalling lists of words tend to be based on the acoustic properties of the word. For example the word *vote* might be remembered as the word *boat*. Because ASL signs do not differ on acoustic properties it is interesting to examine the kind of errors signers make. If signs are simply pictorial units which are processed in a holistic manner then it is possible that errors will be semantic in nature. This would result in confusions of signs such as BIRD with FLY or WINGS. This is not what happened. The intrusion errors made by deaf signers were based exclusively on the manual-visual properties of sign phonology discussed above.

Figure 2. Examples of Minimal Pairs in ASL

a) Minimal Pairs Contrasting in Location

SUMMER UGLY DRY

b) Minimal Pairs Contrasting in Orientation



CHILD THING

Note: This figure is from The Signs of Language (p. 42, p.48) by E. Klima & U. Bellugi, 1979, Cambridge, MA: Harvard University Press. Reprinted by permission.

For example, the sign BIRD was confused with the sign NEWSPAPER which is phonologically similar to the former but differs in location as is indicated in Figure 3 (Klima & Bellugi, 1979). This result indicates that signs are not processed as holistic, pictorial units but are decomposed into their linguistic parameters.

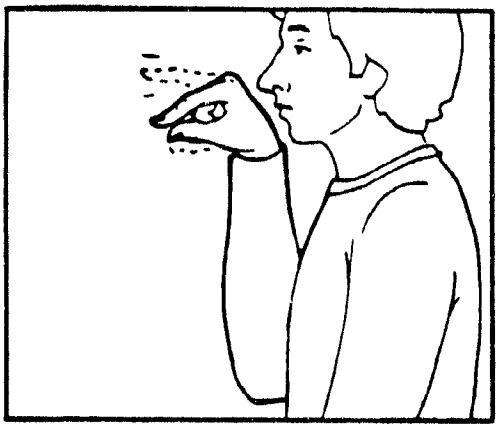
Further evidence for the phonological level of sign languages comes from slips-of-the-hand. The slips made by deaf people in signing are similar in form to slips-of-the-tongue made by hearing people. Errors are made by transposing features of one "phonological" parameter between two signs or by carrying one feature into the next sign (Newkirk, Klima, Pederson & Bellugi, 1980). Importantly, handshapes that are outside of the phonological inventory of ASL do not appear in sign "spoonerisms".

The research discussed above demonstrates that the organization of sign language phonology shares fundamental properties with the phonological organization found in spoken languages. Three lines of evidence support this statement. First, signs are created from a restricted set of units. Second, there are phonological rules which govern the ways in which these units can be combined. Third, both linguistic and psycholinguistic evidence strongly suggests that the structure of sign phonology is linguistically necessary and psychologically real.

The Syllable in ASL

A clear notion of what a syllable looks like in sign language is essential to the present paper. As noted earlier, the production of well-formed syllabic units is crucial to the definition of canonical vocal babbling (Oller, 1986). In order to demonstrate the presence

Figure 3. Sign and Error Pair Made During a Recall Task



BIRD

Sign meaning 'newspaper'

Note: This figure is from The Signs of Language (p. 103) by E. Klima & U. Bellugi, 1979, Cambridge, MA: Harvard University Press. Reprinted by permission.

of canonical sign babbling it will be necessary to understand syllable structure in ASL.

The definition of the syllable is the subject of great controversy, even in spoken languages where linguistic research is well advanced. There is general agreement that such a unit exists for each language; the disagreement focuses on exactly what comprises a syllable in any given language. For spoken languages, a general definition states that "the syllable is an abstract programming unit in terms of which speech is articulated" (Kenstowicz & Kisseberth, 1979, p. 256).

The problem arises in specifying what is included in the "abstract programming unit". Kahn (1980) proposed three rules to predict how a word would be broken up into syllables. Briefly these are: (a) make each [+syllabic] segment (usually a vowel) the syllable nucleus, (b) include the maximal string of possible syllable initial consonants preceding the vowel, and (c) include the maximal string of possible syllable final consonants following the vowel, providing that those consonants were not previously assigned to the next vowel. Clearly what is [+syllabic] and what the possible syllable initial and syllable final consonant strings are will vary from language to language.

Given the focus on consonants and vowels in the definition of a syllable, it is reasonable to question whether or not this structure is applicable to sign languages. However, Kahn's definition was an attempt to specify how the "abstract programming unit" might be realized in the specific, acoustic prcperties of the speech stream. If we return to Kenstowicz and Kisseberth's general definition of the syllable as an "abstract programming unit" it is clear that there is

nothing which would preclude its application to sign languages.

The definition for the syllable in ASL is no less controversial. Sign researchers fully agree that such a unit exists for sign languages (D. Brentari, personal communication, May 17, 1989, Coulter, 1986a, 1986b; Liddell, 1984, Newkirk, 1980, Sandler, 1986; Wilbur, 1982, 1987, in press, Wilbur & Nolen, 1986) As in spoken languages, the disagreement concerns which elements belong in the syllabic unit for ASL Recognition of the syllabic level of sign language phonology has been spurred by discussions of sequential models of ASL phonology.[2]

The sequential model proposed by Liddell (1984) suggests that signs are divisible into two types of segments, movement (M) and hold (H). These segments combine in a limited number of ways that are analogous to the possible consonant-vowel (CV) combinations found in spoken languages Liddell compares M and H in sign languages and C and V in spoken languages, suggesting a similarity of function between these segments. He stops short, however, of directly applying his model to a theory of the syllable itself.

Using Liddell's M and H segments as his base, Coulter (1986b) proposes a syllable theory which equates M with V segments and H with C segments. He supports his theory through an analysis of the sonority hierarchy in both spoken and sign languages. In spoken languages V is generally longer in duration and louder than C, and

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[2] Traditional models of ASL phonology maintained one distinction between signed and spoken languages. Unlike spoken languages, which combine phonemes in a linear or sequential fashion to produce words, sign languages appeared to combine phonemes simultaneously to produce signs Recent models of ASL phonology have demonstrated the sequential aspects sign language phonology. The traditional simultaneous analysis of ASL signs could not explain significant portions of the lexical corpus. Many reduplicated signs, compound signs, and signs with handshape and location change were unsatisfactorily handled or left out of previous analyses all together (Liddell, 1984). The need for sequential models of phonology is currently recognized by the majority of sign language researchers (see Padden, 1988 for a discussion of this issue).

therefore is higher in sonority, giving it greater perceptual salience. The nucleus of the syllable is generally chosen from the vowels or sonorous units in the language. Applying the idea of sonority to sign languages, Coulter looked for a physical feature which would distinguish the two kinds of segments in sign languages. He chose the criterion of relative velocity of the segments and was able to distinguish M and H along this dimension. The highly sonorous element for ASL was the M segment which Coulter identified with the V segment of spoken languages. The element with lower sonority was H which was produced with a much slower segment speed. Coulter equated H with the C segment of spoken languages.

This syllable structure is supported by the evidence that native signer's intuitions about the number of syllables in a sign equals the number of syllables found using the M and H segments (Coulter, 1986b). Further support for this theory idea comes from evidence that the syllable identified in this way is also the unit of emphatic stress in signs (Coulter, 1986b).

Problems with Coulter's theory stem from his reliance on Liddell's (1984) analysis of signs into M and H segments. Liddell's work does not distinguish between two types of movement in ASL (Wilbur 1982, 1987, in press). It is possible to have path and/or local movement in an ASL sign. Liddell's theory only considers path movement and ignores the importance of local movement. Path movement refers to a change in location of the sign. For example, the sign KING has its first contact point at the left shoulder and then moves diagonally across the body to its second contact point at the right hip. Local movement, on the other hand, does not necessitate a change in location. Local movement is the result of either a handshape change, e.g., the alternation between G and bO in

the sign BIRD (see Figure 3), or an orientation change, e.g., movement at the wrist or elbow as in the sign YES. In Wilbur's theory, every syllable must have movement, and movement results from a change in handshape, location, orientation, or any combination of these three parameters.

In addition to her concerns about the inclusion of local movement in a complete theory of the syllable, Wilbur (in press) disagrees with the use of M and H segments in a sequential analysis. She prefers to use an autosegmental approach with three separate tiers, one each for handshape, location, and orientation (see also Padden & Perlmutter, 1987; Sandler, 1986 for further discussion of tiers in ASL). The possibility remains open that additional tiers may be required for other information such as non-manual markers (i.e., change in facial markers, or body stance that co-occur with a sign). Very little research has been done on the importance of these non-manual markers for syllable structure in ASL.

For this paper, the criterion established by Wilbur (1987, in press) and Brentari (personal communication), will be used as the basis for a definition of the syllable in ASL.[3] The basic requirement is that every syllable must exhibit movement or change.

A well-formed ASL syllable contains:

(a) a handshape,
(b) a location, and
(c) a handshape change, and/or
a location change, and/or
an orientation change.

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[3] I would like to acknowledge the help of Diane Brentari (Linguist, University of Chicago) for discussions on the syllable structure in sign languages, and for highlighting the minimally relevant units of the syllable in ASL.

A note on the physical measurement of sign syllables.

Coulter's (1986a, 1986b) work on defining the sign syllable using relative velocity is very important. The use of an objectively quantifiable measure to determine sign syllable status will contribute to the metaphonological analyses of canonical sign babbling. At the present time, the use of a physical measure of syllabicity in sign languages is untenable. Coulter's work is still in progress and has not yet been published. Nor has he systematically considered other possible options for physical measures of syllable status. Wilbur (in press) mentions alternatives such as acceleration, change in acceleration (technically, jerk), tension, or force. It is also quite possible that a combination of the above measures will be needed to adequately describe the sign syllable, as this is the case for the measures used in spoken languages. Until these options are systematically pursued with adult signers, and some agreement is reached with other researchers involved in sign syllable research, it will not be possible to present physical measures of syllabicity in sign babbling.

The requirement for a physical measure of syllabicity comes from adopting a metaphonological approach (Oller, 1986). This approach attributes canonical vocal babbling status based on both acoustic and phonetic properties of the vocalization. The purpose of the metaphonological approach is to determine when the child is producing vocalizations with well-formed syllable structure. Vocalizations that meet the acoustical criteria such as resonance, intensity, and formant range, are then transcribed. As is pointed out above, the equivalent of an acoustic measurement of the syllable for sign languages is not currently available. Nevertheless, a linguistic

definition of the sign syllable, requiring the presence of certain features such as handshape change or location change, can be applied to children's manual productions. The linguistic definition of a sign syllable that will be used in this thesis is presented above. Using this definition, it is entirely possible to meet the requirement that children's utterances be the production of well-formed syllables. As a result, canonical sign babbling status can still be attributed.

It should be noted that the use of Oller's metaphonological criteria sets a high standard for this research. The majority of vocal babbling research is conducted relying solely on phonetic transcriptions. Acoustic measures of well-formed syllable structure are generally not provided in current vocal babbling research. The definition of sign babbling used in analyzing the data presented in this paper absolutely requires the presence of well-formed syllabic structure to be demonstrated. As a result, these data are no less valid due to the lack of a physical measure for the sign syllable. Syllabic units can be reliably identified using a set of linguistic requirements. It is fully expected that, should a reliable physical measure of sign syllabicity be established, the results of data analysis using those criteria would corroborate the findings in the present paper.

Phonological Acquisition in ASL

Relatively little is known about the development of ASL phonology *per se*; most studies of early language acquisition have focused on the acquisition of signs. Two studies have examined the acquisition of the handshape parameter in ASL (Boyes-Braem, 1973; McIntire, 1977). No studies exist that examine the acquisition of all four phonological parameters of sign language. This is tantamount to studying hearing children's acquisition of the voice/voiceless

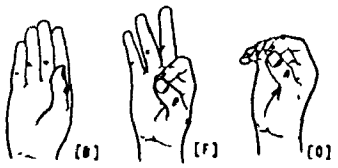
feature of speech and ignoring all of the other components, such as place of articulation, that are necessary to produce a linguistically relevant sound.

The first study (Boyes-Braem, 1973) predicted the acquisition of phonological features using two criteria: the first, a consideration of anatomical constraints and the development of motor control of the hand, and the second, a distinctive feature analysis of ASL handshapes. A feature is considered distinctive if a change in that feature results in a change in meaning of the word or sign, that is, a feature for which minimal pairs can be found in the language. Boyes-Braem proposed four levels or stages of acquisition. The handshapes, and the stages with which they are associated, are displayed in Figure 4. The first stage consists of handshapes which require either the whole hand (**5**, **A**, **A_S**, **C**) or independent manipulation of the thumb and index finger (**L**, **bO**, **G**). These handshapes are likely to be useful to the child for other non-linguistic functions such as pointing and grasping. The remaining three stages consist of handshapes which the child must develop solely for linguistic purposes. Boyes-Braem predicted that the order of acquisition of these handshapes would be dependent upon the difficulty of the anatomical requirements for the features of each handshape. The first digits to achieve voluntary control are the thumb and index finger; independent movement of the middle fingers is the most difficult. The handshapes which required these more complex features (e.g., **K**, **R**, **8**, **Y**, **W**) were predicted to be learned late.

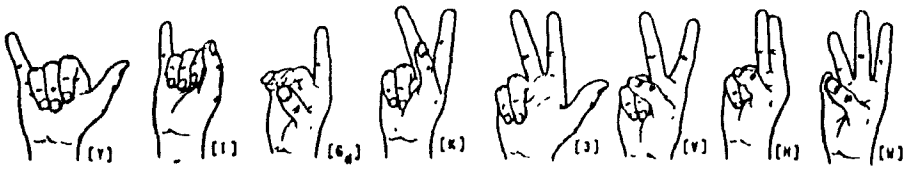
In addition to the factors mentioned above, Boyes-Braem discussed five secondary factors which may have influenced use of handshape. These secondary factors were: use of mimetic elements

Figure 4. Boyes-Braem's Stages of Phonological Acquisition in ASL

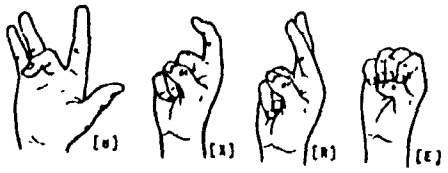
Stage 1



Stage 2



Stage 3



Stage 4

Note: The handshapes used in this figure are from The Signs of Language (p. 44) by E. Klima & U. Bellugi, 1979, Cambridge, MA: Harvard University Press. Reprinted by permission.

to clarify descriptive statements, anticipation and retention of handshape across signs, preference for index fingertip contact, presence of visual feedback (i.e., can the child see her hand or must she rely on haptic feedback?), and nature of the movement required for the sign. The first two factors influenced the use of handshape in adults as well as children. The secondary factors that were of greater interest were those that affect only children's signing.

The predictions made by this theory of phonological acquisition were that, barring secondary influences, children would acquire handshapes in a certain order according to the difficulty of the features. Secondly, if the child had not yet mastered a handshape, a phonologically related handshape from an earlier stage would be substituted. This substitution is regularly observed in hearing children. Complex sounds are often "reduced" and a simpler sound which shares a distinctive feature such as place of articulation is produced in its place. For example, a child may replace the /sh/ in the word *fish* with an /s/ because it is easier to produce (Reich, 1986).

Evidence supporting these predictions came from the errors made by Boyes-Braem's subject, a 31 month old deaf child of deaf parents. Some errors were motivated by the secondary factors mentioned above, however, the majority of the errors made consisted of substitutions of an earlier handshape for a more complicated handshape that had not yet been mastered. The handshapes most commonly chosen as substitutes were from the Stage 1 group, comprising 75% of substitutions. This confirmed their position as primary handshapes for the child. In addition, the substitutes were not randomly chosen but were phonologically

related to the adult handshape for the sign. In other words, the substituted handshapes shared distinctive features with the desired handshape.

Boyes-Braem based her study on a one-hour videotape of a 31 month old child. As a result, the study must be treated as preliminary evidence only, and as a starting point for further research. Given the limited nature of the data, one hour of videotape from one linguistically competent child, it is difficult to determine if the phonological development follows the proposed stages. Nevertheless, the predictions generated by this theory are interesting and testable.

The second study (McIntire, 1977) followed the phonological development of one deaf child of deaf parents between the ages of 13 and 21 months. These data were examined in light of the predictions made by Boyes-Braem's theory. The data from this child supported the primacy of the Stage 1 handshapes with the exception of the handshapes **C** and **L** which were not used often. The Stage 1 group accounted for 97% of all substitutes made by this child. It must be noted that McIntire's subject was an average of one year younger than Boyes-Braem's subject at the time of the videotaping sessions. It appeared that this child had not yet mastered any of the handshapes from the later stages. As a result, while supporting the primacy of Stage 1 handshapes, these data did not help to confirm the order of acquisition of the more complex handshapes.

The evidence presented in both of these papers were phonological errors made by children who were already signing. The actual course of acquisition of handshapes themselves has not been studied. Neither the order of acquisition of handshapes, nor the age at which handshapes are mastered by the child is clear from the

available evidence. The data provided by an analysis of signed babbling directly addresses these issues.

Research Objectives

The goals of this thesis are threefold. The primary goal is to establish whether children acquiring sign language as their native language produce canonical sign babbling. The second goal is to examine the phonetic and syllabic structure of the early linguistic productions of the deaf children. In addition, for the first time, the phonetic analysis includes an examination of children's acquisition of the movement, location, and orientation parameters. A syllabic analysis of children's sign babbling and early sign is also conducted for the first time. The third goal is to determine whether or not canonical sign babbling and early signs share a continuity of phonetic and syllabic structure. This continuity has been demonstrated for canonical vocal babbling and early words. The implications of the above analyses for the biological foundations of language will be considered.

Methodology

Subjects

Two deaf children of deaf parents and three hearing children of hearing parents participated in this study (N = 5). The ages of the subjects ranged from approximately 10 to 14 months The deaf children were acquiring American Sign Language. The hearing children were acquiring two distinct spoken languages, English and French. Two of the hearing children were from French speaking homes, and one child was from a bilingual home where both French and English were spoken

The parents of the first deaf child, Kate, lived and worked in a deaf community in Northern California Kate was an only child at the time of this study. The parents of the second deaf child, Victor, lived and worked in Montréal.[4] Victor was the second child in his family; he had an older deaf sister (age 2,3 at the time of his birth). The parents of both of these children were elementary school teachers in schools for profoundly deaf children. Both of these families were active members of the deaf community in their respective neighbourhoods

The three hearing children in this study were all from the Montréal area. These children served as controls for the deaf children. The most important criterion for choosing these children was that they had no exposure to any sign language. The two children from the French families are called Marie-Claire and

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[4] This family was originally contacted through the MacKay Centre for Deaf and Physically Handicapped Children. We would like to extend our thanks to the MacKay Centre for their help in locating this family.

Michèle in this study, and the third child from the bilingual home is called Charles.

The deaf children selected for participation in this study met stringent criteria in order to ensure the purest language environment possible (i.e., minimal or no influence from the spoken majority language). Only children who were both profoundly and prelinguistically deaf, and who had two deaf parents -- both of whom used a natural signed language as their primary mode of communication -- were selected. Additionally, no cognitive deficits or physical problems were present in either of these children. Both of these children are school-age now. Their linguistic, cognitive, and social development are entirely normal and age-appropriate.

It is noteworthy that a sample size of two deaf children constitutes a significant number due to the rarity of this population. For example, of the estimated 500 000 profoundly deaf people in the United States, only 9% of them are born to deaf parents (Schein & Delk, 1974). Holding aside such issues as degree of hearing loss and age of onset, the percentage of this group of deaf people (9% born to deaf parents) who (a) are married to another deaf person, (b) have profoundly deaf children (rather than hearing or hard-of-hearing children), and (c) use ASL in the home as their primary means of communication, comprises an even smaller group.

Indeed, this population is quite rare. A recent census of Canadian deaf children (MacDougall, 1987) indicates that deaf children acquiring sign from deaf parents are equally rare in Canada. At the time of this study, Victor, the ASL child from Montréal, was the only deaf infant of an ASL signing family in Québec.[5]

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[5] This was established by the census taken for the McGill Study of Deaf Children in Canada (MacDougall, 1987).

A final, more socially related factor influences the recruitment of deaf subjects. Once this population is identified, it can be additionally difficult to recruit subjects as there is reticence about participating in research, particularly with hearing researchers.

Procedure

Data collection. The children were videotaped for approximately one hour every month as part of an ongoing longitudinal study being conducted at the Laboratory for Language, Sign, and Cognitive Studies (Director, L.A. Petitto) at the Department of Psychology at McGill University in Montréal, Canada.[6] Taping occurred in the child's home or in a comfortable videotaping studio at McGill, depending upon the families' proximity to the university. Taping sessions at approximately 10, 12, and 14 months were selected for analysis in this study. The exact ages of each child at the time of taping, as well as the duration of each tape, are found in Table 1.

Structured taping sessions were designed to permit direct observation of particular aspects of the children's development. Elicitation tasks and toys were chosen to encourage gestural and linguistic behaviour. Typically, the child, mother and experimenter participated in each taping session. All taping sessions were conducted in the families' primary language. The taping sessions for Charles, the child from the bilingual family, were conducted primarily in English. Each session consisted of three parts.

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[6] Only Kate's data constitute an exception to this. Her data were collected as part of Dr. Laura Petitto's dissertation research (Petitto, 1986, 1987), under the auspices of Dr. Ursula Bellugi, Director, Neurolinguistics Laboratory, The Salk Institute for Biological Studies, La Jolla, California.

Table 1. Ages at Taping and Duration of Taping Sessions for Each Child

Child	Language	Age (yr;month.day)	Length of Videotape (minutes)
Kate	ASL	0;10.10	55
		1;00.00	25
		1;02.17	10*
Victor	ASL	0;09.26	60
		0;11.29	45
		1;01.23	60
Marie-Claire	French	0;09.27	30
		0;11.27	40
		1;02.14	40
Michèle	French	0;10.10	35
		1;00.14	50
		1;03.07	50
Charles	English/ French	0;11.09	30
		1;00.08	75
		1;01.29	50

* This session was taped by Kate's parents at their home. This explains the short duration of the tape. There was no tape at 13 months that could have been substituted. Despite the brevity of this session Kate does produce a significant amount of linguistic activity. It is for this reason that the tape was included in the corpus.

1. Warm-up period: A warm-up period of approximately 5-10 minutes was initiated to allow the child to adjust to the taping situation and the experimenter; during this period the child was allowed to move freely about the room.

2. Object interaction task: A period of interaction between the child and adults occurred next. This lasted approximately 30-45 minutes. During this time, toys were provided by the experimenter to facilitate communicative interactions and elicit linguistic behaviour between the mother and child and/or child and experimenter. To enable both within child and cross-sectional comparisons of the children's behavior, similar or identical toys were shown to each child at a given age. The items consisted of both common household objects (e.g. comb, mirror) and other age-appropriate toys (e.g. stuffed animal at 10 months, toy cash register at 14 months).

The toys were not presented in a specified order, nor was it a requirement that a certain amount of time be spent with any particular toy. The goal of this interaction period was to elicit linguistic and gestural communication. Any toy that was successful to this end was naturally in use for a longer period of time. An effort was made, however, to ensure that the children were presented with the same toys at the same ages. A list of toys used in the taping sessions can be found in Appendix A.

The experimenter maintained a relaxed, non-directive manner while presenting the child with toys and asking questions such as "What is this?" or "What do you do with this?".

3. Solitary play: Finally, a period of 5-10 minutes of solitary play was initiated. Here the experimenter engaged the parent in

conversation while the child remained nearby with his or her toys. The purpose of this period was to allow the child to play alone, as this has been observed to be successful in eliciting babbling.

Transcription and computer data-base analyses. After videotaping the children, data were extracted from the tapes for subsequent analysis in the following way. All hand activity was transcribed for all children, both deaf and hearing, in the same manner. First the gesture, signs, proto-signs and potential sign babbling forms were coded. An example of this transcription sheet can be found in Appendix B. Second, forms that were identified as potential sign babbling forms were transcribed using sign phonetic notation (Stokoe et al. 1976; see below), noting the possible linguistic properties of these productions. The transcription sheet used for this purpose can be found in Appendix C. The information coded in both the general and detailed transcriptions are presented below.

The transcription procedure required to extract the necessary data from the videotapes is an extremely time intensive one. The first, general coding procedure for all the gestures requires 10 pieces of information per frame (e.g., hand form, use, context). The second, specific coding procedure requires notation of an additional 10 frames of information (e g., eye gaze, contact, location). This represents roughly 50 hours of transcription per hour of videotape. Each videotape was fully transcribed twice. All tolled, the transcription of Kate and Victor's data required approximately 500 hours of transcription time.

I. General transcription form. All hand activity was coded in terms of the following characteristics:

(i) hand forms, precise information about the physical form of each of the child's hands was noted (this is discussed further below) e.g., open hand with spread fingers vs. clenched fist,

(ii) hand of production, right or left hand,

(iii) empty handedness, whether an activity was performed with an object in hand or the hand was free of objects,

(iv) form combinations, whether the form occurred alone or in combination with other forms,

(v) target object, the object that was involved or referred to by the child's form (the apparent referent of a form),

(vi) use, whether the form was used to request, comment etc.,

(vii) context, information about the child's surroundings, who they were interacting with, and the focus of the current activity,

(viii) parental interpretation, e.g., the response to the child's hand activity,

(ix) signs, signs (and proto-signs) in deaf children and words (and proto-words) in hearing children were noted also with regard to entries 4 through 8 above, and

(x) comments, any unusual or interesting characteristics of the child's behaviour or the parental response were noted here.

II. Sign phonetic notation. Hand activities judged to be actual or possible instances of babbling were transcribed using a system adapted from Stokoe et al (1976) and widely used in the notation of ASL (Boyes-Braem, 1973; Charron, 1989; Klima & Bellugi, 1979;

McIntire, 1977; Petitto, 1986, 1987). This transcription system is based upon the phonetic structure of ASL and requires notation of handshape, movement, location, and palm orientation parameters for both hands. These parameters are discussed in greater detail in the Background section of this thesis (pp. 26-29). Attribution of syllabic status can be made given the phonetic information discussed above. Recall that the definition of a well-formed syllable requires:

(a) a handshape,
(b) a location, and
(c) a handshape change, and/or
a location change, and/or
an orientation change.

Potential sign babbling forms were transcribed along the following features:

(i) eye gaze, direction of eye gaze during production of form,
(ii) object, the object that was involved or referred to by the child's form (the apparent referent of a form),
(iii) contact, form produced in contact with an object or with the body,
(iv) right handshape, the handshape prime produced by the right hand,
(v) right movement, the movement prime produced by the right hand,
(vi) right palm orientation, the orientation prime produced by the right hand,
(vii) location, the location prime in which the form was produced,

(viii) left handshape, the handshape prime produced by the left hand,

(ix) left movement, the movement prime produced by the left hand,

(x) left palm orientation, the orientation prime produced by the left hand, and

(xi) facial expression, non-manual markers produced in conjunction with the form.

Transcriber Reliability. Reliability was calculated separately for each deaf child. Portions of both Kate and Victor's data were re-transcribed by a fluent signer of ASL. These transcriptions were checked against those of the author. Reliability was 90% for Kate's gestural points and 82% for her signs, ill-formed signs, and sign babbling in her 10 month videotape session. A randomly chosen 20 minute segment of Victor's 12 month tape was transcribed by the same signer. Reliability on this tape was 95% for all coded behaviours.

The reliability for the hearing children's gestures was calculated in a similar way. Each tape was transcribed by two coders. The overall reliability of the transcription of the hearing children is 92%. This represents approximately 25% of the hearing children's data.

Methodological Considerations

Three types of hand activity were of particular interest here: the deaf children's communicative gestures, their sign babbling, and, finally, their early signs. The hearing children's data were of interest for two reasons. First, they provided the basic data which allow cross-modal comparisons of children's pre-linguistic

gestures. Second, as controls, the hearing children provide the necessary data to ascertain that the hand activities classed as babbling are not in fact forms common to all children, regardless of the type of linguistic input they receive. Accurate classification of gesture, sign babbling, and sign requires clear definitions of these behaviours.

By far, the most common methodological problem in the study of hearing children's vocal babbling is the precise classification of transitional utterances as babbling. The greatest difficulty lies in determining the onset/offset boundaries for the phenomenon. This problem was mentioned earlier in the Introduction (pp. 16-21); recall the decision not to include cooing as part of the babbling phenomenon was discussed. At what point does the researcher begin to classify utterances as babbling rather than as cooing? The meta-phonological approach developed by Oller and his colleagues has helped to address this issue by presenting an empirical definition of the necessary characteristics of babbling. This definition is based on the production of canonical syllables which share the acoustic properties of adult speech. The onset of the production of these syllables indicates the beginning of canonical babbling.

A more difficult decision remains in determining whether a particular utterance is a babble or a word. Each researcher must come up with his or her own criteria to make this distinction and these criteria are often quite different depending upon the particular question the individual is addressing. For example, recall that Vihman et al. (1985) ignored the communicative function of the child's utterance and classed utterances as words if their phonetic form could be related to identifiable adult models. All utterances for which there was not an identifiable relationship with an adult

word were considered babbling. In contrast, recall that Menn (1983) classified utterances as babbling if they were meaningless. If an utterance showed a recurrent association between sound and meaning, regardless of its phonetic similarity to the adult word, it was called a word. These examples demonstrate the radically different solutions posited in response to the same problem.

The problem of classification is amplified by the existence of utterances which don't fall into either class of babbling or word. These utterances, which are recurrent, patterned vocalizations, have been called proto-words (Menn, 1978, 1983). They are difficult to classify because, although they have some sound-meaning correspondence, they are used in a restricted range of contexts In addition they may serve only one communicative function for the child. Menn gives an example of a proto-word which was used repeatedly by her subject, but only when he was in the living room watching the family dog play in the front yard. The same "word" did not transfer to any other situations, nor was it used to refer to the dog in any other context (Menn, 1978). This example suggests that proto-words are not fully symbolic and therefore not words; yet, at the same time they do convey meaning and therefore cannot be classified as babbling.

In the case of signed babbling these same methodological considerations arise. One must clearly define how to differentiate motoric behaviour from babbling, and babbling from actual attempts to sign. In addition, because gesture also occurs in the visual-manual modality, a methodological problem unique to this type of research arises. It is extremely important to differentiate what is linguistically relevant, babbling and attempts to sign, from what is

non-linguistic, in this case, gesture. At the same time, one must also ensure that the hand activity which is labelled babbling in deaf children does not occur in hearing children, albeit as prelinguistic gestures. In order to forge the necessary distinctions and safeguard against possible confusions, clear operational definitions of babbling, gestures, proto-signs, and signs are necessary.

Sign Babbling. Sign babbling is the production of an utterance which conforms to the syllabic and phonetic structures of sign languages. The form has no conventional meaning, and therefore no referent in the real world. It may be produced privately or in "conversation" with another person. Although infants may babble intentionally to receive visual, aural, or kinesthetic feedback, they can not be said to be intentionally trying to produce particular phonetic hand primes or sound units (vis-a-vis deaf and hearing children's babbling forms, respectively).

The syllable in sign language is based on changes of handshape, location, or orientation (Wilbur, in press) It is the child's consistent production of a well-formed syllabic unit which signifies the onset of canonical sign babbling (Oller, 1986; Oller et al, 1985; Oller & Eilers, 1988). The requirement of a canonical unit presents a way of distinguishing babbling from the random motoric behaviours, such as swatting, that all children do with their hands

It is expected that canonical signed babbling will appear as a distinct class of hand activities found only in the deaf children. It should be noted that hearing children of deaf parents are expected to produce canonical sign babbling if they are acquiring a sign language as their native language. The production of these linguistically relevant hand activities is in no way dependent on the deafness of the individual, but rather on the particular language environment in

the acquisition years. Research to address this prediction is currently being conducted (Petitto & Marentette, in progress).

Signs. Another hand activity which is expected to be unique to the deaf children is their production of actual signs. Sign status is determined through an analysis of the form, content, function, and use of the utterance If the form is highly similar to the adult form of the sign, has conventional meaning, is used for multiple goals (i.e., request, comment), and across multiple contexts, then the form will be considered a sign. The parental interpretation of the utterance, and the presence of a context which supports that interpretation, will be considered only as supporting evidence in the attribution of sign status.

Proto-signs. Signs are symbols which have a principled relationship between form and referent. The phonological form of a sign is stable. During the transition period from sign babbling to first signs, a special type of utterance occurs which marks the development of meaning and form. These are called proto-signs (after proto-words, see Menn, 1978, 1983). Proto-signs are utterances which, although they have a real world referent, are not fully symbolic and are used in a restricted set of contexts or for a restricted set of functions. In addition, proto-signs do not exhibit the fully developed phonological form of the adult sign.

Communicative gesture. The class of hand activity which is most important to distinguish from babbling is that of gesture. Communicative gestures can refer, pick-out, point to or signal a referent in the world. However, the relationship between the form of a gesture and its referent differs from that exhibited by signs. The form of a gesture is not limited to a particular referent and, as a result, it does not symbolize the referent but serves only to signal

or pick it out. The same gesture can be used for a wide variety of referents and contexts but is likely to be used for a restricted set of functions, generally for requesting. These differences distinguish gestures from signs and words from the onset of linguistic behaviour.

The empty-handed gestures produced by children at this age are primarily indexical, such as pointing, or instrumental in that they are used to effect some change in the environment, such as raising one's arms to be picked up or put down; note that in the latter case, the form of the gesture is part of the actual activity. Gestures such as these are found in both hearing and deaf children (Petitto, 1988). Sign babbling is limited to the production of canonical sign syllables which exhibit phonetic properties of sign languages. Gesture is a hand activity which is not constrained by linguistic parameters. It is the presence or absence of systematic phonetic and syllabic properties which allows the separation of gesture and babbling.

Other Hand Activity. Certain hand activities are not considered in great detail in this study. These include motoric hand activity such as scratching, overlearned and practiced social gestures such as kissing, hugging and waving bye-bye, and routinized, gesturally-based games such a pat-a-cake. These types of behaviour represent roughly less than 5% of the corpus. Showing, reaching, and giving are universally observed in children of this age and are not considered here as potential candidates for sign babbling. Because this paper focuses on manual babbling and hand activity, head activities such as mouthing objects, and gestures such as sniffing to a flower are not included.

Data Analyses

The three questions of interest that guide the analysis of the data are as follows.

1. Is sign babbling the equivalent of canonical vocal babbling, differing only in modality?
2. What phonetic and syllabic properties emerge from the deaf children's early sign productions?
3. Is there phonetic and syllabic continuity between sign babbling and early signs.

In order to answer these questions the following analyses are presented.

A general overview of the data is presented to establish that sign babbling is unique to the deaf children in the study This includes an analysis of the deaf and hearing children's gestural productions.

Seven other analyses are conducted which establish that the sign babbling of the deaf children is truly canonical sign babbling and is equivalent in all respects, save modality, to the canonical vocal babbling of hearing children These analyses are: (a) age of onset, (b) phonetic structure, (c) syllabic structure, (d) canonical babbling ratio, (e) reduplication, (f) stages of manual productions, and (g) continuity of babbling and early signs. In conducting these analyses the data necessary to address the second and third questions above are provided.

Results

Striking examples of canonical sign babbling were produced by the deaf children, Kate and Victor, throughout the 10 to 14 month period examined in this study. The deaf children's canonical sign babbling was qualitatively and quantitatively different from the non-canonical sign babbling produced by the hearing children studied. A general overview of the manual activity of both the deaf and hearing children is presented below. This establishes that sign babbling did occur and was distinct from both communicative gestures and signs. The more detailed analyses of the sign babbling of Kate and Victor are presented following the general overview Detailed analyses were conducted in terms of seven of the defining features of canonical vocal babbling. Through this analysis the three central questions of the thesis are addressed.

1. Is sign babbling canonical?
2. What phonetic/syllabic properties emerge in the early linguistic productions of children acquiring sign language?
3. Is sign babbling continuous in phonetic and syllabic form with early signs?

General Overview

The hand activity of the deaf and hearing children in this study can be classified into three categories:

(i) forms that appeared exclusively as sign babbling and were produced primarily by the deaf children,

(ii) forms that appeared exclusively as communicative gesture and were produced by both deaf and hearing children, including the indexical gesture, pointing, and

(iii) signs, proto-signs, and ill-formed signs, which were produced exclusively by the deaf children.

The distribution of sign babbling, gestures, and points for the hearing children is presented in Figure 5.[7] For all three children, the majority of their manual activity involved the production of communicative gestures Charles produced a larger proportion of pointing gestures than Marie-Claire and Michèle. Sign babbling constituted a small portion (between 1% and 12%) of the total hand activity produced by the hearing children. The sign babbling produced by the hearing children was not canonical. This claim is supported by the results of the detailed analyses presented below.

The deaf children displayed a much different profile. Figure 6 presents the distribution of sign babbling, gestures, and points for Kate and Victor. There was little difference in the actual number of gestures produced by Kate and Victor. Nevertheless, gestures comprised a much smaller proportion of the total manual activity for these two children in comparison with the hearing children. A large proportion (48%) of Kate's manual activity in the 10 month session was pointing. The sign babbling of both Kate and Victor constitutes between 15% and 37% of the total manual activity in a given session. Evidence presented in the detailed analyses below support the conclusion that Kate and Victor's sign babbling was canonical in nature. The actual frequencies of sign babbling, gesture and points for all five children can be found in Appendix F.

A more complete picture of the manual activity of Kate and Victor includes each child's production of lexical items such as signs, proto-signs and ill-formed signs. The distribution of sign babbling, gesture, lexical items and points are presented in Figure 7

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[7] The term sign babbling is applied to the manual productions of the hearing children that exhibited well-formed phonetic and syllabic properties. This is commensurate with the use of the term vocal babbling to refer to the vocalizations of deaf infants that exhibited well-formed phonetic and syllabic properties.

Figure 5. Distribution of Sign Babbling, Gesture and Points for the Hearing Children

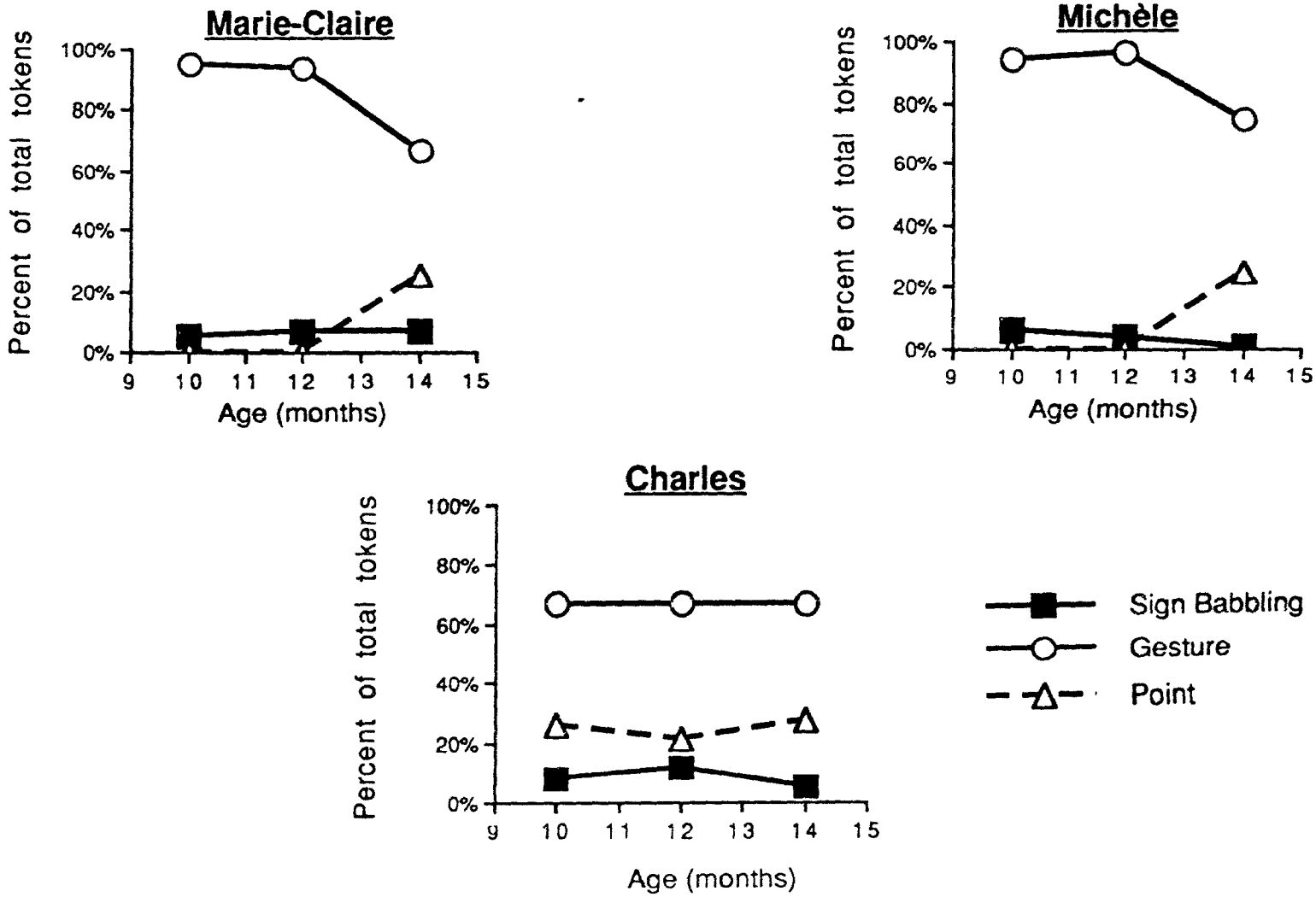


Figure 6. Distribution of Sign Babbling, Gesture and Points for the Deaf Children

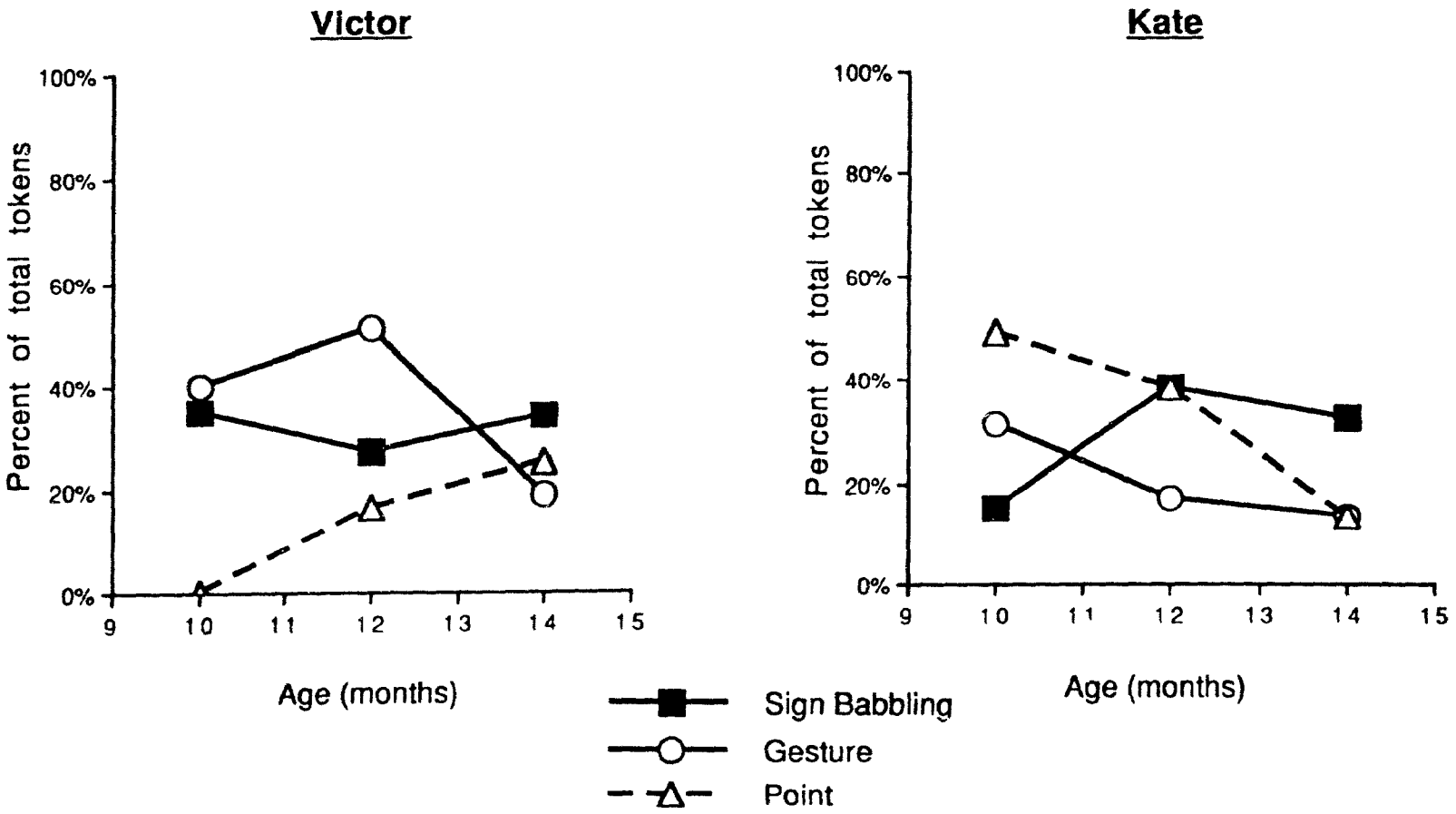
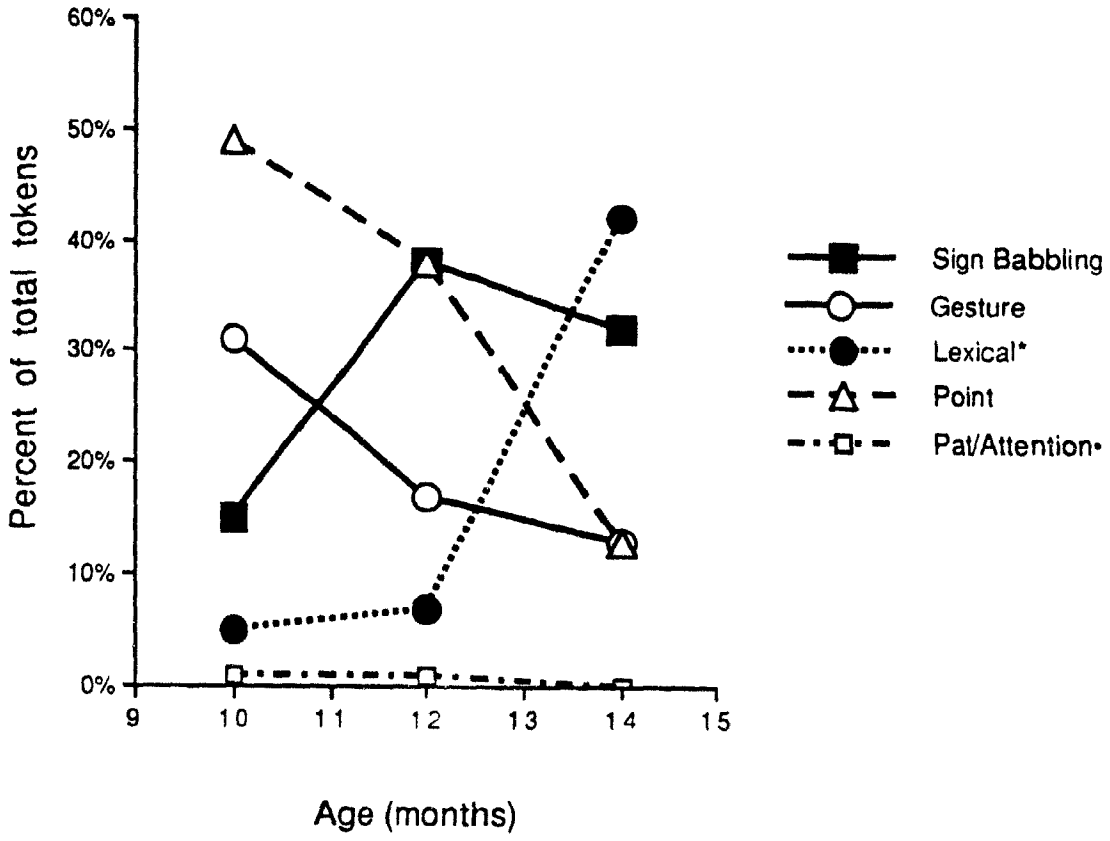


Figure 7. Distribution of Sign Babbling, Lexical Items, Gestures, and Points for Kate



for Kate and Figure 8 for Victor. Both Kate and Victor produced well-formed signs by 12 months of age.

The three categories of manual activity found in this study are described more fully below

Sign babbling. The two deaf children in this study produced a total of 191 tokens of canonical sign babbling. These tokens were sorted into types based on phonological similarity. There were 31 types of canonical sign babbling produced by Kate and Victor. These types are described in Appendix D. There was some similarity of canonical sign babbling types between Kate and Victor; 8 of the 31 types were produced by both children. This similarity suggests that there must be some organization in the linguistic input received by the child that makes certain features of the language salient. This organization would explain why children happen to produce an overlapping set of forms when, theoretically, they could do anything with their hands. The same type of overlap is found in the vocal babbling of hearing children (Locke, 1983). Of all the possible linguistics sounds that occur in the world's spoken languages, hearing children tend to produce a universal subset of sounds in their vocal babbling.

The sign babbling of Kate and Victor was often produced in combination with other sign babbling, points and true signs. Of the 191 tokens of sign babbling, 91 tokens (47%) were produced in combination with other manual activity.

Examples of the canonical sign babbling of Kate and Victor can be found in Figure 9. The examples presented in Figure 9 all involve reduplication, which is not portrayed in the figure Only the basic unit is displayed for each example, but the children's actual

Figure 8. Distribution of Sign Babbling, Lexical Items, Gestures, and Points for Victor

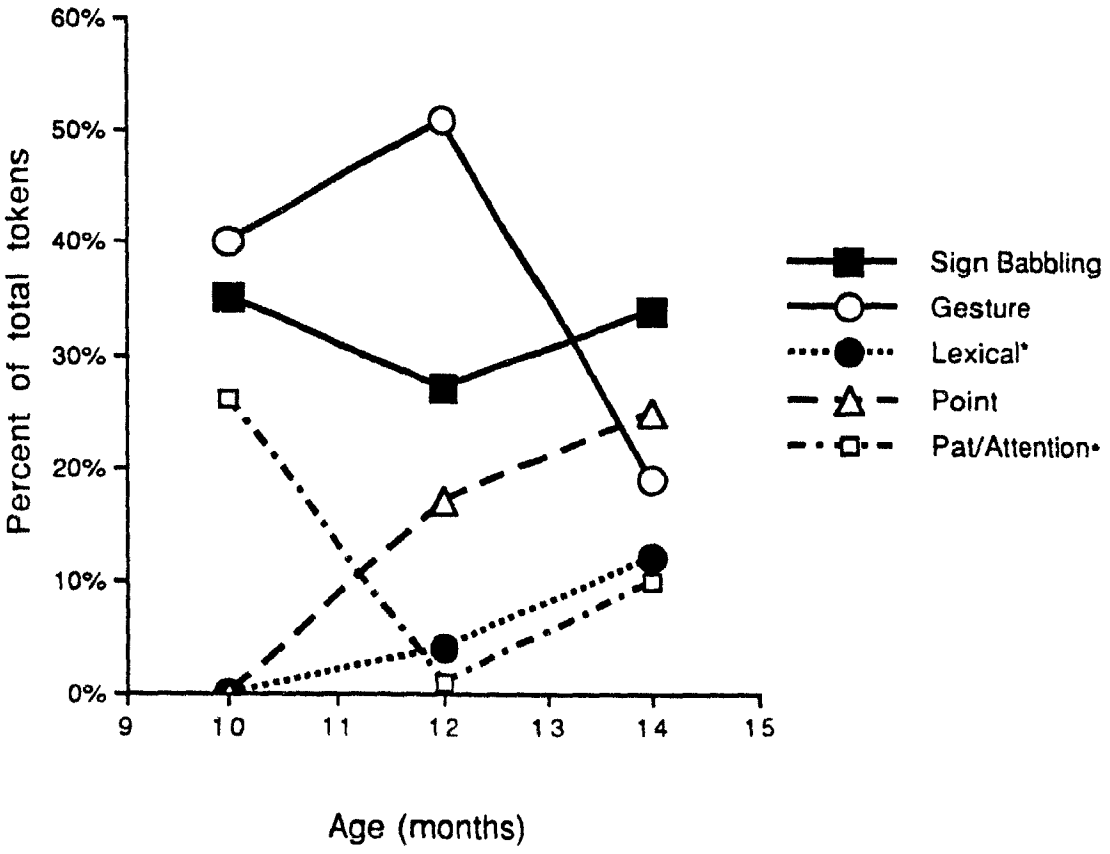
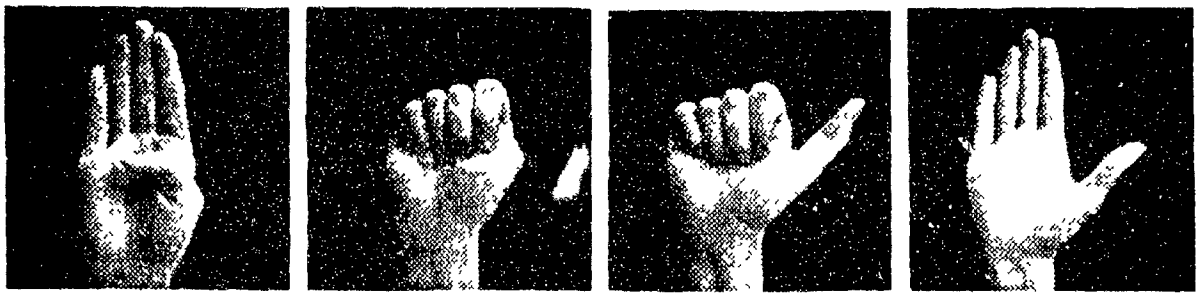


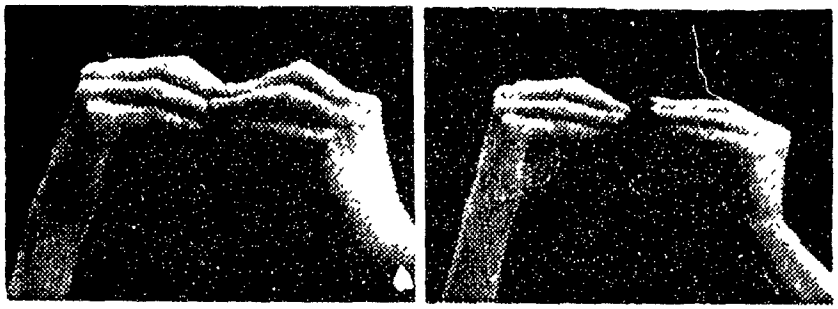
Figure 9. Examples of Canonical Sign Babbling

a) **roll** sequence

b) **bb** sequence

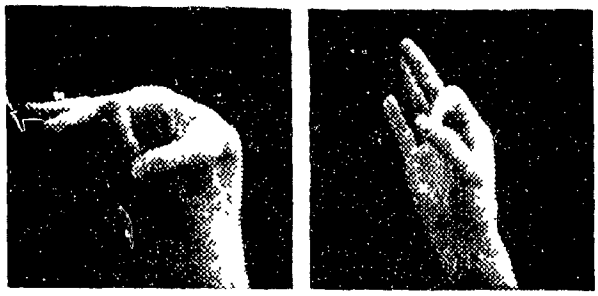


c) **B** to **A** sequence

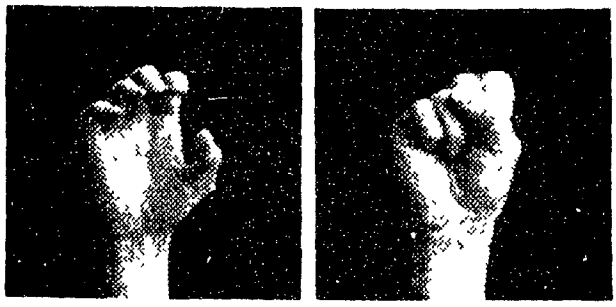


d) **O** sequence

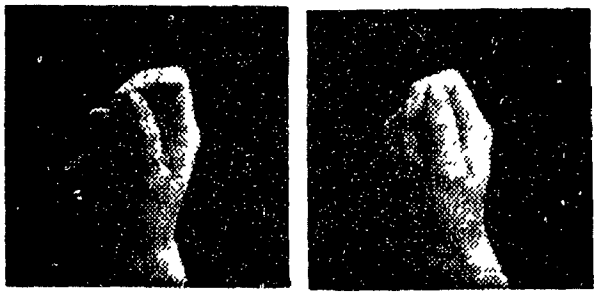
Figure 9. Examples of Canonical Sign Babbling



e) **F** sequence



f) **52** sequence (o/c)



g) **bO** sequence

production of these forms always involved a repetition of this basic unit.

The three hearing children in this study produced many fewer tokens of sign babbling (n = 32 vs. 191 tokens for the deaf children), and a total of only 6 different types (vs. 31 types for the deaf children). Of these types, three are produced by all of the children in the study, both deaf and hearing The remaining three types were produced by only one hearing child, however each of these types was also produced by either Kate or Victor. One example of sign babbling that was produced by all of the hearing children can be seen in Figure 9g. Importantly, there were no sign babbling types that were unique to the hearing children. This is a significant fact which bears on the type of input the children received. The hearing children had no exposure to sign languages. With no relevant linguistic input it is not surprising that the children did not produce any unique forms of sign babbling.

The occurrence of non-canonical sign babbling in the hearing children is similar to a deaf child's production of the occasional true consonant in their vocal babbling. By virtue of the fact that they have mouths and can produce sounds, deaf children will accidentally produce sounds that are relevant to speech. The same holds true for hearing children. By virtue of the fact that they have hands, hearing children will occasionally produce forms that are phonetic units in sign languages.

The sign babbling of the hearing children was rarely produced in combination with other manual activity. Of the 32 tokens of sign babbling, 3 tokens (9%) were produced in combination with

communicative gestures. None were combined with other sign babbling forms or with pointing.

The distribution of types and tokens of sign babbling for both the deaf and hearing child appears in Table 2. As is clearly demonstrated, there was a very large difference between the amount of sign babbling produced by the deaf children and the amount of sign babbling produced by the hearing children.

Communicative gesture. The deaf and hearing children produced similar types and amounts of communicative gestures. The gesture types produced by the children in this study are listed in Appendix E. There were six gesture types that were not produced by the deaf children. Three of these were gestures related to particular objects ("putting to", "dialing", and "sweeping"). This is due to the fact that the necessary objects (a toy telephone and a whisk) were not present in the taping sessions with the deaf children. The absence of these toys was an experimental oversight as they were typically present in all taping sessions. There are certainly examples of Victor gesturing with these items in later taping sessions. A fourth gesture type was called "gimme 5" and was produced only by Charles. This gesture was explicitly taught to Charles by his parents, and was elicited from him regularly with the request to "gimme 5", hence the name. The two remaining gesture types that were not produced by the deaf children are "roll object" or "shaking". Opportunities were available for Kate and Victor to produce these gestures, however, it is not unreasonable that there is not complete agreement in the gestures types produced. Complete agreement would not be expected in comparing the gestures of any two groups of children, regardless of whether they were hearing or deaf.

Table 2. Type and Token Counts for Sign Babbling in Each Child

	Deaf				Hearing					
Age	**Kate**		**Victor**		**Marie-Claire**		**Michèle**		**Charles**	
(months)	Type	Token	Type	Token	Type	Token	Type	Token	Type	Token
10	10	39	10	42	1	1	2	4	2	3
12	12	31	7	27	2	3	1	3	4	7
14	3	10	7	42	2	6	1	1	3	4
Total	**20**	**80**	**19**	**111**	**4**	**10**	**2**	**8**	**5**	**14**

The distribution of types and tokens of communicative gestures produced by each child by age is presented in Table 3. It is clear that both the deaf and hearing children produce communicative gestures. There is strong similarity in the type and amount of gesturing in which they engage.

Signs. The signs, proto-signs and ill-formed signs produced by Kate and Victor are presented in Table 4. Both Kate and Victor produced their first well-formed signs at 12 months. The signs, proto-signs and ill-formed signs are not considered as separate groups in this thesis. As a group they are referred to as lexical items in this text. The hearing children did not produce any examples of signs, proto-signs, or ill-formed signs.

Overlapping form This category represents a very small portion of the data There was one type, open/close (o/c), that occurred both as a gesture and as a sign babbling form. As discussed in the Methodology section, there are many difficulties inherent in distinguishing types of manual activity. Given these difficulties, it is not surprising that there was one form that was particularly difficult to classify. Kate produced a large number of o/c tokens in her taping session at 10 months (n = 40). These tokens were produced both as gesture (n = 19) and as sign babbling (n = 21). The criteria by which the two forms were distinguished are as follows.

1. Gesture: This was clearly an excitatory behaviour which marked Kate's desire to touch or hold an object. Sometimes it was produced with both hands and was marked by bouncing of her entire body (n = 7). Often this gesture was accompanied by a similar o/c action of her feet. This gesture was indexical, it often occurred as part of the activity of reaching for an object. Other times the form

Table 3. Type and Token Counts for Communicative Gesture in Each Child

	Deaf				Hearing					
Age	**Kate**		**Victor**		**Marie-Claire**		**Michèle**		**Charles**	
(months)	Type	Token	Type	Token	Type	Token	Type	Token	Type	Token
10	9	82	10	48	6	20	14	66	4	26
12	6	15	10	50	10	41	14	65	6	40
14	3	4	9	24	13	37	11	64	13	55
Total	**12**	**101**	**16**	**122**	**17**	**98**	**21**	**195**	**14**	**121**

Table 4. Signs and Ill-Formed Signs Produced by Kate and Victor by Age

Kate

10 months

Type	Token
•BIRD/DUCK	9
•HAT	1
•TURTLE	3

12 months

Type	Token
•DUCK	1
•I-LOVE-YOU[a]	3
EAT	1
WHAT	1

14 months

Type	Token
•FATHER	2
•BITE	1
•TALK-TALK	1
_N NO	1
WHAT	1
DOG	1
BITE	1

Victor

12 months

Type	Token
•MOTHER	3
HELLO	1

14 months

Type	Token
•FLOWER	4
•CUP	1
EAT	1
HEY	1
____Q TOUCH[b]	2
HELLO	6

• These are ill-formed signs that were not phonologically correct pronunciations of the adult sign.

[a] In ASL a single form constitutes the meaning "I love you". It is this sign that Kate attempted to produce.

[b] This is the only instance of a proto-sign that was uncovered in these tapes. While other proto-signs may have existed, they were not evident in the present corpus. In English this form conveys the meaning "Can I touch it?".

was made in contact with an object, suggesting that Kate was trying to grab it (n = 7). Kate's eye gaze was always directed at the object of extension.

2. Sign Babbling: This form was typically produced with one hand (18/21 tokens are produced with the right hand). It was usually produced in combination with other instances of sign babbling or with a point (n = 17). Sometimes the sign babbling form of o/c was used to mediate the action of reaching, that is, Kate would crawl over to an object, stop, produce the o/c form, and then reach for the object (n = 8) This is in contrast with the gesture form of o/c which was always produced as part of the reaching sequence, there was no interruption or mediation of action involved in the gesture There are two instances where Kate produced the sign babbling o/c form while looking at her own hands Figure 9f is an example of Kate's o/c form.

An example from Kate's 10 month session clarifies why some instances of the o/c form were regarded as sign babbling The experimenter was holding a doll in front of Kate. Kate looked at the doll and produced an o/c form. The experimenter offered Kate the doll by moving it closer to her. Kate pushed the doll away and, still looking at the doll, again produced the o/c form The experimenter offered Kate the doll again, and, for the second time, Kate pushed it away. By pushing the doll away, Kate indicated that she was not interested in holding it. From this example it is clear that Kate was not using the o/c form simply as a gesture to indicate she wanted to have the doll.

In hearing children, the o/c gesture was generally produced while the child was trying to grasp something out of reach or to

indicate to the parent or experimenter that a particular object was wanted. The form was usually produced with one hand while the child was looking at the object. In general, the form was not repeated. This is in contrast with Kate's production of the sign babbling o/c form which was always repeated Often the o/c form of the hearing children was produced in contact with the object. This makes the o/c form a candidate for gesture rather than sign babbling. Most pre-linguistic communicative gestures are produced with an object in hand (Petitto, 1988). The sign babbling in this study was predominantly empty-handed (n = 189/191 tokens [99%]).

The o/c form appeared in Victor only as a gestural form, not as a sign babbling form It appeared in the gestures of all three hearing children. The form appeared as sign babbling only in Kate's 10 month tape.

Summary Three distinct classes of hand activity were produced by the children in this study One of these classes was labelled sign babbling. This class was produced much more frequently by the deaf children who were acquiring ASL than by the hearing children who had no exposure to sign language. In addition, the sign babbling of the deaf children was regularly produced in combination with sign babbling and signs as well as other forms of manual activity such as communicative gesture and pointing. The hearing children rarely produced sign babbling in combination with other manual hand acitivity. On the few occasions in which they did produce combinations, they always involved non-indexical communicative gestures. Other differences between the sign babbling of the deaf and hearing children are presented below. Both the deaf and hearing children produced highly similar types and tokens of communicative gestures. One deaf child used one form as

both a communicative gesture and as sign babbling. The deaf children produced signs, proto-signs and ill-formed signs. These linguistic productions were not observed in the hearing children.

In order to address the questions of interest in this thesis, the sign babbling data was further examined along seven features. These seven features include the defining features of canonical vocal babbling. These analyses demonstrate that the deaf children's sign babbling was canonical while the sign babbling of the hearing children remained non-canonical for the duration of the study

1 Age of Onset

The first taping session occurred at 10 months for both Kate and Victor By this time both of the children were producing substantial amounts of sign babbling (see Table 2). While it is not possible to determine the exact age of onset of sign babbling for these children, it is clear that both Kate and Victor began sign babbling within the 7-10 month age range that has been specified for canonical vocal babbling (Oller & Eilers, 1988).

2. Phonetic Structure

The phonetic structure of sign babbling was analysed along the four phonological parameters of ASL (as discussed previously, pp. 26-29). These parameters are handshape, movement, location, and orientation. The form of the sign babbling was consistent with the phonetic structure of sign languages. A subset of the ASL primes for each of the four parameters was produced in the sign babbling of Kate and Victor Individual preferences were also noted

Handshape primes. The sign babbling forms were produced using a small set of handshape primes. The total number of handshape primes in ASL is 40, however, a much smaller set (n = 13)

was used in the deaf children's sign babbling. The handshape primes produced in the sign babbling of Kate and Victor are presented in Figure 10.[8] With one exception (**A4**), these are all common handshapes of ASL. The exception, **A4**, is a possible but non-existing handshape in ASL. It is quite likely that this handshape exists in other sign languages.[9]

The distribution of handshapes for each session by child is presented in Table 5. There is individual variation in handshape prime use. Kate did not use **A1** or **A4** at all, and produced only 1 token of **C**. She preferred to use **5**, **A2**, **O**, **bO**, and **52**. Victor on the other hand, preferred to use **5**, **A**, **A4**, **G**, and **52**, making little use of the **O** and **bO** handshapes. He did not produce any tokens of **C** and only 1 token each of **8** and **F**.

The frequency of use of each handshape prime is presented in Table 6. Four primes, **5**, **52**, **A**, and **A2**, comprise 61% of the total handshape primes produced. Three primes, **8**, **F** and **C**, represent less than 5% of the total handshape primes produced in the corpus.

With the data in Table 6 it is possible to consider the predictions made by Boyes-Braem (1973) about the stages of handshape development (see pp. 39-44, in particular Figure 4). Boyes-Braem predicted that the handshapes **A**, **A2** (her $\mathbf{A_S}$), **L**, **bO**, **G**, **5**, and **C** would be the first handshapes used by the child. This stage

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[8] It must be noted that the B in this study represents three B primes. These primes each contributed a very small percentage of the data. The individual primes were: **B** with thumb extended (2% of handshape primes), **B** with thumb across the palm (2% of handshape primes), and the neutral **B** displayed in Figure 5 (1% of handshape primes). This data is still represented in the handshape analysis because the primes were collapsed into one phonological form.

[9] The handshape **A4** does not occur in Langue des Signes Québecoise (Petitto & Charron, in progress), or British Sign Language (Kyle & Woll, 1985). Many of the world's sign languages have not yet been analysed by linguists. Phonetic analyses have been conducted on only a select few of those sign languages that linguists have uncovered. For this reason, it is impossible to say whether or not **A4** occurs in any sign language.

Figure 10. Handshape Primes Used by Kate and Victor for Sign Babbling

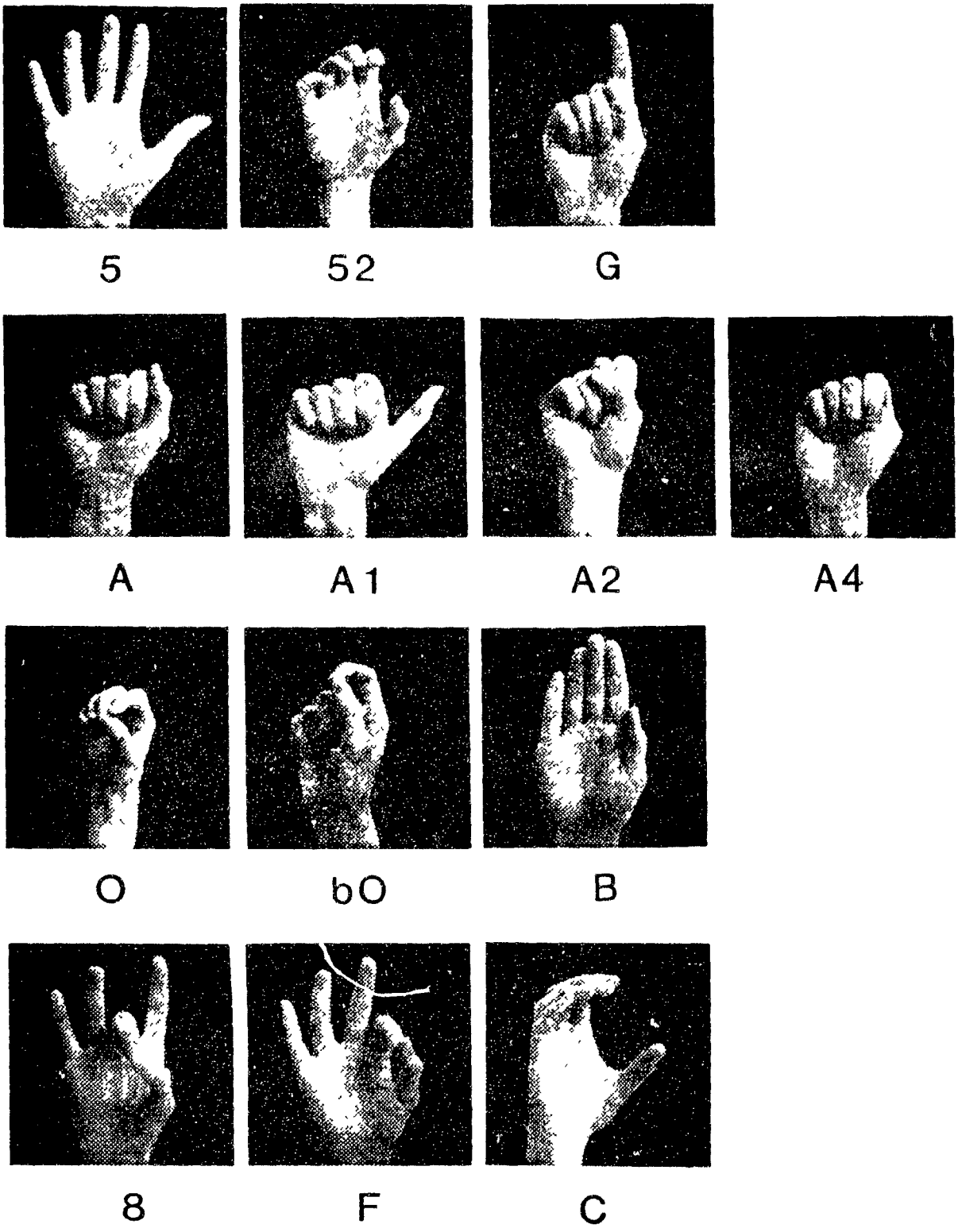

Table 5. Percent of Handshape Primes Produced by Kate and Victor at Each Age

Age	5	52	A	A1	A2	A4	O	bO	B	G	8	F	C
Kate													
10	23	19	5	0	30	0	8	0	1	11	0	2	1
12	30	9	5	0	0	0	18	16	7	0	9	7	0
14	45	0	0	0	18	0	18	18	0	0	0	0	0
Victor													
10	8	3	21	11	3	22	8	6	14	0	2	2	0
12	15	6	32	0	6	9	0	0	3	29	0	0	0
14	68	15	4	4	0	0	6	0	4	0	0	0	0
TOTAL	**28**	**11**	**11**	**3**	**11**	**6**	**9**	**5**	**6**	**7**	**2**	**2**	**>1**

Table 6. Frequency of Handshape Primes for Kate and Victor's Sign Babbling

Handshape	Frequency	Percent of Handshape Tokens	Cumulative Percent
5	79	28	28
52	32	11	39
A	32	11	50
A2	31	11	61
O	25	9	70
G	19	7	76
A4	17	6	82
B	16	6	88
bO	13	5	93
A1	9	3	96
8	5	2	98
F	5	2	99
C	1	0	100

would be followed by the acquisition of the handshape primes **B**, **F**, and **O**. As can be seen in Table 6, some of these predictions were supported by the present data. The handshapes **5**, **A**, **A2** and **G** are frequently produced in the sign babbling of Kate and Victor. These handshapes clearly belong in Stage 1 and support Boyes-Braem's claim.

The data also indicate differences with Boyes-Braem's Stage 1. The handshapes **C** and **L** were clearly not acquired early by Kate and Victor. Kate produced 1 token of **C**, and **L** was not produced by either child. These data suggest that these two handshapes should be placed in a later stage of acquisition. The absence of these handshapes in the early sign productions of another deaf child was also noted by McIntire (1977).

The last handshape from Stage 1 to be considered is **bO**. Although there were tokens of **bO** produced by both children at all three ages, there are other handshapes such as **O** and **B** that were produced more frequently. Both **O** and **B** belong to Stage 2 according to Boyes-Braem. The data presented here do not support a separation between Stage 1 and Stage 2. **B**, **O** and **bO** do not develop later than **5**, **A**, **A2** and **G** in either child. Nor is it true that a greater variation in handshapes was acquired over the four month period studied. Victor produced a wider range of handshape primes at 10 months than he did at 14 months of age (11 as compared to 6 different primes).

This is not to say that there are no stages in handshape acquisition. There are clearly handshapes which were not used by either child. With the exception of the handshape prime **8**, none of

the handshapes in Stage 3 and Stage 4 (see Figure 4) were produced in this corpus.

The handshapes **52**, **A4** and **A1** are not considered by Boyes-Braem. The handshape **52** is formationally related to the handshape **5.** The two handshapes were considered by Boyes-Braem to be variants of one another rather than distinct handshape primes. The same holds true for **A1** which is formationally related to **A**. The handshape **A4** is not considered by Boyes-Braem because this prime does not occur in ASL.

The sign babbling of the hearing children was produced using an even smaller set of handshapes (n = 8) than that of the deaf children. The frequency of handshape primes for the hearing children's sign babbling is shown in Table 7. Four handshape primes (**F**, **O**, **bO**, and **5**) comprised 89% of the data. Only one token was produced of each of the remaining four handshape primes. There are no handshapes unique to the hearing children's sign babbling. The order of frequency of the handshape primes used by the hearing children does not reflect the order of frequency of the handshape primes used in the deaf children's sign babbling.

Movement primes. A limited set of movement primes were used in the sign babbling of Kate and Victor. The sign babbling corpus consisted of 13 of the 24 movement primes used in ASL. The movement primes found in this corpus are described in Table 8.[10] With the exception of **roll** and **flick**, which are relatively uncommon movement primes, all of the other movement primes occur regularly in ASL, that is, they are unmarked movements in ASL.

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[10] The table does not include six movement primes that together constituted less than 3% of the total movement tokens. These six movement primes were: movement away from the body, to-and-fro movement, wriggling of the fingers, touching action, linking action, and bending of the fingers at the knuckles.

Table 7. Frequency of Handshape Primes for the Hearing Children's Sign Babbling

Handshape	Frequency	Percent of Handshape Tokens	Cumulative Percent
F	14	40	40
O	7	20	60
bO	7	20	80
5	3	9	89
B	1	3	91
G	1	3	94
A	1	3	97
8	1	3	100

Table 8. Descriptions of Movement Primes

Label	Description
1	upward movement
2	downward movement
3	up and down movement
7	movement toward body
1 2	twisting movement, that is both pronation and supination, as in the dominant hand in the sign COOK
1 3	nodding or bending of wrist, as in the sign YES
1 4	opening action, one handshape opens to a second handshape, e.g., 8>5
1 5	closing action, one handshape closes to a second, e.g., 52>A2
1 8	convergent action, hands approach each other
2 3	separation of the two hands
flick	rapid release of finger, as in the sign AWFUL
hold	no movement
roll	sequential thumb contact with fingertips of same hand

The distribution of movement primes for each session by child is presented in Table 9. Kate did not produce any sign babbling involving upward movement (type **1**). Although, Victor produced a fair amount of upward movement at the 10 month session (24% of movements in the session), he did not use this movement at all in later sessions. There are clear individual preferences regarding movement primes The majority of Kate's sign babbling was produced using movement **15** (82% of movement at 10 months). This movement prime represented only 2% of Victors movements at 10 months. Victor preferred to use movements **7** (81% at 12 months) and **3** (58% at 14 months).

The frequency of movement primes is presented in Table 10. The three movement primes discussed above, **15**, **7**, and **3**, constitute 59% of the movement primes used in the total corpus. These three primes occurred with a much higher frequency than the other primes presented in Table 10.

The frequency of movement primes for the hearing children's sign babbling is presented in Table 11. Note that 84% of the movements produced in their sign babbling are comprised of one movement prime (**roll**). This movement prime accounts for only 7% of the deaf children's sign babbling. Only one token each of the remaining 5 movement primes was produced by the hearing children in their sign babbling.

Location primes. The sign babbling of Kate and Victor was produced primarily in the signing area (see Figure 1). There are a few examples where Victor extended his arm out of the signing space (n = 3). Also, Kate produced one token of sign babbling on her right leg. This was quite appropriate however, because she had just

Table 9: Percent of Movement Primes Produced by Kate and Victor at Each Age

Age	1	2	3	7	12	13	14	15	18	23	flick	roll	hold
Kate													
10	0	3	0	5	0	0	3	82	0	0	0	5	3
12	0	6	0	3	9	12	6	42	3	3	3	12	0
14	0	14	7	14	21	14	0	14	0	0	0	14	0
Victor													
10	24	2	10	24	0	5	0	2	2	5	14	10	2
12	0	4	0	81	0	0	4	0	0	0	0	11	0
14	0	4	58	4	2	0	0	0	6	10	0	0	15
TOTAL	5	4	16	19	3	4	2	24	2	4	3	7	4

Table 10. Frequency of Movement Primes for Kate and Victor's Sign Babbling

Movement	Frequency	Percent of Movement Tokens	Cumulative Percent
15	48	24	24
7	39	19	43
3	33	16	59
roll	15	7	67
1	10	5	72
2	9	4	76
hold	9	4	81
13	8	4	85
23	8	4	89
12	7	3	92
flick	7	3	96
18	5	2	98
14	4	2	100

Table 11. Frequency of Movement Primes for the Hearing Children's Sign Babbling

Movement	Frequency	Percent of Movement Tokens	Cumulative Percent
roll	27	84	84
twist	1	3	87
23	1	3	91
flick	1	3	94
hold	1	3	97
15	1	3	100

finished signing DOG which is correctly produced in contact with the right thigh. The production of sign babbling within the constrained space permitted by the language is significant because it lends additional support to the theory that gesture and language are distinct communicative functions from the beginning of language acquisition Petitto (1986, 1987a) noted that the pointing gestures of her subject Kate (the same Kate appears in this study) were produced outside of signing space. In contrast, the linguistic points produced by Kate remained inside of the signing space

The only location primes used in ASL that were not produced as part of the sign babbling corpus were those in which a sign is made in contact with the passive hand or arm of the signer. A list of the location primes produced in the sign babbling corpus can be found in Table 12.

The distribution of location primes by session for Kate and Victor is presented in Table 13. There were four location primes (**2**, **3**, **6**, and **RS+**) which were not produced by Kate. Kate preferred to use the locations **1**, **LS** and **RS**. This means that the majority of Kate's sign babbling was produced in the space to the front and sides of her body, not in contact with her body. Victor demonstrates quite a different pattern. Half of Victor's sign babbling in the 14 month session occurred in location **1**; this is commensurate with Kate's choice of location. What was striking about Victor's data was the high proportion of sign babbling which occurred on the **head**, **ears** or **face**. At the 10 month session 25% of Victor's sign babbling occurred in this region, by the 12 month tape this had increased to 89%. At the 14 month tape 50% of Victor's sign babbling was produced in this region. Victor's pattern contrasts markedly with

Table 12. Descriptions of Location Primes

Label	Description
1+	centre space, with the signing arm extended in front
1	centre space, the neutral signing space in front of the body
2	top or back of the head
3	the temples, or forehead
5	chin
6	cheek
6 3	the area around the ear
8 7	the space in front of the right shoulder, this is the space where most fingerspelling takes place
8 8	the right leg
LS	the space to the left side of the body
RS	the space to the right side of the body

Table 13. Percent of Location Primes Produced by Kate and Victor at Each Age

Age	1	1+	2	3	5	6	63	8	88	LS	RS	RS+
Kate												
10	18	0	0	5	0	0	0	5	0	21	51	0
12	26	0	0	16	0	0	6	3	0	16	32	0
14	10	0	0	0	10	0	0	0	10	20	50	0
Victor												
10	5	21	2	0	14	2	7	2	0	21	14	7
12	0	0	0	4	11	15	59	4	0	4	4	0
14	50	0	0	50	0	0	0	0	0	0	0	0
TOTAL	24	2	13	4	3	3	13	3	1	13	20	5

the pattern presented by Kate, whose sign babbling was produced predominantly in the neutral space in front of her body.

Victor's pattern is unexpected. Boyes-Braem (1973) predicted that children would prefer to see their hands and rely on visual feedback, rather than rely on kinesthetic feedback. Kate's data supports Boyes-Braem's prediction. Victor, on the other hand, clearly violated this prediction as he contributed the majority of **ear**, **face** and **head** location tokens. The overall frequency of occurrence of each location prime for both Kate and Victor can be found in Table 14.

The frequency of location primes produced in the hearing children's sign babbling are presented in Table 15. None of the hearing children's sign babbling was produced in contact with their body. This differs significantly from the sign babbling of the deaf children. Kate, who produced the majority of her sign babbling in the space in front of her body did produce tokens of sign babbling in contact with her chest, chin, and ears. Nor does the pattern presented by the hearing children seem to fit in with boyes-Braem's predictions of the preference for visual feedback. The hearing children never looked at their hands when they were producing a sign babbling form.

Palm orientation primes. All six possible palm orientation primes were used in the combined sign babbling corpus of Kate and Victor. The distribution of the orientation primes is presented in Table 16. Victor did not produce any tokens of the **up** orientation prime in his sign babbling. The frequency of orientation primes can be found in Table 17.[11]

[11] The frequency of orientation primes for the hearing children in this study is not presently available.

Table 14. Frequency of Location Primes for Kate and Victor's Sign Babbling

Location	Frequency	Percent of Location Tokens	Cumulative Percent
Centre	47	24	24
Right	40	20	44
Head	26	13	57
Ear	25	13	69
Left	25	13	82
Right Shoulder	9	5	86
Temple	7	4	90
Chin	6	3	93
Cheek	5	3	95
Chest	5	3	98
Centre, arm extended	3	2	99
Right leg	1	1	100

Table 15. Frequency of Location Primes for the Hearing Children's Sign Babbling

Location	Frequency	Percent of Location Tokens	Cumulative Percent
Right	18	56	56
Left	9	28	84
Centre	5	16	100

Table 16. Percent of Orientation Primes Produced by Kate and Victor at Each Age

Age	In	Out	Up	Down	Right	Left
Kate						
10	14	5	12	2	26	42
12	5	8	14	32	19	22
14	0	13	13	50	13	13
Victor						
10	21	58	0	12	0	9
12	35	13	0	3	13	38
14	10	4	0	74	6	6
TOTAL	**19**	**16**	**5**	**28**	**13**	**18**

Table 17. Frequency of Orientation Primes for Kate and Victor's Sign Babbling

Orientation	Frequency	Percent of Orientation Tokens	Cumulative Percent
Down	59	29	29
In	40	19	48
Left	38	18	66
Out	34	16	82
Right	27	13	95
Up	7	5	100

3. Syllabic Structure

The sign babbling of Kate and Victor exhibited the syllabic properties of ASL. A well-formed syllable in ASL involves a handshape plus a location, and one of the following types of change: either handshape change, location change, orientation change, or a combination of the above (as discussed on p. 37). This renders seven possible syllable types:

(i) handshape change (H),
(ii) location change (L),
(iii) orientation change (O),
(iv) handshape/location change (HL),
(v) handshape/orientation change (HO),
(vi) location/orientation change (LO), and
(vii) handshape/location/orientation change (HLO).

Examples of each syllable type were found in the sign babbling corpus. Figure 9 provides examples of the each basic type of syllable. Examples of handshape change can be found in Figure 9a, b, c, f, and g. An example of location change is found in Figure 9d. Figure 9e demonstrates an example of an orientation change syllable.

The distribution of syllable types by each session for both Kate and Victor is presented in Table 18. In addition to the seven syllable types discussed above, Victor provided a clear example of the use of a non-manual marker to indicate syllabicity. This example of sign babbling involved a repeated negative head shake. Victor's hands, in the **A** handshape, were placed above or behind his ears for the duration of each production. No other movement was involved in this form. Eight tokens of this syllable type were produced by Victor at the 12 month taping. This represents 30% of

Table 18. Percent of Syllable Types Produced by Kate and Victor at Each Age

Age	H*	L	O	HL	HO	LO	HLO	NM	Hold
Kate									
10	87	5	0	5	0	0	0	0	3
12	68	10	13	0	6	3	0	0	0
14	0	30	30	20	20	0	0	0	0
Victor									
10	24	62	0	5	5	2	0	0	2
12	15	56	0	0	0	0	0	30	0
14	5	86	0	0	0	0	2	0	7
TOTAL	37	45	4	3	3	1	1	4	3

*see p. 98 for the legend
NM = non-manual

the syllable types produced by Victor in that particular session.[12] Finally, 5 tokens of sign babbling did not exhibit any of the above types of syllable structure. These tokens were produced with a definite **hold**, with no handshape, location, or orientation change observed. These tokens were included in the sign babbling count because they exhibited phonetic similarity with other tokens of sign babbling. Also, they were not similar to the static sign primes to be discussed below.

Individual differences were readily apparent. Kate produced a large number syllables involving handshape change (87% of syllable types in the 10 month session). She also produced the only examples of orientation change syllables (n = 7). Victor displayed a clear preference for the location change syllable type; he produced between 56% and 86% of the syllables using this type. As was mentioned above, he also produced the only examples of non-manual syllables in the corpus.

The frequency of syllable types is presented in Table 19. Location change and handshape change constitute 82% of the syllable types produced in the sign babbling of Kate and Victor.

The frequency of syllable types produce in the hearing children's sign babbling is presented in Table 20. A very limited set of syllable types were produced in the sign babbling of the hearing children. Handshape change constitutes 88% of the sign babbling syllable types produced in the hearing children. This is a result of the hearing children's dependence on the roll movement prime (see Table 11).

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[12] I would like to thank Diane Brentari (Linguist, Univeristy of Chicago) for pointing out the importance of non-manual markers of syllabicity, and in particular for identifying Victor's use of a non-manual marker in this type of sign babbling.

Table 19. Frequency of Syllable Types for Kate and Victor's Sign Babbling

Syllable Type	Frequency	Percent of Syllable Types	Cumulative Percent
Location	85	45	45
Handshape	71	37	82
Non-Manual	8	4	86
Orientation	7	4	90
Handshape/ Location	6	3	93
Handshape/ Orientation	6	3	96
No Change	5	3	98
Location/ Orientation	2	1	99
Handshape/ Location/ Orientation	1	1	100

Table 20. Frequency of Syllable Types for the Hearing Children's Sign Babbling

Syllable Type	Frequency	Percent of Syllable Types	Cumulative Percent
Handshape	28	88	88
Location	2	6	94
Orientation	1	3	97
Hold	1	3	100

Syllable Concatenation. In addition to considering what type of syllables were involved in sign babbling, one must examine the ways in which these syllables were combined within an utterance. Three types of combinations were found in the sign babbling of Kate and Victor: monosyllabic, reduplicated and variegated sign babbling.

Monosyllabic forms are the simple production of one of the syllable types discussed above. These forms constituted 48% of the deaf children's sign babbling corpus. This is the equivalent of a hearing child's production of /da/ in vocal babbling.

Reduplicated forms involved the repeated production of a syllable. These forms contributed 44% of the sign babbling corpus. An equivalent of this in the hearing child is the production of /dada/. It is the production of reduplicated babbling which is associated with canonical vocal babbling.

Variegated vocal babbling involves the production of a multisyllabic utterance involving two different syllables. This generally begins around 12 months of age. An example of variegated babbling is the utterance /bada/. Reduplication of this form results in the form /badabada/.

Variegated sign babbling involved the concatenation of two or more different syllables within one sign babbling token. Variegated sign babbling represented 8% of the sign babbling corpus. Of the variegated sign babbling produced by Kate and Victor, 9 out of 15 tokens were also reduplicated.

The variegated sign babbling of Kate and Victor did not become more frequent as they matured. This is a different pattern from the developmental pattern exhibited in the vocal babbling of hearing children. An important point must be made about the validity of this

comparison. ASL is a predominantly monosyllabic language, as a result there are not many variegated syllables used in ASL (D. Brentari, personal communication, May 17, 1989; Coulter, 1986b). It is important to compare the syllabic complexity of Kate and Victor's sign babbling with the syllabic complexity of hearing children who are acquiring a monosyllabic spoken language such as Chinese. The observation that children produce variegated syllables with increasing frequency after 12 months of age was based on English children. It is clearly not valid to compare the development of syllable complexity in children acquiring English and ASL, without the additional knowledge of what Chinese children do.

4. Canonical Babbling Ratio

The canonical babbling ratio is the ratio of canonical utterances to total utterances. A child is not considered to be producing canonical babbling until this ratio is achieved and maintained over time. This ratio was set at 0.20 by Oller & Eilers (1988) in their studies of canonical vocal babbling. This same ratio has been applied to the deaf children in this study. It should be noted that this presents a much more stringent requirement for the deaf children. This is due to other competing hand activities such as gestures, pointing, and signs, which are all produced using the same articulators. During the canonical vocal babbling stage, the oral articulatory system is not used for such a wide variety of communicative functions, as the only competing signals are crying and perhaps words.

This proviso is particularly relevant with regard to Kate's 10 month session. In this 55 minute session Kate produced 130 points. This is an extraordinarily large number or points for one child to produce in one session. The largest number of points produced by

another child in a session of similar length is 31 by Victor at 14 months. Had Kate's points not been included as part of the total utterances produced, the canonical babbling ratio would be 0.29 for that session.

The canonical babbling ratios for Kate and Victor are presented in Table 21. A large portion of both Kate and Victor's hand activity during these sessions was sign babbling. These children clearly met and exceeded Oller's canonical babbling ratio requirement.

The canonical babbling ratios of the hearing and deaf children are compared in Figure 11. None of the hearing children met or exceeded the canonical babbling ratio requirement at any time during this study.

5. Reduplication

Reduplication is a commonly noted feature of canonical vocal babbling. An example of reduplication in canonical vocal babbling would be the utterance /dadada/. Both Kate and Victor produced reduplicated sign babbling forms. Overall 47% of the sign babbling tokens produced were reduplicated.

6. Stages of Manual Productions

Three stages were discerned in the manual activity of the deaf children. These stages were static sign primes, syllabic babbling, and jargon babbling.

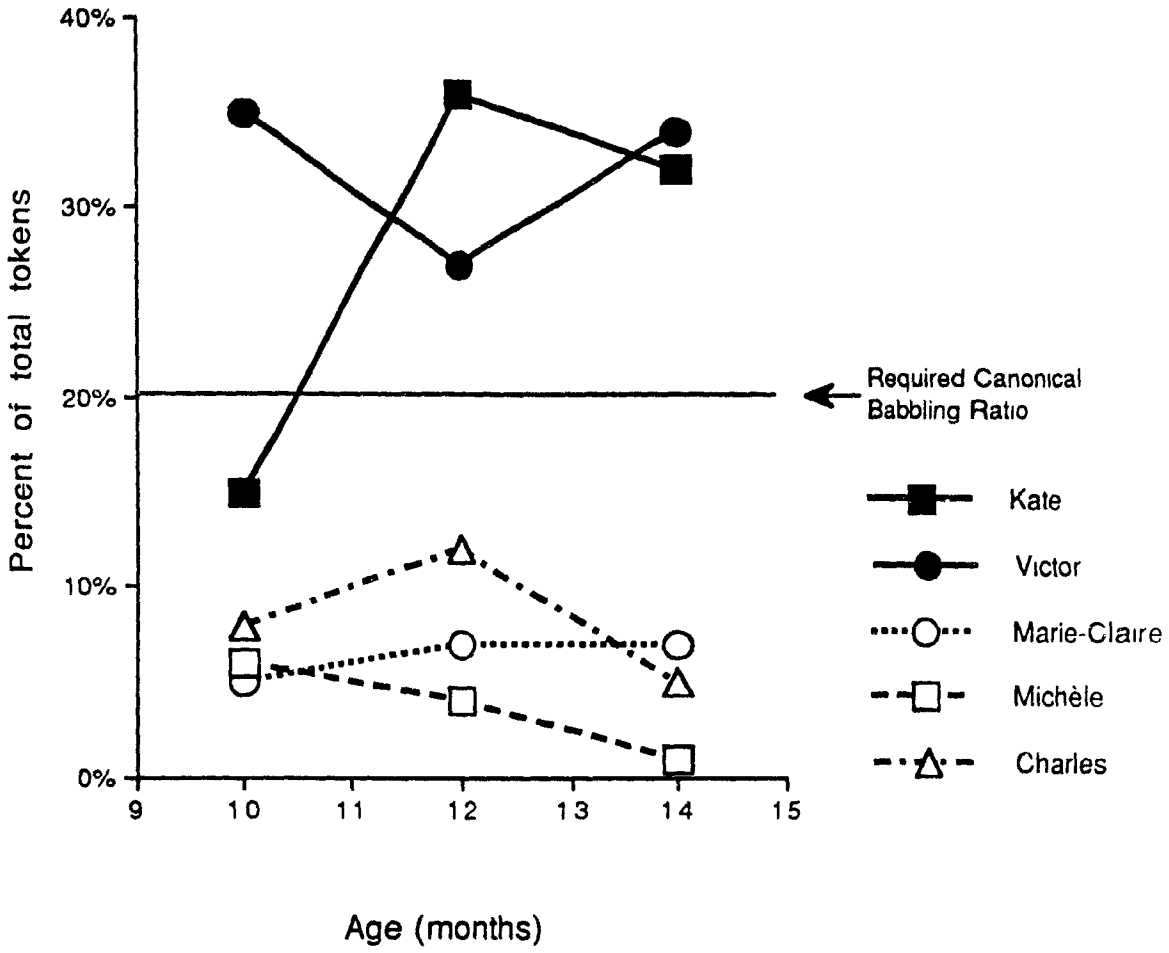
Static sign primes. Static sign primes involved the production of resting state handshapes. The static forms are clearly not candidates for canonical sign babbling because the forms did not involve any handshape, location, or orientation change. As a result, they were not considered possible tokens of sign babbling and were not coded. The comments presented here are based on observation of the children in this study and other children and must be confirmed

Table 21. Canonical Babbling Ratios for Kate and Victor by Age

Age (months)	10	12	14
Kate	.15*	.37	.32
Victor	.35	.27	.34

* In this session Kate produced an usually high number of points (n = 130). If pointing were not included in the canonical babbling ratio, Kate's ratio for this session would be 0.29.

Figure 11. Canonical Babbling Ratios for Each Child by Age



through further analysis. This work is currently in progress. Children at an age younger than 10 months are also being studied to determine when the age of onset and course of development of static sign primes.

The static sign primes generally involved the production of a handshape which was maintained for some time. The typical handshapes used for this form were **G**, **F** and **bO**. The child's arm did not necessarily remain stationary during this time. These forms seem to be entirely unintentional as the child attention was always focused elsewhere, and the child never seemed to be trying to communicate using these forms. These forms seem to be produced equally often by both deaf and hearing children.

Syllabic babbling. Both the phonetic and syllabic structure of this type of sign babbling were similar to the phonetic and syllabic structure of sign languages. The analyses of Kate and Victor's sign babbling presented in this paper have focused on the production of this type of form. This form clearly occurred by 10 months of age in both Kate and Victor. Some examples of sign babbling which exhibited syllabic structure were found in the hearing children. The tokens of the hearing children's sign babbling never reached a significant proportion as measured by the canonical sign babbling ratio. In addition, the phonetic and syllabic structure of the hearing children's sign babbling was very restricted. The variety and complexity of sign babbling produced by the deaf children in this study was never attained in the sign babbling of the hearing children.

Jargon babbling. At 12 months of age both Kate and Victor produced jargon sign babbling. This is the production of long

sequences of sign babbling in sentence-like frames with the correct prosodic markings of ASL.

One interesting example of jargon babbling was produced by Kate at age 14 months. This sequence clearly demonstrates her playing with the phonological features of her language. Mother and Kate were sitting on the couch looking at a book. On the front cover of this book there was a picture of a number of animals. Mother was naming the animals and encouraging Kate to sign. Kate looked at the book, then she looked to her mother and signed DOG. This sign is made with the palm of the **5** hand making a repeated contact with the right leg. Kate's version of the sign DOG involved many more repetitions than are normally produced. Without a break in rhythm, Kate then turned this sign into part of a sequence of jargon babbling. She continued the repeated contact with her leg, but changed the point of contact from the palm of her hand to the tip of her thumb. This was repeated a number of times, then, while maintaining the **5** handshape,the thumb of the right hand was brought to contact with her chin.

It should be noted that these three units, the sign DOG, thumb contact on right leg, and thumb contact on chin were all produced with the **5** handshape. This constitutes rhyming in ASL. This is similar to a hearing child producing a sequence such as "*dog dog dog bog bog bog gog gog gog*" with a sentential intonation pattern.

Victor also produced examples of jargon babbling. At 12 months of age Victor produced the following sequence. Mother showed Victor a picture of himself and told him that it was a picture of him. Victor looked at the picture, and took it in his right hand. He then switched the picture to his left hand in order to produce the following sequence with his right hand:

point to picture + SIGN BABBLING + point to picture + SIGN BABBLING + SIGN BABBLING. None of these sign babbling forms carried any meaning. Nonetheless, they were used in combination with each other in a sentence-like construction.

Jargon sign babbling in deaf children acquiring sign language has also been noted by Petitto (1987a). Petitto reports the production of a sequence similar to Victor's by a deaf child (Carla) of deaf parents. Carla produced strings of sign babbling in combination with points while looking at a book. The jargon sign babbling produced by Carla maintained the prosodic and phrasal contours of ASL. The production of jargon sign babbling by deaf children indicates that these children have acquired prosodic, phrasal, syllabic, and phonetic features of their language (Petitto, 1987).

There were no examples of jargon sign babbling in the hearing children.

7. Continuity

The continuity of both phonetic and syllabic structures between the deaf children's sign babbling and their early signs, proto-signs, and ill-formed signs was considered. Because the analysis focused on structural properties of these linguistic units, it was not necessary to be concerned with the referential and symbolic distinctions that differentiate signs, proto-signs and ill-formed signs. Signs, proto-signs and ill-formed signs have therefore been considered as one group called lexical items in this analysis.

The analysis of continuity between vocal babbling and early words conducted by Vihman et al. (1985) is a statistical one. Differences between vocal babbling and early words within a subject must be smaller than differences between vocal babbling and early

words between different subjects. This definition of continuity takes into account the individual differences that exist between subjects (Locke, 1987; Oller et al., 1985; Vihman, 1986; Vihman et al., 1985, Vihman et al., 1986). The analysis uses Spearman's rank order correlation coefficient, among other statistical tests. In the present study continuity can not be determined through a statistical analysis such as the one used by Vihman et al. (1985). A minimum of 5 to 10 subjects are needed to perform valid statistical analyses. Continuity between the phonetic and syllabic form of Kate and Victor's sign babbling and lexical items is assessed using the frequency of production of the phonetic primes and syllabic types of the children's manual productions.

Phonetic Structure. The handshape, movement, location, and, orientation primes of both Kate and Victor's lexical items show a considerable overlap with the repertoire of primes used in their sign babbling. The individual preferences for certain primes carried over into the lexical items of both children.

The frequency of handshape primes produced in the lexical items of Kate and Victor is presented in Table 22. The most frequent handshape prime was **5**, this handshape was involved in 47% of their lexical productions. This handshape was also the most frequent handshape in the sign babbling. Overall, the handshapes used in the lexical items are largely similar to those used in the sign babbling.

There are two exceptions to this. The lexical items are marked by a conspicuous absence of A handshapes (**A**, **A1**, **A2**, and **A4**), as only 1 token of **A4** was seen in the lexical items.[13] The

[13] The token of A4 was produced in an ill-formed sign by Victor. This explains how a prime which does not belong to the language could be produced in a lexical item.

Table 22. Frequency of Handshape Primes for Kate and Victor's Lexical Items

Handshape	Frequency	Percent of Handshape Tokens	Cumulative Percent
5	27	47	47
G	8	14	61
O	6	11	72
52	5	9	81
bO	5	9	90
B	3	5	95
A4	1	2	97
C	1	2	98
3	1	2	100

handshapes **A** and **A2** constituted 22% of the handshapes involved in the sign babbling corpus. The other difference between the sign babbling and lexical items was Kate's production of a **3** handshape in the sign DUCK (see Figure 4 for a picture of the **3** handshape).

Finally, note that the **C** handshape only occurs once in the lexical items. This supports the conclusion made earlier that **C** should not be considered one of the Stage 1 handshapes.

In the sign babbling corpus, the movement primes **15**, **7**, and **3**, represented 59% of the movements. The frequency of movement primes in the lexical items of Kate and Victor is displayed in Table 23. These three movement primes, **15**, **7**, and **3**, comprise 54% of the movements in their lexical items. This represents a significant overlap in the movement primes used in sign babbling and lexical items.

One difference between the sign babbling and lexical items was found with the movement prime **bb**. This prime comprised 15% of the movements in the early sign corpus. Only one token of this prime was produced in the sign babbling corpus (see footnote 3). Three other movement primes, **8**, **9**, and **6**, contributed to the early sign corpus. One token each of two of these primes, **8** and **9**, were produced in the sign babbling corpus (see footnote 3).

The frequency of location primes for the lexical items of Kate and Victor is presented in Table 24. The locations for the lexical items are very similar to those used in the sign babbling. The location primes **left**, **right**, and **centre** are used to produce 41% of the lexical items, as compared to 57% of the sign babbling. One location that was used in the lexical items was **left shoulder**, this location prime did not occur in the sign babbling. The location **chin**

Table 23. Frequency of Movement Primes for Kate and Victor's Lexical Items

Movement	Frequency	Percent of Movement Tokens	Cumulative Percent
15	11	23	23
7	11	23	46
bb*	7	15	61
3	4	8	69
hold	4	8	77
13	3	6	84
8*	3	6	90
2	2	4	94
roll	1	2	96
9*	1	2	98
6*	1	2	100

* These four movement primes were not included in Table 8. These labels represent the following movements:
bb = bending of fingers at the knuckles
8 = movement away from signer
9 = to and fro movement
6 = side to side movement

Table 24. Frequency of Location Primes for Kate and Victor's Lexical Items

Location	Frequency	Percent of Location Tokens	Cumulative Percent
Centre	9	20	20
Chin	8	17	37
Left	7	15	52
Left Shoulder	5	11	63
Right	4	9	72
Head	4	9	81
Nose	4	9	90
Chest	1	2	92
Cheek	1	2	94
Right leg	1	2	96
Right Shoulder	1	2	98
Arm	1	2	100

was used more often in the lexical corpus than in the sign babbling corpus. Note also the sign (BITE) which was produced on the location prime **arm**. This location prime represents the only major location prime that did not occur in the sign babbling corpus.

The individual preferences of Kate and Victor continued to be evident in the lexical corpus. Kate produced the majority (60%) of her signs in the space in front of her body. Victor, on the other hand, continued to produce the majority (53%) of his signs in contact with his head and face.

The last parameter to be considered is orientation. The frequency of orientation primes in the lexical items is presented in Table 25. All of the six possible orientation primes were produced in the lexical corpus of Kate and Victor. The one significant difference between the use of orientation primes in lexical items and sign babbling concerned the **down** orientation In the sign babbling corpus **down** contributed 21% of the orientation tokens. In the lexical corpus **down** was used much less, contributing only 4% to the corpus. Victor did not produce any tokens of the **up** orientation, either in his sign babbling, or in his lexical items.

The phonetic structure of the lexical items of both Kate and Victor show a strong overlap with the phonetic structure of their sign babbling. Although previously unused primes did occur in the lexical items, the majority of lexical items were produced using primes that were also prevalent in the sign babbling corpus.

Syllabic Structure. Four syllable types were produced in the lexical items of Kate and Victor. The frequency of syllable types produced in the lexical corpus is presented in Table 26. Location change and handshape change predominated; they comprised 89% of

Table 25. Frequency of Orientation Primes for Kate and Victor's Lexical Items

Orientation	Frequency	Percent of Orientation Tokens	Cumulative Percent
In	25	54	54
Out	9	19	73
Up	6	13	86
Right	3	6	92
Down	2	4	96
Left	2	4	100

Table 26. Frequency of Syllable Types for Kate and Victor's Lexical Items

Syllable Type	Frequency	Percent of Syllable Types	Cumulative Percent
Location	21	46	46
Handshape	20	43	89
Handshape/ Orientation	3	7	96
Non-Manual	2	4	100

syllables of the lexical corpus. These same syllable types comprised 82% of the sign babbling corpus. This represents a substantial overlap in the syllabic structure of sign babbling and lexical items. There were no examples of orientation change syllables, nor of any of the combination syllables with the exception of handshape/orientation change.

The non-manual syllables deserve a special note. One token in particular was very interesting. This token was Victor's production of the sign CUP at 14 months. Victor and his father were sitting at the table. Father had asked Victor where his cup was many times. Victor looked at his father and signed CUP in the following way: his right hand, in the **C** handshape was placed with the thumb in contact with the chin. The adult sign for CUP is made by twisting the wrist back and forth while maintaining thumb contact with the chin. Victor, however, did not produce this type of movement. Instead, he tilted his head and arched his entire body backwards in a very exaggerated manner. During this time his hand remained stationary in contact with his chin. Victor's parents laughed at this rendition of the sign CUP. Victor clearly knew that movement was involved in the sign. He seemed to play with this movement, substituting a whole body movement for the required hand movement.

The overlap of syllabic types produced in sign babbling and early lexical items provides strong support for the continuity of sign babbling and early signs.

Summary of Results

The sign babbling of Kate and Victor exhibited all of the required features of canonical babbling. Both children were producing sign babbling regularly at 10 months of age. Their sign

babbling exhibited the phonetic structure of sign languages. The sign babbling forms also exhibited well-formed syllabic structure. Both children met and maintained the canonical babbling ratio throughout the duration of the study. A large proportion of the sign babbling of Kate and Victor consisted of reduplicated syllables. The production of reduplicated forms is one of the most immediately salient features of canonical vocal babbling. Three stages of sign babbling were observed in Kate and Victor. These stages of manual activity were found, these were static sign primes, syllabic babbling and jargon babbling. The static sign primes are not syllabic, and therefore do not meet the requirements for canonical babbling. Both syllabic and jargon sign babbling involved the production of well-formed syllables, thereby meeting the requirement for canonical babbling. Finally, sign babbling was found to be continuous in both phonetic and syllabic form with the early lexical productions of both Kate and Victor. These seven factors strongly support the conclusion that the sign babbling of the deaf children was canonical.

The sign babbling of the hearing children did not exhibit the same features. Although instances of sign babbling with the required phonetic and syllabic form were produced, the hearing children did not produce canonical sign babbling. The frequency of occurrence of the sign babbling tokens was much lower than that exhibited by the deaf children. The variety and complexity of the sign babbling of the hearing children was severely constrained and clearly reflected the lack of sign language input. Nor was the sign babbling of the hearing children used in combination with other instances of sign babbling or pointing. These factors support the

conclusion that the sign babbling produced by the hearing children in this study was not canonical.

The deaf children's sign babbling exhibited the phonetic and syllabic structure of sign languages. A constrained set of handshape, movement, and location primes were used in the sign babbling of Kate and Victor. All of the possible orientation primes were produced in the sign babbling corpus. The syllabic structure of sign babbling was consistent with the syllabic structure of sign language. It must be noted that Victor produced a type of sign babbling which was syllabic due to the presence of a non-manual marker. The presence of non-manual markers in both the sign babbling and early lexical productions of these two children suggests that this may be a more basic form, and is more central to sign syllable research than is reflected in the current research. This finding stresses the importance of considering non-manual markers of syllabicity in adults.

The phonetic structure of sign babbling was largely continuous with the phonetic structure of the lexical items produced by Kate and Victor. There was a striking continuity between the syllabic form exhibited in a child's sign babbling and the syllabic form she or he exhibited in the lexical items produced. Thus, clear continuity was observed between sign babbling and lexical items.

Discussion

The results of this thesis provide strong evidence that canonical sign babbling occurs in children who are acquiring a sign language from their deaf parents. The deaf children in this study produced canonical sign babbling. The sign babbling of the hearing children was qualitatively and quantitatively different from the canonical sign babbling of the deaf children. The deaf children's canonical sign babbling exhibited a much wider range of phonetic primes and syllabic types than was observed in the sign babbling of the hearing children. The deaf children also produced a much higher frequency of sign babbling. The differences found in the manual productions of deaf and hearing children in this study support the conclusion that children exposed to sign language produce canonical sign babbling. The hearing children in this study, although they produced sign babbling forms, never produced canonical sign babbling.

The canonical sign babbling of the deaf children exhibited strong phonetic and syllabic similarities to the phonetic and syllabic contours of sign languages. The canonical sign babbling also exhibited strong phonetic and syllabic similarities to ASL. Canonical sign babbling is influenced both by the general phonetic and syllabic structure of world sign languages and by the particular phonetic and syllabic contours of the environmental language. The relative weight of these contributions is yet to be determined. A constrained set of handshape, movement, location and orientation primes were produced in the canonical sign babbling of Kate and Victor. Although there were examples of all types of sign syllables,

two syllabic types predominated in the canonical sign babbling corpus. Further, the production of non-manually marked syllables in Victor's canonical sign babbling suggests that this type of syllable should be given greater attention in sign syllable research. Individual differences were noted in both phonetic and syllabic structures. These differences were most noticeable with the location primes and syllabic types. The presence of individual differences in the canonical sign babbling of Kate and Victor does not represent anything unusual about the sign babbling data. Individual differences are regularly noticed in hearing children's vocal babbling (Locke, 1987; Vihman, 1986; Vihman et al, 1985; Vihman et al, 1986).

Given the similarities between the phonetic and syllabic structure of canonical sign babbling and sign languages, it is not surprising that continuity was observed between the phonetic and syllabic structure of the canonical sign babbling and the early sign productions of Kate and Victor. The majority of their lexical productions were produced from the phonetic repertoire established in their canonical sign babbling. The individual differences noted in Kate and Victor's canonical sign babbling were also noted in their production of lexical items.

The distinction between gesture and language is also supported by the canonical sign babbling of Kate and Victor. Their canonical sign babbling exhibited both phonetic and syllabic properties of sign language. In contrast, the communicative gestures produced by the hearing and deaf children in this study were highly similar in form and function. These gestures did not exhibit the phonetic and syllabic properties of sign language. The finding that gestures and language are distinct from the very beginnings of language acquisition supports previous work by Petitto (1986, 1987, 1988).

Despite the fact that gesture, sign babbling, and signs occur in the same modality for children acquiring sign language, gestural and linguistic modes of communication are separated and used in distinct ways by the child.

These results provide evidence that babbling is a language-related phenomenon and is not a result of the development of speech *per se*. If babbling occurred simply as a function of the development of articulatory and motoric control of the oral cavity, canonical sign babbling would not be expected to occur. Evidence of canonical sign babbling provided by the two deaf children in this study call into question the assumption that babbling is related to the development of speech. Instead, these data support Lenneberg's theory that babbling is a function of the development of the language faculty itself.

The implications of these data are discussed with regard to two questions: (a) Why do children produce canonical babbling?, and (b) What is the significance of the hearing children's non-canonical sign babbling?

Why Do Children Produce Canonical Babbling?

The occurrence of canonical sign babbling in the two deaf children in this study provides evidence of a link between babbling and language. If babbling is related to language acquisition in either modality, sign or speech, then the function of babbling cannot be specifically related to speech alone. Ferguson and Macken (1983) have suggested that babbling is a form of play through which the child learns about phonology. Jusczyk (1989) suggests a more specific function for babbling. The onset of canonical babbling is marked by the child's production of well-formed syllables. This discovery of the syllable presents the child with a unit that can be

used to analyse the phonetic elements of language (Jusczyk, 1989). In addition, the syllabic unit can be used to gain information about the possible combinations of elements (the phonological rules) that are unique to each language. The data in this thesis support this theory. The phonetic and syllabic forms used by the child in canonical babbling predominate in the child's first signs or words. The acquisition of first signs or words, and the child's journey into the use of reference and meaning, would surely be more manageable were the child able to utilize some previously mastered phonological forms. Those phonological forms are acquired during the canonical babbling period.

Canonical babbling also provides powerful support for the reality of a level of language analysis that consists of form without meaning. Canonical babbling provides the child with an opportunity to analyse and manipulate the pure form of language, be it signed or spoken language. During this time, the child produces meaningless forms and plays with these forms in an attempt to sort out the auditory or visual shape of her language.

What Is the Significance of the Hearing Children's Non-Canonical Sign Babbling?

The sign babbling produced by the hearing children in this study was not canonical. It was produced using a very small set of phonetic primes and was predominantly composed of one syllable type. The lack of variety and complexity in phonetic and syllabic structure is not surprising because these children did not receive any sign language input. This profile mirrors that presented by the vocal babbling of deaf children (Oller et al, 1985; Oller & Eilers, 1988; Stoel-Gammon & Otomo, 1986; Stoel-Gammon, 1988). Deaf

children do not produce canonical vocal babbling The consonantal inventory of the vocal babbling deaf children produce is much more restricted than the consonantal inventory of the canonical vocal babbling produced by their hearing peers (Stoel-Gammon, 1988) The lack of variety in the consonantal repertoire of the deaf children is not surprising because these children cannot benefit from the auditory linguistic input in their environment

What is the significance of the non-canonical sign babbling produced by the hearing children in this study and the non-canonical vocal babbling produced by deaf children? If we consider a wider range of facts about infant manual and vocal behavior a pattern emerges.

Fogel (1981) and Fogel & Hannan (1985) have found that hearing children engage in systematic motoric hand activity beginning as young as 9 weeks of age This hand activity involved the production of six hand forms consisting of a hand clasp, pointing, a spread hand, a curled hand, a fist, and a thumb to finger hand form With the exception of the hand clasp form, these hand forms have similar handshape primes in ASL· pointing resembles the **G** handshape prime, spread resembles **5**, curl resembles **52**, fist resembles **A**, and thumb to finger resembles the **F** handshape prime With the exception of **F** these handshapes were among the most frequently used in the canonical sign babbling of the deaf children in this study. Although Fogel (1981) and Fogel & Hannan (1985) do not interpret their results in this light, it seems plausible that the manual activity they studied indicates a readiness of the hands to produce sign language This is similar to the way that early vocalizations indicate a readiness of the oral articulators to produce spoken language.

The hand activity described by Fogel and Hannan above resembles the non-canonical static sign babbling forms observed in the deaf and hearing children in this study. For the two deaf children who were exposed to sign language input, this manual activity developed into canonical sign babbling at approximately 7 to 10 months of age. By 12 months of age, the canonical sign babbling of the deaf children became jargon sign babbling. At approximately the same time (around 12 months) their first signs were produced.

Similar stages are found in the hearing child's development of vocalizations (Oller, 1980; Stark, 1980). From birth, both hearing and deaf infants produce vocalizations. For children who are exposed to, and can benefit from, spoken language input, these vocalizations develop into canonical vocal babbling at approximately 7 to 10 months of age (Oller & Eilers, 1988). By 12 months of age, the canonical vocal babbling of hearing infants includes variegated syllables. At approximately this age, hearing children produce their first words.

The non-canonical sign babbling of the hearing children and the non-canonical vocal babbling of deaf children are significant because they indicate that the language faculty is prepared to produce linguistic input in either the auditory/oral or visual/manual modality. Deaf and hearing children produce similar manual and vocal activity until approximately 7 months of age. If a child is exposed to sign language input, she will begin to produce canonical sign babbling between 7 and 10 months of age. If no spoken language input is available to her, her vocalizations will never become canonical. If a child is exposed to spoken language input, she will begin to produce canonical vocal babbling between 7 and 10 months of age. If no sign language input is available to her, her manual

activity will never become canonical. This is summarized in Table 27. This theory about the development of manual and vocal hand activity into canonical babbling has been put forth by Petitto (1985, 1987a, 1987b, 1988, Petitto & Marentette, 1989)

Table 27. The Development of Manual and Vocal Activity into Canonical Babbling by Language Input

Input	Manual Activity	Vocal Activity
Spoken Language	Non-Canonical	Canonical
Sign Language	Canonical	Non-Canonical

It is important to note that there does not seem to be a lag in language development because the child is acquiring sign language, nor do the data in this study support the claim that sign language develops earlier. This supports the findings of Petitto (1988), who found that deaf children do not acquire sign language earlier The claim that deaf children acquire sign language earlier has been made by Orlansky & Bonvillian (1988).

The existence of the manual activity discussed by Fogel (1981) and Fogel & Hannan (1985) suggests that the child is well prepared to produce signed or spoken language. Evidence that the child is equally well prepared to process sign language input is provided by

Carroll & Gibson (1986). Hearing infants aged 4 months, with no exposure to sign language, were able to discriminate different types of movement. The movements used in this study were based on certain movement primes of ASL. This result suggest that young infants do have the basic visual processing mechanisms necessary to perceive phonological distinctions relevant to sign languages.

These facts suggest that both acoustic and visual units are equi-potential transmission/reception channels in the ontogeny of language. Hearing and deaf children initially engage in similar hand and vocal activity. If the child is exposed to a systematic, internally organized, communicative signal via either channel, the language acquisition processes will become engaged, and the child will proceed along the path to learning that language -- regardless of the modality.

The existence of canonical sign babbling suggests that the human organism may be equipped with a flexible language capacity that can freely map itself onto either modality. This flexibility suggests that language may be controlled by an open genetic program which does not specify a primary modality for language (Petitto, 1987a, 1987b, 1988; Petitto & Marentette, 1989; Shatz, 1985). By looking at the form of canonical babbling in this alternate channel, we gain another window into the resiliency of particular language structures.

This study represents the first analysis of children's canonical sign babbling. The canonical sign babbling produced by the two children in this study provide convincing evidence of the existence of such a phenomenon. This result must be confirmed through similar studies of other children acquiring sign language. Also, a cross-linguistic study of sign babbling would provide compelling

evidence of the truly universal and linguistic nature of canonical babbling. Preliminary evidence of cross-linguistic sign babbling has been presented by Petitto (1987b, 1988)

In order to directly test questions regarding the equi-potentiality of the modalities for language, it will be necessary to observe the development of young deaf infants from birth. In addition, current research is being done using hearing children of deaf parents. These children are certainly acquiring a sign language as their native language. It is possible to follow this population directly from birth, thereby acquiring the longitudinal data necessary to determine the age of onset of the various stages we expect to observe. One advantage of using hearing children of deaf parents is that they will most certainly grow up to be bilingual, this presents the unique opportunity to observe the development of canonical babbling in <u>both</u> the signed and vocal modalities.

<u>Conclusions</u>

The study reported here has clear implications for research in the fields of babbling and language acquisition Canonical sign babbling occurs in children who are learning sign languages as their native language. As a result, it is clear that babbling is an a-modal phenomenon which occurs with equal ease in either the auditory/oral or the visual/manual modality The modality of the environmental language determines the modality that will be used by the child in her canonical babbling. Canonical babbling is related to the acquisition of language *per se*, not to the development of speech

In addition, the results of this thesis have implications for our understanding of the nature of language and its biological under-pinnings. It is generally accepted that a special link exists between

speech and the language faculty. The existence of canonical sign babbling challenges that relationship. Canonical sign babbling provides evidence of the equi-potentiality of the modalities to serve as reception and transmission channels for language. This equi-potentiality is evident from the very beginnings of the language acquisition process. This finding calls into question traditional assumptions regarding the special nature of speech.

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Appendix A

Complete List of Toys Used in Videotaped Sessions

ball
bell
Big Bird puppet
boat
brush
bubble blower
comb
construction hat
cowboy hat
doll
facecloth
flower
hammer
hand puppet
jar
milk carton
mirror
photographs
picture books
pictures
plastic apple
plastic banana
plastic fish
plastic jug
rabbit puppet
rubber snake
running shoe
spoon
stuffed dog
stuffed duck
sunglasses
tambourine
teddy bear
toothbrush
toy car
toy phone
toy record player
toy tv
train
turtle
weebles
whisk

Appendix B

General Transcription Form

VT	Frame	Hand	EH	Form	Combination	Target Object	Use
6	1112	both	no	drinking	no	cup	spontaneous

Parent's Interpretation	Comments
	playing with Laura

Appendix C

Transcription Form for Sign Phonetic Notation

VT	Frame	Hand	EH	Form	Eye Gaze	Target Object	Contact
2	2951	both	yes	52 sequence	object to mother	Big Bird puppet	no contact

Right Handshape	Right Movement	Right Orientation	Location
52 to A2	15, repeat	left side	centre

Left Handshape	Left Movemer	Left Orientati	Facial Exp	Comments
52 to A2	15, repeat	right side		

Appendix D

Descriptions of Types of Sign Babbling

Note: The categorization of sign babbling tokens into types is based on the phonetic similarity of tokens. All tokens classed as one type share a distinctive feature. The "name" given to each sign babbling type is the name of the phonetic prime which distinguishes the type. The number of tokens per type as well as the syllable type of each sign babbling type is also presented

Sign Babbling Type	Tokens	Syllable Type
5 sequence 1	3	location change
5 sequence 2	4	location change
5 sequence 3	4	location change
5, head sequence	15	location change
5, centre sequence	5	location change
5, chest sequence	2	location change
5, chin sequence	1	location change
52 sequence	21	handshape change
52, G sequence	8	handshape change
8 sequence	3	handshape change
A sequence	2	handshape change
A4 sequence	11	location change
A, cheek sequence	4	location change
A, ear sequence	9	location change
A, head sequence	13	non-manual change
A, mouth sequence	3	location change
B to **A** sequence	10	handshape change

Sign Babbling Type	Tokens	Syllable Type
B sequence	2	handshape/orientation change
bb sequence	1	handshape change
bO sequence	8	handshape change
F sequence	5	handshape change
flick sequence	3	handshape change
flex sequence	2	orientation change
G sequence	5	location change
O sequence 1	7	handshape change
O sequence 2	2	handshape/location change
O sequence 3	11	location change
O, chest sequence	1	location change
roll sequence	8	handshape change
twist sequence	4	orientation change
clasp sequence	12	location change, or handshape change

Appendix E

Descriptions of Types of Communicative Gesture

Gesture Type	Description
bang	hit empty hand on object in hand
banging	hit hand on object, object in hand
combing	combing action with object in hand
clap	clap hands together
dialing	circular motion like dialing a phone
drinking	putting an object to the mouth and tilting either head or object
flap arms	movement of arms at sides of body from below the waist to shoulder level or higher and back to waist
gimme 5	spread hand raised above head
hand on head	hands placed on head, there was no movement involved in these gestures
open/close	repeated opening and closing of the fingers from an open or curved hand
pressing	self-explanatory, typically involved a finger rather than the whole hand
pulling	self-explanatory
pushing	self-explanatory, typically involved the whole hand
putting in	putting an object into another object, e.g., putting money into the cash register
putting on	putting an object on its proper place, e.g., putting a hat on one's head
putting to	putting the telephone to one's ear

Gesture Type	Description
raise arms	raising arms above the head
roll object	moving an object on a flat surface, typically involved cars and balls
shaking	shaking an object in the air, e.g., a tambourine
throwing	self-explanatory
turning	turning an object, e.g., turning a button on a toy radio
twisting	self-explanatory, typically involved the lid on a jar
waving	waving an object in a large arc in the air

Appendix F

Frequency of Sign Babbling, Gesture, and Points for All Children

Child/Age	Sign Babbling	Gesture	Point
Marie-Claire			
10 mos	1	20	0
12 mos	3	41	0
14 mos	6	37	14
Michèle			
10 mos	4	66	0
12 mos	3	65	0
14 mos	1	64	20
Charles			
10 mos	3	26	10
12 mos	7	40	13
14 mos	4	55	23
Kate			
10 mos	39	82	130
12 mos	31	15	33
14 mos	10	4	4
Victor			
10 mos	42	48	0
12 mos	27	50	17
14 mos	42	24	31