POST MILAN ASL & ENGLISH LITERACY:

Issues, Trends, & Research

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our species. The two basic strategies employed instead would dazzle the modern student of propaganda. In the first case, participants peddled their opinions about the superiority of speech by appealing to the notions of science popular at the time. Based on an apparent misunderstanding and misuse of Darwin's views, participants advanced arguments in favor of speech that bore only a gross resemblance to Darwin's theory of biological evolution through natural selection. Yet, by invoking Darwin, their opinions had the power of appearing scientific. Here, deaf people's use of signed languages was likened to the animalistic communication of *non*-human primates, in particular, the chimpanzee. For example, F. Ferreri, a leader of deaf education in Italy wrote in the years following the Congress of Milan: "What can one say of these very deaf who, lacking an education that would give them a clear and exact appreciation of the great gift of speech, persist in considering as natural language their violent and spasmodic miming, which can at best simply establish their kinship with the famous primates" (Cuxac, 1980, cited in Lane, 1989, p. 409). Non-speaking, signing deaf people were compared to subhumans on the phylogenetic tree. "Everyone knows," said the French inspector general from the Ministry of the Interior, "that the deaf are inferior in all respects. Only professional philanthropists have said they are men like everyone else. . . . Similar to *homo-alalus*, to man without speech in prehistoric times, yet even more retarded since they cannot hear, they pass among like men as their shadows, without hearing them, without understanding them: all human things are foreign to them" (Cuxac, 1980, cited in Lane, 1989, p. 401). Indeed, Alexander Graham Bell was to cite the Congress of Milan "as proof of natural selection: the oral method was fittest to survive" (Winefield, 1981, cited in Lane, 1989, p. 395), precisely the line of argumentation employed by some congress participants in Milan.

In the second strategy, participants drew their arguments in support of speech from theology. Here, entirely unsubstantiated testimonials were advanced by participants who boldly pronounced that speech was the optimal means for thinking, for expressing rational thought, and for moral reasoning. In particular, speech alone, they claimed, was capable of expressing the contents of the soul (Lane, 1989). A report prepared and distributed at the Congress of Milan by Marius Magnat (the hearing former director of an oral school for deaf children in Geneva and a member of the program committee of the congress), captured the extreme claims being made about speech at Milan and afterward. Among other things, Magnat wrote that only speech "facilitates the acquisition and use of ideas . . . has more precision than sign, makes the pupil the equal of his hearing counterpart, allows spontaneous, rapid, sure, and complete expression of thought, and humanizes the user . . ." (Magnat, 1880, cited in Lane, 1989, p. 388). Indeed, the explicit assertion by Magnat, and many others at this congress and subsequently, was that the manual languages

of deaf people were distinctly lacking in the above properties. He went on to state that "manually taught children are defiant and corruptible. This arises from the disadvantages of sign language. It is doubtful that sign can engender thought. . . . Sign cannot convey number, gender, person, time, nouns, verbs, adverbs, [and] adjectives" (Magnat, 1880, cited in Lane, 1989, p. 388).

Regretfully, for nearly 100 years, the Congress of Milan and the similar congresses that followed it have had profound consequences for deaf people and their signed languages. On the one hand, such congresses led to draconian educational policies for deaf people. On the other, they suppressed the scientific inquiry that would have resulted in informed and impartial evaluation of their claims.

What kind of scientific evidence would have addressed the veracity of the above claims? I will discuss below at least three lines of research that would have been—and are—critical to evaluate such claims.

First, analyses of the linguistic properties of signed languages were needed. Indeed, over the past three decades, intensive linguistic research on the signed languages of the world has revealed that they are naturally evolved, non-universal (non-invented) languages that have the full expressive and grammatical capacity of spoken languages. For example, linguistic analysis of American Sign Language (ASL), a naturally evolved language that is used by many deaf people in the United States and parts of Canada, has revealed that it exhibits formal organization at the same three levels found in spoken language, including a sub-lexical level of structuring internal to the sign (analogous to the phonetic, phonemic, and syllabic levels [Battison, 1978; Bellugi, 1980; Brentari, 1989, 1990; Coulter, 1986; Lane & Grosjean, 1980; Liddell, 1990; Liddell & Johnson, 1989; Perlmutter, 1989, 1991; Sandler, 1986; Stokoe, 1960]), a level that specifies the precise ways that meaningful units are bound together to form complex signs and signs are combined to form sentences (analogous to the morphological and syntactic levels [Baker-Shenk, 1983; Fischer & Siple, 1990; Klima & Bellugi, 1979; Liddell, 1978; Padden, 1981; Supalla, 1982]), and a level that specifies the precise ways that sentences are joined into conversational and discourse patterns (Wilbur & Petitto, 1981, 1983). This research has yielded the surprising conclusion that human languages are not restricted to the speech channel.

Second, sociolinguistic analyses of natural signed languages were needed. Sociolinguistic studies that would examine the social and cultural conditions under which natural signed languages are used have now been conducted. These studies have revealed that signed languages exhibit sociolinguistic patterns identical to those observed in spoken languages. For example, signed languages demonstrate the same type of historical changes that are seen in spoken languages (e.g., the same processes of expanding their lexicons through borrowings, loan words, and compounding [Klima & Bellugi, 1979;

Woodward, 1976; Woodward & Erting, 1975]). Signed language users from distinct signed language communities (for example, the ASL community and the Langue des Signes Québecoise [LSQ] community) demonstrate regional accents, lexical variation depending on socioeconomic status, and lexical variation depending on age and educational background (Battison, 1978). Further, users of distinct signed languages abide by language-specific (tacit) rules of politeness, turn-taking, and other conversational and discourse patterns found in spoken languages (Hall, 1983; Wilbur & Petitto, 1981, 1983).

Crucially, each of the distinct signed languages of the world delineates a distinct cultural group—one that is *not* the counterpart of the majority (spoken) language group (Hall, 1989; Lane, 1989; Padden & Humphries, 1989; Petitto, 1987c; Rutherford, 1988). For example, as is true for users of spoken languages, a signer's use of a particular signed language clearly identifies him or her as having a distinct cultural affiliation and as being a member of a distinct cultural community. Each signed-language community is bound by a distinct system of shared beliefs and attitudes that is expressed in a variety of ways, including (a) poetry, (b) humor and jokes, (c) indigenous artistic expression through theater and dance, (d) indigenous meeting customs and traditions (witness, for example, the ubiquitous deaf social clubs in the ASL and LSQ communities, as well as in the other signed-language communities throughout the world), (e) deaf religious groups, (f) deaf sporting events, (g) deaf newspapers and other publications, and so forth. Note that such group activities are not merely the "deaf" versions of the spoken-language majority's cultural events. Each of the distinct signed languages of the world (including ASL and LSQ) reflects the social attitudes and beliefs of a distinct class of people, bound by their language. These cultural communities are not the mirror images of larger spoken-language groups (for example, English speakers with regard to ASL users or Canadian French speakers with regard to LSQ users).

Many questions remain, however, necessitating a *third* line of research. Though many people may now grant that signed languages are "real" languages, persistent and powerful misconceptions about these languages remain. The biases can be summarized as follows: Speech is special, privileged, critical to human language and its acquisition; speech is fundamentally better than sign; sign is secondary, parasitic on speech. Such views are very deeply held, because they invoke biology—and especially lay people's notions of evolutionary biology. A common misconception is that signed languages are *biologically inferior* to speech. In regard to ontogeny, many hold that speech is "neurologically privileged" in the brain as compared to sign. In regard to phylogeny, many have assumed that signed languages are necessarily "younger" than speech in evolutionary terms. The ability to produce speech sounds is said to have evolved first (Lieberman, 1984, 1991), with signing abilities being "piggy-backed" onto the older speech production mechanisms.

The notion that signed languages are real languages, but somehow lower than the higher status spoken languages, is reminiscent of the late 19th-century division of spoken languages into *high* languages (e.g., those used in Western Europe) and *low* ("primitive") languages (e.g., those used by aboriginal peoples). Though subsequent scientific studies have shown the high-low division of spoken languages to be wholly false, similar investigations of the spoken-signed high-low dichotomy have not been abundant. To better evaluate the high-low dichotomy with regard to spoken and signed languages, a deeper look at the biological presuppositions and premises upon which these notions are based is necessary. Indeed, if we want to understand the biological foundations of a capacity in ontogeny, we must examine its beginnings in the organism. Similarly, if we want to understand the biological status of speech versus sign, we must look to the very beginnings of early language acquisition across these two modalities. It is this issue that I will now address.

My journey toward understanding the biological foundations of human language has followed a varied path, involving (a) comparative analyses of two different species, apes and humans, (b) comparative analyses of languages in two different modalities, signed and spoken, and (c) comparative analyses of the structure, grammar, and acquisition of different signed languages. In trying to understand the biological foundations of a capacity, it is first necessary to determine the extent to which the capacity is species-specific. Therefore, while still a college undergraduate, I moved into a house with an infant male West African chimpanzee, whom we named "Nim Chimpsky." This animal was part of a research project at Columbia University in which I attempted to raise the chimp like a child and teach him signed language. Our research question concerned whether aspects of human language were species-specific or whether human language was entirely learnable (and/or teachable) through environmental input (Terrace, Petitto, Sanders, & Bever, 1979).

Although there is much controversy surrounding ape language research, what has remained surprisingly uncontroversial about all of the ape language studies to date is this: *All chimpanzees fail to master key aspects of human language structure, even when you bypass their inability to produce speech sounds by exposing them to other types of linguistic input, for example, natural signed languages.* In other words, despite the chimpanzee's general communicative abilities, its linguistic capacities do not equal what we humans do with language, be it signed or spoken. This fact immediately challenges the insidious comparisons between deaf people's signing and chimpanzee communication that were made at the Congress of Milan and thereafter. It further led me to the hypothesis that humans possess something at birth *in addition to* the mechanisms for producing and perceiving speech sounds.

In this paper, I will summarize four major discoveries from over a decade of scientific research in my laboratory. Though my research has been motivated

by basic questions in cognitive science and cognitive neuroscience concerning the neural architecture underlying language in the brain, my research findings reveal a stunningly different picture about our species' capacity for language than that advanced by our predecessors at, and well after, the Congress of Milan. To be sure, the research findings discussed below fail to confirm each and every tenet advanced by Magnat and the many others like him, both at the Congress of Milan and over the intervening 100 years since it took place. To take but a few of the prevalent misconceptions of signed languages advanced by Magnat and others, below we will see that spoken language 1) is *not* alone in facilitating "the acquisition and use of ideas," 2) does *not* have "more precision than sign," and 3) is *not* alone in allowing "spontaneous, rapid, sure, and complete expression of thought" (Magnat, 1880, cited in Lane, 1989, p. 388).

Indeed, the findings of my laboratory have led me to propose a new way to construe human language ontogeny. Below, I will advance the hypothesis that speech is *not* critical to human language acquisition. Instead, our species appears to be sensitive, at birth, to specific distributional patterns, or structures, encoded in the input—not to the specific modality of input. Further, there appears to be a biologically based *equipotentiality* of the modalities (spoken and signed) used to receive and produce natural language: If the environmental input contains the requisite patterns, human infants will attempt to produce (and acquire) those patterns, irrespective of whether the input is spoken or signed. The brain-based implications of my research are very clear: The biological mechanisms in the brain that determine the timing, content, course, and sequencing of human language acquisition—and human language representation in the brain—do not appear to discriminate between spoken and signed language input. Alas, it would appear that people discriminate between the two types of input (signed and spoken)—but the human brain does not.

Background

Many contemporary theories of very early language ontogeny are based on the hypothesis that the hearing infant's emerging linguistic abilities are determined by mechanisms underlying the production and perception of speech, per se, and/or mechanisms of general perception. Given that only languages utilizing the speech modality (i.e., spoken languages) are studied, it is in principle impossible to find data that would do anything but support this hypothesis. Only by examining languages in another modality (i.e., signed languages) can we more fully determine the relative contribution of motor production and perception constraints—versus other factors (e.g., abstract regularities of linguistic structure)—to the time course and nature of early language acquisition.

Below, I will compare hearing and deaf infants' acquisition of spoken and signed languages. Because spoken and signed languages utilize different

modalities (acoustic versus visual), and because the motor control of spoken and signed language articulators are subserved by different neural substrates in the brain, comparative analyses of these languages provide critical insights into the effect of modality on the structure and acquisition of language. Indeed, the existence of these languages permits us to tease apart which aspects of language acquisition reflect modality-specific properties of the language transmission/reception mode, and which aspects reflect modality-free properties of language representation.

My research addresses two fundamental questions in cognitive science and cognitive neuroscience, involving both the infant and its interaction with the environment: 1) Are infants born with any innate mechanisms that aid them in the task of acquiring language? If so, are any of them specifically sensitive to the unique organizational properties found only in natural language, or are general perceptual mechanisms sufficient for discerning the regularities of linguistic structure? 2) Are some aspects of the environmental input more critical than others to beginning and maintaining the language acquisition process?

Research Findings

Identical Time Course in Speech and Sign Acquisition

Monolingual Children—To investigate whether certain aspects of environmental input are more critical than others in early language acquisition, I conducted comparative analyses of monolingual hearing children, aged 8 months through 4 years, acquiring spoken language (English or French) and monolingual deaf children of the same ages acquiring signed language (ASL or LSQ).[2] The most striking finding was that deaf children acquiring signed languages from birth do so without any modification, loss, or delay in the timing, sequence, content, and maturational course associated with all linguistic milestones observed in spoken language (Petitto, 1984, 1986, 1987a, 1988, 1992; Petitto & Marentette, 1990). Beginning at birth and continuing through age 5 and beyond, speaking children and signing children exhibit identical stages of language acquisition, including the syllabic babbling stage (ages 7-10 months, approximately), variegated and jargon babbling stage (10-12 months and older), first-word stage (12-18 months), first-two-word stage (18-22 months), and morphological and syntactic developments (22-36 months and older). Signing children and speaking children also exhibit remarkably similar semantic, pragmatic, discourse, and conceptual complexity (Charron & Petitto, 1991; Petitto & Charron, 1988).

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[2]ASL and LSQ are distinct, naturally evolved signed languages. Neither ASL nor LSQ is based on the majority spoken language used around it (English and French, respectively). Further, LSQ is distinct from the signed language used in France.

Such findings are surprising. Previously, some researchers had posited that signed languages may be acquired earlier than spoken languages due to (a) maturational-rate differences between the visual cortex and the auditory cortex and differences between the motor control of the limbs and that of the oral-vocal tract (Bonvillian, Orlansky, & Novack, 1983; Bonvillian, Orlansky, Novack, & Folven, 1983; Folven & Bonvillian, 1991; Meier & Newport, 1990), (b) the larger size of manual gestures, which permits more opportunity for parental molding of infant hands (Bonvillian, Orlansky, & Novack, 1983), and (c) the occurrence of non-arbitrary, iconic signs in signed languages (Brown, 1979). Indeed, some researchers have further claimed that first signs are acquired earlier than first words, although they agree that all other milestones are the same in both modalities (Bonvillian, Orlansky, & Novack, 1983; Bonvillian, Orlansky, Novack, & Folven, 1983; Folven & Bonvillian, 1991; Meier & Newport, 1990). My findings do not confirm these hypotheses.[3] They also cast doubt on the hypothesis that the ability to hear and produce speech, per se, determines the time course and content of human language acquisition.

Bilingual, Bimodal Hearing Children—To further determine whether speech is critical to language acquisition, a study of hearing children, aged 7 months through 24 months, in bilingual, bimodal homes (ASL/English and LSQ/French) was conducted. These hearing children had been exposed to both signed and spoken languages from birth. The results revealed that they achieved all linguistic milestones (vocal and manual babbling, first words and first signs, first two words and first two signs, etc.) in both modalities at the same time and on the same time course as do children acquiring two spoken languages (Genesee, 1987; Petitto, Costopoulos, & Stevens, in preparation; Petitto & Marentette, 1990).

These findings are inconsistent with the hypothesis that speech, per se, is critical to language acquisition, and they challenge the related hypothesis that speech is uniquely suited to the human brain's maturational needs in language

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[3]Almost all of the claims regarding the earlier onset of first signs than first words stem from one group of researchers (Bonvillian, Orlansky, & Novack, 1983; Bonvillian, Orlansky, Novack, & Folven, 1983; Folven & Bonvillian, 1991). In their studies, Bonvillian and his colleagues provided two dates for the occurrence of "first signs": They were said to appear at 8.2 months if the productions contained "recognizable" adult phonetic forms and if they were not required to be used "referentially." If, on the other hand, "signs" were required to be used "referentially," then a second date was provided for these infants' first signs: 12.6 months. Therefore, it would appear that these researchers mislabeled and misattributed genuine instances of manual babbling in signing infants at 8.2 months as being first signs (recall that the syllabic babbling stage occurs at age 7-10 months). The typical age for first signs, in reality, is what they reported as their second date for first signs (i.e., around 12 months).

ontogeny. If speech, per se, were "privileged," bilingual/bimodal hearing children might be expected to attempt to glean every morsel of speech they could get from their environment, favoring the speech input, and therefore, acquire signs later. This was not observed. Taken together, these findings support an alternative hypothesis that speech, per se, is not critical to the language acquisition process. The findings also provide support for the hypothesis that language is under maturational control and unitary timing constraints determine the acquisition of all linguistic milestones in both spoken and signed languages (cf. Lenneberg, 1967).

Manual Babbling

The Phenomenon—Despite differences between spoken and signed language articulators, infants acquiring these languages produce fundamentally similar linguistic structures. The discovery of infant manual babbling provides a clear window into this phenomenon. In the course of conducting research on signing infants' transition from pre-linguistic gestures to first signs, I discovered a class of manual behaviors that contained linguistically relevant units, was produced in entirely meaningless ways, and was wholly distinct from all other manual activity during the "transition period" (age 9-12 months). Subsequent analyses revealed that this class of manual activity is constituted of genuine instances of *manual babbling* (Petitto 1984, 1986, 1987a, 1987b).

The discovery of manual babbling was very surprising and very controversial. A hallmark of human development is the regular onset of vocal babbling well before infants are able to utter recognizable words (Lenneberg, 1967). All previous theorizing about the origin of babbling in hearing infants held that the syllabic *structure* of infants' vocal babbling was determined by the development of the vocal tract and the neuroanatomical and neurophysiological mechanisms subserving the motor control of speech production (Locke, 1983; MacNeilage & Davis, 1990; MacNeilage, Studdert-Kennedy, & Lindblom, 1985; Studdert-Kennedy, 1991; Van der Stelt & Koopmans-van Bienum, 1986).

An additional study was undertaken to understand better the underlying basis of this extraordinary behavior. Physical and articulatory analyses (as in acoustic and phonetic analyses of sound) were conducted of all manual activity produced by a group of ASL deaf and English hearing infants aged 10, 12, and 14 months. The introduction of hearing controls to this study was crucial, because it was necessary to determine whether the manual activity observed in deaf infants exposed to signed languages was similar to or different from that which is observed in all infants, even those who are not exposed to signed languages. The findings, reported by Petitto and Marentette (1991), revealed unambiguously a discrete class of linguistically relevant, meaningless manual activity in ASL deaf infants that is structurally identical to the meaningless vocal babbling observed in hearing infants. Indeed, its structure is wholly

distinct from all infants' motor manual activity (Thelen, 1991; Thelen & Ulrich, 1991) and communicative gestures (Petitto, 1988, 1992). Most surprising of all, manual babbling possesses *syllabic organization*. It alone possesses signed phonetic units and combinations of units that are structurally identical to the phonetic and syllabic organization known only to human language (signed or spoken). The findings raised the following question: Given that the same babbling units (i.e., phonetic and syllabic) are observed to occur across two radically different modalities, *where does the common syllabic structure come from?*

To address this question, studies were conducted comparing all infants' rhythmic, non-linguistic hand/body movements (Thelen, 1991) with sign-exposed infants' rhythmic, opening-closing movements, which form the nucleus of signed (and spoken) syllabic babbling. One goal was to address an hypothesis alternative to the one offered here: that manual babbling does not share syllabic organization with vocal babbling but is, instead, more similar to all hearing and deaf infants' rhythmic motor activity. A further goal was to identify any universals of syllabic structure in the signed and spoken modalities, should they exist.[4] To do this, the precise physical properties of infant manual syllabic babbling (e.g., its timing, rate, velocity, and fundamental frequency) were compared with those of infant vocal syllabic babbling. Preliminary analyses using an Optotrack computer visual-graphic analysis system—the output of which is analogous to a spectrographic representation of speech, but which was built here for signed languages—have revealed the following: 1) systematic *differences* in the rhythmic timing, velocity, and spectral frequencies of sign-exposed infants' manual babbling as compared with the rhythmic hand activity of all infants' (be they hearing or deaf); 2) systematic *similarities* in the timing contours of manual and vocal babbling; and 3) converging structures in infant *and* adult-to-infant sign/speech productions suggesting that all humans, at birth, may possess peak sensitivity to a rudimentary *timing envelope* (a rhythmic timing bundle in natural language prosody of about 1.2 seconds, which is currently under intensive investigation). (See Petitto, Ostry, Sergio, & Levy, in progress, for a comprehensive discussion of the formal differences between syllabic manual babbling and other rhythmic manual activities in infants.) In addition, early handedness differences may distinguish manual babbling/linguistic productions from other motoric manual activity (Marentette, Girouard, & Petitto, 1990).

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[4]As is common and healthy in scientific discourse, there is dissenting discussion about the sign syllable. However, it has focused largely on whether "hold" is analyzed as being part of the syllabic stem along with "movement," or whether it occurs with movement due to a phonological process (Brentari, 1989, 1990). Crucially, however, despite technical arguments of linguistic theory, there is no debate over the existence of syllabic organization within signed languages.

Such studies have provided new insights into the contribution of the body's motor production constraints to the structure of the syllable in human language (be it spoken or signed), and they have provided a key window into the elementary units of perceptual sensitivity that may underlie very early language acquisition in our species. I will return to the implications of such studies (as well as their preliminary results) below, where I will propose a theory of early language ontogeny.

Cross-Linguistic Analyses of Manual Babbling in ASL and LSQ—New data have been collected on the entire range of manual activity of ASL and LSQ infants 8 to 20 months of age (Petitto, in preparation-a). As in vocal babbling, these deaf infants first produced common sign-phonetic units—units that were not drawn from the particular sign-phonetic inventories of either ASL or LSQ. To be clear, infants exposed to signed languages from birth do not manually babble in any particular signed language. However, as has been reported for vocal babbling (de Boyssen-Bardies & Vihman, 1991), language-specific phonetic units are observed in these infants' manual babbling at around 12 months or after. Thus, manual babbling occurs in more than one signed language, and the effects of experience with the target language observed in hearing infants are also observed in deaf infants.

Manual Babbling in Hearing Infants—An entirely unexpected finding that emerged from the studies of timing milestones discussed above was that bilingual/bimodal hearing infants exposed to signed and spoken languages produce *two* kinds of babbling—manual and vocal—within the same developmental window (Petitto & Marentette, 1990). Analysis of newly collected data from eight infants (4 ASL/English; 4 LSQ/French) has revealed that these infants demonstrated the same stages of babbling in both modalities. The infants also demonstrated intriguing parallels in the overall types of phonological processes that they exhibited, regardless of the modality. Crucially, *modality-specific differences* regarding the specific phonological permutations that are possible/impossible in the respective modalities have also been observed and are currently under investigation (Petitto, in preparation-b).

Taken together, the above findings indicate that babbling in early language ontogeny is not restricted to speech. Such cross-modal convergent findings point to the existence of a robust period of human language ontogeny during which infants produce the raw "form" of language, which may ultimately help them identify the inventory of units and permissible combinations of units in their target language (cf. Jusczyk, 1986). They also point to the idea that the syllable may be a natural unit of language distinctions (Bertoncini, Bijeljac-Babic, Blumstein, & Mehler, 1987; Bertoncini & Mehler, 1979; Moon, Bever, & Fifer, 1992). My ongoing work is providing new insights into the origin of

universal patterns in all infant babbling, as well as into modality-specific differences. In so doing, these studies are providing a window into the relative contributions of raw phonological constraints (i.e., linguistic/structural) versus motor production constraints in early phonological development.

Dissociation Between Early Language and Gesture

Deaf and hearing infants exposed to signed languages consistently differentiate between linguistic signs and communicative gestures throughout their development, even though 1) signs and gestures reside in a single modality, and 2) some signs are iconic (pictorial) and/or indexical and, being so, share formational and referential properties with some common gestures used in Western culture. My study of pronoun acquisition (Petitto, 1987a) provides a clear demonstration of this phenomenon. In spoken language acquisition, children begin to produce their first words at around 12 months, but they do not begin producing personal pronouns (e.g., *you*, *me*) until around 18 months. Even then, hearing children exhibit unstable knowledge of pronouns, with some producing systematic pronoun-reversal errors (e.g., saying "you" when they mean "me").

Unlike pronouns with arbitrary forms (e.g., the $y + o + u$ in spoken English), linguistic pronouns in ASL are made by pointing: Pointing to one's self means ME, and pointing to the addressee means YOU. Given that the linguistic pronoun in ASL is formed by pointing, will deaf children differentiate linguistic and gestural communication about self versus other? If children's acquisition of language is driven exclusively by a general cognitive and/or communicative competence in symbolizing (Bates, Bretherton, Shore, & McNew, 1983), then deaf children's knowledge and use of prelinguistic pointing (ages 9-12 months) should give them an advantage relative to hearing children in acquiring linguistic pronouns.

This does not occur. Like hearing children, deaf children begin using the pointing gesture in rich communicative ways—pointing to objects, people, and so forth—at ages 9-12 months. At 12 months, all pointing to people stops, only to re-emerge at around 18 months, the precise period when hearing children first use pronouns. However, during the 12- to 18-month-old period, all gestural communicative pointing (e.g., to objects and locations) continues in frequent, rich, and varied ways, and, also like hearing children, all reference to self and other is accomplished through the use of names (e.g., *Mommy*, *Daddy*, *Eva*). Surprisingly, like hearing children, signing deaf children produce reversal errors (e.g., pointing to another, as in YOU, when they mean ME, or vice versa), which can only be made by ignoring the "transparent" (indexical) nature of the pointing gesture (see Petitto, 1987a, for an explanation of why children make reversal errors).

Children's consistent differentiation between language and gesture supports the hypothesis that aspects of the structural and conceptual underpinnings of children's knowledge and use of language are distinct from their knowledge and use of gesture.

Constraints on Language Versus Gesture

I have observed that young hearing children acquiring words (at around 12-18 months) produce even their earliest lexical items in constrained ways that correspond to different word types or *kinds* (Petitto, 1992). Said another way, words (and signs) "refer"—be it to things in the world or to abstract concepts in our heads—and the things that words (and signs) refer to typically form a conceptual group known as a kind (Quine, 1977). Although this finding corroborates those reported for word acquisition in slightly older hearing children (Huttenlocher & Smiley, 1987), other researchers have asserted that children's earliest lexical items are not so constrained (Nelson, 1988). Additionally, I have observed that young children exposed to signed languages from birth also produce their earliest lexical items in constrained ways corresponding to "sign" types or kinds that are identical to word types or kinds. Indeed, both signing and speaking children use their early lexical items in ways that suggest that their tacit hypotheses about the meanings of novel words or signs are constrained according to such conceptual groupings or kinds. Specifically, the range of referents over which children apply a particular word or sign form particular kinds (e.g., kinds of objects, kinds of events, kinds of locations, kinds of possessions).

The above pattern is not true, however, of all children's use of gestures, including "symbolic gestures" (empty-handed gestures that "stand for" referents—brushing motions at the head for a hairbrush, for example). Although occurring within the identical time period as words or signs, symbolic gestures are used both within and across word or sign kind boundaries. For example, the same gesture will often be applied to a location, an event, and an object (in a broad associative manner), rather than to one particular category or kind. Further, symbolic gestures appear only *after* children have the corresponding lexical item in comprehension and/or production (the "twist" gesture, for example, was observed only after children had the word or sign for *open*), and the frequency of symbolic gestures is exceedingly low relative to children's early lexicon. These findings challenge the hypothesis that gestures precede language (Bruner, 1975) and the hypothesis that gestures have the same symbolic status as words (Bates et al., 1983). Indeed, symbolic gestures appear to be parasitic on language rather than the reverse (Goldin-Meadow & Morford, 1989; McNeill, 1985).

The finding that gestures and language are used in distinct ways provides support for the hypothesis that distinct mechanisms for processing specifically

linguistic information may underlie aspects of language ontogeny (Chomsky, 1988; Gleitman, 1981; Pinker, 1984), and it provides key insights into the nature of linguistic and conceptual constraints underlying children's early lexicon, which are being further investigated (Waxman & Petitto, in progress). That signing infants exhibit this gesture-sign dissociation is especially illuminating because, again, both types of information reside in the same modality. What cues in the input, if any, aid these children in differentiating gesture from sign? Caretakers' gestural versus language input provides a tell-tale clue: First, neither speaking nor signing caretakers' gestures are formed from a restricted set of units; they are produced with forms that often vary from context to context. That is, they lack sub-lexical (phonetic, syllabic) organization. Second, caretakers further produce their gestures as concatenated lists—lists that (a) virtually never involve non-pointing gesture + gesture combinations (instead, point + gesture and vice versa are most common) and (b) rarely if ever exceed two units in length, regardless of the specific content of the combinations. Indeed, adult gestural input lacks the rhythmic, stress, and timing variables that are unique to natural language prosody, be it spoken or signed (it also lacks a syntax). I hypothesize from these and other findings that infants possess a sensitivity to both sub-lexical and prosodic variables (e.g., the fall-rise patterning, stress, and temporal cues that bind words or signs into clauses, phrases, and sentences), and that this sensitivity permits them to distinguish gestures from signs or words. This hypothesis figures prominently in the theory that I will advance below.

Theoretical Questions

The key issue for students of early brain development is not *that* signed and spoken languages are acquired similarly, but to determine *why* this is so. How is it possible that languages in two radically different modalities can be acquired on a similar time course? Given that the common structures do not directly reflect the structural (production) constraints on the given modality (spoken or signed), where does the capacity to produce common structures come from? Why isn't there a preference for speech, given that there is every indication that speech has been selected for? Answers to these questions will provide insights into the mechanisms that underlie early language acquisition in all humans.

A Theory of Early Language Ontogeny

The above findings do not support the hypothesis that speech-based production mechanisms, per se, wholly determine early language ontogeny. Because the neural substrates that control the motor production of speech and sign differ, a prediction consistent with this hypothesis is that the time course

and specific structures evidenced in spoken and signed language acquisition should differ. The present findings do not confirm this prediction.

I propose an alternative account regarding the origins and nature of early language ontogeny in all humans, one that addresses the question of how the common time course and common structures in early signed and spoken language acquisition are possible.

The Infant: A Pattern- or Structure-Recognition Mechanism

Signing and speaking infants' ability to produce common structures (see babbling and time-course studies) and their apparent sensitivity to sub-lexical and prosodic cues that bind units (see gesture-language studies) suggest that a common mechanism may be operating across signed and spoken language input. All infants may be born with a sensitivity to units of a particular size with particular distributional patterns in the input regarding aspects of the form, or *structure*, of language, irrespective of the modality of the input. The hypothesis advanced here is that this sensitivity reflects the existence of structural constraints present at birth—a *structure-recognition mechanism*—by which particular distributional patterns in the input have peak threshold saliency over others. It is further hypothesized that the structure-recognition mechanism is specifically tuned to the unique stimulus characteristics of the input that correspond to two aspects of linguistically organized input—not modality—including (a) input structures that correspond to the patterns of rhythm, timing, and stress common to natural language prosody, and (b) input structures that correspond to the maximally contrasting, rhythmically alternating patterns common to the level of the syllable in natural language.

Biological Plausibility—The infant's sensitivity to aspects of language structure at birth may derive from a structure-sensitive mechanism similar to that which has been postulated for the recognition of faces (Gross, 1992; Horn & Johnson, 1989; Johnson & Morton, 1991). For example, it is presently held that there is in the brain no single "feature detector" neuron, per se, for the detection of faces, but rather, "patterned ensembles" of neurons (area IT in primates) that are selectively sensitive to particular spatial-configurational patterns in the input. The particular configurational patterns happen to correspond to just those frequency values that are found in faces (Gross, 1992). Similarly, the infant's nascent sensitivity to aspects of language structure may reflect the presence of a neural substrate that is uniquely sensitive to the stimulus values specified in prosodic and syllabic structure. Specifically, the substrate may contain combination-sensitive neurons and neurons tuned for contrasts (Sussman, 1984, 1989), which would make possible the infant's initial sensitivity to aspects of input that contain these particular values. Note that I am not proposing that the substrate, should it exist, has a particular

language's structure written into it at birth, but that it is a mechanism ready to differentially process input signals consisting of the language-specific values specified above (i.e., the rhythmic and temporal variables and maximally contrasting units that are unique to the prosodic and sub-lexical organization of human language). The nascent sensitivity to these patterns can serve as the foundation upon which knowledge of language is subsequently built.

Parental Input—No doubt, parents' specifically linguistic interactions and general caring (affective) interactions with their infants provide enormous clues to language structure. Indeed, parents impart structural information using multiple modalities: voice/intonation changes, facial/lip movements, expressions, and so on (Fernald et al., 1989). This is why it is probably best that the infant's sensitivity to structure is not tied to one modality. However, it would appear that we still need to posit some mechanism by which the infant is made capable of *attending to* particular input structures that will ultimately be relevant to the target language. In other words, there still must be some mechanism that provides the infant with the ability to perceive, in the first place, the adult's vocal and/or facial cues that are carrying information relevant to early language ontogeny. For example, adult prosodic cues can mark (a) variations in rhythm, timing, and stress that can regulate infant attention, which is important for adult-infant "shared regard," (b) conversational and interactional alternating patterns important for achieving rudimentary discourse conventions, (c) phrase structure information critical to the acquisition of syntax (e.g., clausal, phrasal, and word boundaries), (d) phonetic segment information and its combinatorial possibilities in the target language, and so forth (no specific ordering of importance is intended here; prosodic variables can convey multiple types of information simultaneously). Indeed, by merely "giving" infants innate sensitivity to the two features of natural language structure specified above (prosodic and sub-lexical/syllabic), we provide them with the initial means to begin the language acquisition process well in advance of their having knowledge of the target language's grammar and meanings. This is because all of the types of information carried in prosody listed above (reference cues, conversational conventions, phrase structure, phonetic segments, etc.) are, in principle, derivable through sensitivity to these two levels of natural language phonology. Thus, the infant's sensitivity to particular aspects of the input over others—posited here to be a structure-recognition mechanism present at birth—may provide the infant with the ability 1) to attend to, 2) to lay down in memory, and crucially, 3) to establish a motor production loop with particular aspects of the abundant input that is bombarding its senses.

The Environment

The specific modality of the environmental input is not critical either to begin or to maintain human language acquisition. Speech, per se, is not critical to the human language acquisition process. Instead, it is the structure of the input that is the key, essential factor to both beginning and maintaining that process. To be clear, linguistically structured input—and not modality—is the critical factor required to begin and maintain very early language acquisition.

Within Infant Interactions: Structural, Motor, and General Perceptual Constraints

When perceptual input, be it visual or auditory, enters, it may shunt around the brain, hitting its special processors (e.g., vision, the structure-recognition mechanism that I refer to above). The structure-recognition mechanism will be engaged if the incoming perceptual information contains the specific structures above, thereby permitting 1) tacit decomposition of the input, which ultimately provides the infant with knowledge of the phonetic units and possible combinations (cf. Jusczyk, 1986) and 2) links with motor production that constrain the production of such structures. Because information about the input modality is preserved (Damasio, Damasio, Tranel, & Brandt, 1990; Maurer, 1993; Meltzoff, 1990), an infant can begin to produce babbling units in sign (if exposed to sign), babbling units in speech (if exposed to speech), and babbling units in sign and speech (if exposed to both modalities). Thus, language ontogeny begins through the complex interaction of three mechanisms: 1) the general perceptual mechanism, 2) constraints on motor production, and crucially, 3) specific structural constraints that are especially tuned to particular aspects of linguistic input. (For a discussion of why general perceptual mechanisms and general motor mechanisms are insufficient to account for early human language acquisition, see Petitto, 1993).

Predictions

The above processes can and do occur across multiple modalities. Language acquisition is not restricted to speech. The prediction here is that as long as it contains the appropriate patterns or structures relevant to natural language, input should be acquired on the same time course, irrespective of modality. The findings of the above studies demonstrate this pattern.

Language Phylogeny

In the foregoing account, I have provided the behavioral facts of early language ontogeny that have emerged from studies in my laboratory. It has been my primary goal to explain these facts. To this end, I have advanced a theory of early language ontogeny that I will be refining and testing for many years to come.

However, many educators and researchers alike have speculated on the supremacy of speech by devising intriguing stories about its evolutionary superiority. Although, to be sure, it is not advisable to go from behavioral facts of language ontogeny to theories of language phylogeny, the prevalence of "just-so" accounts about the supremacy of speech begs for some equally plausible alternative accounts for all of us to consider. Thus, like others, I am able to provide hypotheses about the relationship between the present data and language phylogeny. Note that whether hypotheses about language phylogeny are viable or not, the behavioral observations of early language ontogeny identified above remain, strong and clear. In other words, although it is desirable that accounts of language ontogeny be compatible with hypotheses about language phylogeny, it is utterly essential that hypotheses about language phylogeny be wholly consistent with the facts of language ontogeny. In many instances, this has not been the case, especially regarding hypotheses about language phylogeny that ignore the facts of signed language acquisition. For example, the facts supporting the observation that there is an equipotentiality of the signed and spoken modalities in receiving and producing language in ontogeny have been clearly demonstrated. Such facts have been routinely ignored, and the time has come for them to be attended to. I will provide, below, some extremely preliminary speculations about language phylogeny that, at the very least, are consistent with the facts of early signed and spoken language acquisition.

Why isn't there a preference for speech in language ontogeny? What about language has been selected for?

It has been argued that the mechanisms for producing speech were selected for first, and then came language (i.e., syntax) (Lieberman, 1984, 1991). I will offer two alternative preliminary hypotheses based on the premise that first language—that is, aspects of both its form and its conceptual underpinnings—was selected for, and then came the means for producing it.

Hypothesis A—This hypothesis may be summarized as follows: Particular patterns relevant to natural language structure have been selected for, but the expressive apparatus is still in the process of being selected for. The most critical aspects of language—its densely packed, hierarchically organized, rhythmically patterned structure—have been selected for, but the modality has not yet been fully selected for. Either selection for speech has been imperfect or selection for speech is not quite "there" yet.[5] What could this mean in terms of language phylogeny? It could mean that some form of symbolic capacity existed

[5]I thank Kevin Dunbar for first suggesting this possibility to me.

prior to the ability to express it. That is, perhaps we have a clue regarding a *direction of effect*: Internal factors—deriving, for example, from an awareness of self/consciousness, the symbol (as in *X* stands for *Y*), and so forth—could have exerted pressure on the means for producing their contents.

Why do most people speak? Most of us speak, but all of us have the capacity to sign in ontogeny. This fact is not trivial. Indeed, speech does have certain signaling advantages (perhaps in its rate of transmission and reception). Whatever the elusive advantage is, it provided speech with an edge. However, there is no evidence of a preference for speech in language ontogeny. Again, this may imply that speech has been largely selected for (which is why most of us speak) but that the selection process, though good, has been imperfect; we would expect this, given that nature is a "tinkerer." Perhaps, without being "goal-oriented," speech is still in the process of being selected for. Selection has occurred for "language"—that is, aspects of its abstract structure—but the expressive modality has not yet been fully selected for, although it has come very close regarding existing speech perception and production mechanisms. Perhaps, in the distant future, we will see a strong preference for speech in ontogeny—but perhaps not (again, the tinkerer has no goals, as such).

Hypothesis B—According to this hypothesis, the evolution of language has not occurred exclusively in terms of the mechanisms for the motor production of speech (as is commonly asserted). To solve the problem of differentiating between speech-linguistic information and speech-nonlinguistic information being received and expressed in the same auditory modality, perhaps "the brain" was pushed to some other level of language abstraction.[6] Perhaps an abstract structure-recognition mechanism evolved in response to the problem of separating linguistic speech from non-linguistic sounds—a mechanism that does not itself have motor specifications in it, although it *is* linked with them. A "spin-off" of the existence of this structure-recognition mechanism would be that humans could generate alternate pathways for perceiving and producing language because they already had a structure-recognition mechanism that was not tied to a particular modality. *This* may be how it is possible that signed languages exist. And it may be why we see no preference for speech over signed input in language ontogeny, because 1) both demonstrate the requisite structures of natural language, 2) both can be just as easily acquired and used, and 3) both can be just as easily used as a vehicle for the representation and expression of thought.

Note that this hypothesis is distinct from the hypothesis, which it superficially resembles, that argues that language arose in the context of speech and

[6]I thank Leda Cosmides, who first made this connection after I had argued that there appeared to be a common, higher level of abstraction that characterizes the observed commonalities between signed and spoken language structure.

that the brain is consequently neurologically "wired" for speech. According to that hypothesis, when large numbers of deaf people coalesced in a stable way to form communities of signers, signed languages developed within the already existing mental/signaling system geared for speech. Thus, it would not be surprising that speech and signed languages share common linguistic structures. First, however, this account does not explain how such common structures are possible, given that the neural substrates underlying motor control of the speech and sign articulatory apparatuses are distinct. Second, the clear prediction consistent with this hypothesis is that speech should be far better fitted to language structure, expression, and reception than are signed languages. However, all psycholinguistic and neurolinguistic studies to date on the structure, grammar, and acquisition of signed languages have indicated that this is not the case. Third, a further prediction here is that bilingual/bimodal children would show a preference for speech, which has not been observed.

In summary, it may be that certain pressures—for example, the need to separate speech-linguistic from speech-nonlinguistic—were resolved by pulling away from a strictly *speech-motor representation* of language to a new, more abstract *structure-motor* representation. I am well aware of the problem of applying language acquisition data to phylogenetic arguments. However, if pressed, I would say that my data render more plausible this latter hypothesis (B).

Summary and Conclusions

I have argued for the existence of a structure-recognition mechanism in newborns that is uniquely sensitive to particular aspects of natural language structure in the input (i.e., prosodic and sub-lexical/syllabic) and not to modality—that is, not to speech or sound, per se. I have outlined how this mechanism works in conjunction with general motor production and general perceptual constraints in early language ontogeny. I have advanced the hypothesis that speech input, per se, is not critical to the timing, content, course, or sequencing of early language ontogeny. Instead, linguistically relevant structures encoded in the input are key. I have, further, demonstrated that, from birth, there is an equipotentiality of the modalities (spoken and signed) for receiving and producing natural language. As long as the input contains the specific distributional patterns of natural language structure, infants will begin to acquire it, irrespective of the modality of the input. Further, I have suggested ways in which the course of early signed language acquisition, as well as the very existence of human signed languages, can aid our understanding of human language phylogeny.

What We Have Learned Since the Congress of Milan

What transpired at the Congress of Milan—and, regretfully, what can still be seen in pockets of the education of deaf children today—was the human devastation that can result from gross ignorance and prejudice. Fearing human diversity, the Milan participants sought ways to eliminate it—both through their social and political establishments and by using unsubstantiated rhetoric about the biological and moral insufficiency of such diversity (Lane, 1989).

It is sadly ironic that many Milan participants regarded deaf people's use of signed languages as a wholly unilluminating feature, "which can at best simply establish their kinship with the famous primates" (Cuxac, 1980, cited in Lane, 1989, p. 409). Nothing could be farther from the truth. Indeed, the very existence of natural signed languages has proven to be one of the most powerfully illuminating windows into our very humanity. Among many other things, signed languages and the deaf people who use them have fundamentally advanced our scientific understanding of the essential structures of language and thought in our species, providing us with secrets of the organization of language in the brain that have eluded scientists for centuries.

The present research is just a first step. Much more research of this kind must be done—and must be disseminated and acknowledged. However, the implications of the present work are clear: *Signed and spoken languages have fully equal status in the brain.* The human infant brain does not discriminate between language on the hands and language on the tongue. Adults do. Give the brain the tongue, or give the brain the hands, and it will produce the same linguistic structures without any loss, modification, or delay in the timing, content, course, or sequencing of language acquisition.

Turning to the future, it is time for a new generation to come forth and incorporate findings of the present sort into informed and progressive educational programs for deaf children in ways that openly embrace diversity.

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