

**ON THE BIOLOGICAL, ENVIRONMENTAL AND NEUROGENETIC FACTORS DETERMINING  
EARLY LANGUAGE ACQUISITION ; EVIDENCE FROM SIGNED AND SPOKEN LANGUAGES**

**Laura Ann PETITTO**

- Montreal -

**Director : Cognitive Neuroscience Laboratory for Language Sign and Cognition  
McGill University - 1205 Docteur Penfield Ave.  
Montreal -Quebec H3A 1B1**

**A propos des facteurs biologiques, environnementaux et neurogénétiques déterminant l'acquisition initiale  
du langage : données à partir du langage signé et oral.**

Des données sur les stades initiaux d'acquisition du langage signé et parlé sont présentées. Les résultats montrent un grand parallélisme dans le cours temporel de maturation, la structure et le contenu sémantique des stades précoces d'acquisition du langage selon ces deux modalités. De tels résultats indiquent que les mécanismes biologiques sous-tendant les stades initiaux d'acquisition du langage humain ne paraissent pas faire de différence entre l'input linguistique signé ou parlé. Effectivement, il y a à la naissance une étonnante équipotentialité des modalités signées et parlées quant à la réception et l'expression d'une langue naturelle. Pour que langues signée et parlée puissent être acquises de même manière, il se peut que les nouveau-nés humains, à la naissance, ne soient pas réceptifs aux sons ou à la parole, en tant que tels. Au lieu de cela, les nourrissons pourraient être sensibles à ce qui est encodé dans la modalité -que celle-ci soit signée ou parlée. Plus précisément, les nourrissons pourraient avoir une sensibilité innée à certains aspects particuliers de distribution, de rythmes et de structures temporelles qui correspondraient à certains aspects de la structure naturelle du langage. Je propose de plus que l'acquisition initiale du langage résulte de l'interaction de trois facteurs critiques: (i) les capacités perceptives et motrices générales (ii) les facteurs environnementaux et (iii) les sensibilités innées des nourrissons à des structures spécifiques correspondant à des aspects du langage naturel. Ce mécanisme est sous contrôle génétique et environnemental. Dans les tout débuts de la vie, des substrats neuraux génétiquement contrôlés déterminent d'abord la nature des structures distributives, rythmiques et temporelles de l'input qui vont être les plus saillantes pour l'enfant et procurent l'ébauche d'architecture neurale propre à inscrire cette information dans la mémoire. L'input environnemental élague et élargit le substrat neural sous-jacent, processus épigénétique qui finalement représente la capacité cérébrale pour le langage de notre espèce. Donc l'enfant naît avec une sensibilité initiale à certaines structures très particulières. Que ce soit sur les mains ou la langue qu'il rencontre d'abord ces structures, il va essayer de les produire. Une intrigante implication de ces études est que la modalité linguistique, qu'elle soit parlée ou signée, est neurologiquement plastique et peut être neurologiquement déterminée après la naissance. De plus, les données actuelles indiquent que le langage signé et le langage parlé ont un statut biologique égal au sein du cerveau en développement.

**ON THE BIOLOGICAL, ENVIRONMENTAL  
AND NEUROGENETIC FACTORS  
DETERMINING EARLY LANGUAGE ACQUISITION :  
EVIDENCE FROM SIGNED AND SPOKEN LANGUAGES**

Though there is now wider acceptance that signed languages are "real" languages based on linguistic and socio-cultural grounds, a persistent and powerful misconception remains. The misconception can be summarized as follows : "Spoken language is fundamentally "better" than signed language ; sign is inferior (secondary) to speech". The notion that signed languages are "real" languages, but somehow "inferior" or "lower" than the "higher" status spoken languages, is reminiscent of the late 19th century division of spoken languages into "high" and "low" languages. (Here, languages deemed "high" were those used in Western Europe, and "low" or "primitive" languages were those used elsewhere by aboriginal peoples.) Though subsequent scientific studies have shown that the "high-low" classification of spoken languages is wholly fallacious, similar attitudes regarding spoken versus signed languages have not been subject to the same sorts of scientific scrutiny.

The above view about signed languages runs especially deep *because* it invokes biology. At the heart of the misconception is the notion that signed languages are *biologically* inferior to spoken languages. Why is this so? The answer involves a three-tiered set of related assumptions: First, a common quip is "most people speak, so speaking must be better". I call this the "more is better" assumption. Second, drawing from the observation that "most people speak", people have further assumed that this must "prove" that speech, alone, has been selected for over the development or evolution of the species (or, in "phytogeny"). Third, the assumption that speech has been selected for over human evolution, has implicitly been used to support the core, critical assumption about the biological foundations of human language: the brain must be neurologically set for speech early in the developmental history of individual human organisms (or in "ontogeny").

This third assumption has generally been regarded as being true because of the remarkable regularities observed in very early spoken language acquisition. Noting such universal regularities in, for example, the *timing* of the onset of speaking children's early vocal babbling and first words, researchers have concluded that the brain and its' maturation must be attuned to perceiving and producing spoken language input (*per se*) in early life. To be sure, a typical answer to the question "how does early human language acquisition begin?" is that it is the result of, and wholly determined by, the development of the *anatomy of the vocal tract* and the neuroanatomical and neurophysiological mechanisms involved in the *motor control of speech production* (e.g., Locke, 1983 - MacNeilage & Davis, 1990 - MacNeilage, Studdert-Kennedy & Lindblom, 1985 - Van Der Stelt & Koopmans Van Beinum, 1986). An implicit assumption that underlies such views is that spoken languages are better suited to the brain's maturational needs in development. Put another way, the view of human biology that underlies the prevailing third assumption is that the human brain is "hardwired" for speech and that speech is "special" or "privileged". On this view of the brain, then, signed languages can only be regarded as being "*biologically*" inferior to (or "lower" than) spoken languages. By extension, many educators and researchers, alike, have assumed that speech is better in order to achieve "normal" language acquisition.

### **Is there any evidence in support of the alleged "inferior" biological status of signed languages?**

Surprisingly, with the exception of the studies reported below, the critical studies required to evaluate the above assumptions have *not* been conducted. As noted above, most contemporary answers to questions about the biological foundations of language have been based on the core assumption that very early language acquisition is tied to speech. There is, however, a fatal flaw with this assumption: given that only languages utilizing the speech modality are studied, it is in principle, *a priori*, impossible to find data that would do anything but support this hypothesis. Only when a modality other than speech is analyzed can any generalization about the brain's predisposition for speech be evaluated, and, therefore, whether signed languages have the same or different status in the human brain.

### **The critical ontogenetic evidence regarding the biological status of natural signed languages.**

Research in my own laboratory has been directed at understanding the biological foundations of human language. My central aim has been to discover the specific biological and environmental factors that together permit early language acquisition to begin in our species. Studies of very early signed language acquisition offer an especially clear window into the biological foundations of all human language (be it spoken or signed), as well as its biological status in the brain. Spoken and signed languages utilize different perceptual modalities (sound versus sight), and the motor control of the tongue and hands are subserved by different neural substrates in the brain. Comparative analyses of these languages, then provide key insights into the specific neural architecture that determines early human language acquisition in our species. If, as has been argued, very early human language acquisition is under the exclusive control of the maturation of the mechanisms for speech production and/or speech perception, then spoken and signed languages should be acquired in radically different ways. At the very least, fundamental differences in the time course and nature of spoken versus signed language acquisition would suggest that each may be processed and represented in different ways, presumably due to their differing biological status in the human brain.

### **New evidence and new discoveries from comparative studies of spoken and signed languages.**

To investigate these issues, I have conducted numerous comparative studies of children acquiring spoken languages (English or French) and children acquiring signed languages (American Sign Language or Langue des Signes Québécoise), ages birth through 36 months.

The empirical findings from my cross-linguistic and cross-modal studies are clear, (i) *Deaf* children who are exposed to signed languages from birth, acquire these languages on an identical maturational time course as hearing children acquire spoken languages. Deaf children acquiring signed languages from birth do so without any modification, loss, or delay to the timing, content, and maturational course associated with reaching all linguistic milestones observed in spoken language. Beginning at birth, and continuing through age 3 and beyond, speaking and signing children exhibit the identical stages of language acquisition. These include the (a) "*syllabic babbling stage*" (7-10 months, approx.) as well as other developments in babbling (e.g., "variegated babbling", ages 10-12 months and "jargon babbling", ages 12 months and beyond ; Petitto, 1984, 1987 a & b - Petitto & Marentette, 1991 a), (b) "*first word stage*" (11-14 months, approx. e.g., Petitto, 1985, 1986, 1988, 1992, 1993 - Petitto & Marentette, 1991 b - Petitto, Costopoulos & Stevens, in preparation), and (c) "first two-word stage" (16-22 months, approx., Petitto, 1987 a, Petitto & Marentette, 1991 b). Though some researchers have claimed that "first signs" are acquired earlier than "first words", subsequent analyses have revealed that the claim is wholly unfounded.

Surprising similarities are also observed in deaf and hearing children's timing onset and use of gestures. Signing and speaking children produce strikingly similar pre-linguistic (9-12 months) and post-linguistic communicative gestures (12-48 months, e.g., Petitto, 1984, 1987 a, 1992). They do not produce more (or more elaborate) gestures, even though linguistic "signs" (identical to the "word") and communicative gestures reside in the same modality, and even though some signs and gestures are formationally and referentially similar. Instead, deaf children consistently differentiate linguistic signs from communicative gestures throughout development, acquiring, and using each in the same ways observed in hearing children (see Petitto, 1992).

Signing children exhibit highly similar patterns of later grammatical development as well (ages 22-36 months, approx., and beyond), including systematic morphological and syntactic developments (e.g., "over-regularizations", negation, question formation, and so forth ; e.g., Petitto, 1984, 1987a ; see also Newport & Meier, 1985).

Throughout development, signing and speaking children exhibit remarkably similar complexity in their utterances. For example, analyses of young ASL and LSQ children's social and conversational patterns of language use over time, as well as the types of things that they "talk" about over time (it's semantic and conceptual content, categories, and referential scope), have demonstrated unequivocally that their language acquisition follows the identical path as is observed in age-matched hearing children acquiring spoken language (Charron & Petitto, 1991 ; Petitto, 1992 ; Petitto & Charron, 1988).

(ii) *Hearing* children exposed to *both* signed and spoken languages from birth (e.g., one parent signs and the other parent speaks) demonstrate no preference for speech whatsoever, even though they can hear. Instead, they acquire both the signed and the spoken language to which they are being exposed on an identical maturational timetable (the timing of the onset of all linguistic milestones occurs at the same time in both the signed and spoken modalities). In addition, such children acquire the signed and spoken languages to which they are being exposed (e.g., ASL and English, or, LSQ and French) in the same manner that other children acquire two different spoken languages from birth in a "bilingual" home, for example, one with spoken French and spoken English (Petitto, 1985, 1986, 1993 ; see especially, Petitto, 1997, and Petitto, Costopoulos & Stevens, in preparation).

(iii) *Hearing* children who are exposed *exclusively* to signed languages from birth through early childhood (i.e., they receive little or no systematic spoken language input whatsoever), achieve each and every linguistic milestone (manual babbling, "first signs", "first two-signs" and so forth) in signed language on the identical time course as has been observed for hearing children acquiring spoken language and deaf children acquiring signed language. Thus, entirely normal language acquisition occurred in these hearing children (a) *without* the use of auditory and speech perception mechanisms, and (b) *without* the use of the motoric mechanisms for the production of speech (Petitto, 1993, 1997 ; Petitto, Costopoulos & Stevens, in preparation).

### **Significance of biological studies of early signed and spoken language acquisition**

Despite the modality differences, signed and spoken languages are acquired in virtually identical ways. The differences that were observed between children acquiring a signed language versus children acquiring a spoken

language were no greater than the differences observed between hearing children learning one spoken language, say, French, versus another, say, Italian.

Such findings cast serious doubt on the core hypothesis in very early spoken language acquisition : that the maturation of the mechanisms for the production and/or perception of speech, exclusively determines the time course and content of early human language acquisition. These findings further challenge the hypothesis that speech (and sound) is critical to normal language acquisition, and they challenge the related hypothesis that speech is uniquely suited to the brain's maturational needs in language ontogeny.

If speech, alone, were neurologically set or "privileged" in early brain development, then, for example, the hearing infants exposed to both speech and sign from birth might be expected to attempt to glean every morsel of speech that they could get from their environment. Faced implicitly with a "choice" between speech and sign, the very young hearing infant in this context might be expected to turn away from the sign input, favoring instead the speech input, and thereby acquire signs differently (e.g. later). Similarly, deaf *and* hearing infants exposed only to signed languages from birth should have demonstrated grossly abnormal patterns of language acquisition. None of this happened.

What is most interesting about these research findings is that the modality "switch" can be "thrown" *after* birth regarding whether a child acquires language on the hands or the language on the tongue. Such findings have led me to propose a new way to construe human language ontogeny (see especially Petitto, 1993, 1997). Speech and sound are *not* critical to human language acquisition. Instead, there appears to be a stunning, biologically-based *equipotentiality* of the modalities (spoken and signed) to receive and produce natural language in ontogeny (Petitto, 1994).

The only way that signed and spoken languages could be acquired with such startling similarity is if the brains of *all* newborns possess a mechanism that is sensitive to *specific aspects* of the "*patterning*" (or structural regularities) of natural language, irrespective of the input modality. The data reveal that this mechanism is the *same* for both spoken and signed language input. This mechanism enables the infant to attend to and lay down in memory aspects of the patterning of natural language. As this mechanism develops, it in turn influences other developments. Specifically, it guides the neurogenetic processes in the early months of life that shape and refine the neural pathways for the motor control of language production (and perception) - be it speech or sign (depending upon the modality of the language input). Contrary to our common belief about the special status of speech at birth, it now appears that the neural substrates for speech - or sign - do not become neurologically set until *after* birth. In other words, rather than being exclusively "hardwired" for *speech* or sound, our species appears to be "hardwired" to detect aspects of the patterning of *language* (specifically, aspects of its structural and prosodic regularities ; see Petitto, 1993, 1997). If the environmental input contains the requisite patterns unique to natural language, human infants will attempt to produce and to acquire those patterns, irrespective of whether the input is signed or spoken. (For a discussion of the specific neural substrates that underlie this capacity in ontogeny, as well as their possible roots in phytoeny, see especially Petitto, 1997).

In summary, the present findings prove wholly false the existing assumptions about the "biological inferiority" - or, for that matter, the "genetic inferiority" - of signed languages relative to spoken languages. Signed and spoken languages are acquired in the same ways, and on the same maturational time course. With regard to the brain and human biology, this indicates that signed and spoken languages engage the *same* brain-based mechanisms in very early language acquisition.

### Conclusion

Results from studies of early language acquisition provide especially strong evidence relevant to assessing whether signed languages are real languages. Here we see clearly that the prevailing assumption about the biological foundations of human language - indeed, the very assumption upon which notions of the alleged biological superiority of speech over sign rests - is *not* supported when the relevant studies are conducted. Specifically, *no* evidence was found that the newborn brain is neurologically set exclusively for speech in early language ontogeny.

No evidence was found that speech is biologically more "special", more "privileged", or "higher" in status than sign in early language ontogeny. Instead, the key, persistent research finding to emerge is this : the biological mechanisms in the brain that underlie early human language acquisition do not appear to differentiate between spoken versus signed language input. Both types of input appear to be processed equally in the brain. This provides powerful evidence that signed and spoken languages occupy identical and, crucially, equal biological status in the human brain.

### Acknowledgements

I thank the Deaf and hearing families who so lovingly gave their time and support to these studies. I also thank the following for funding this research : Natural Science and Engineering Council of Canada, the MacDonnell-Pew Centre Grant in Cognitive Neuroscience, and the McGill-IBM Cooperative Project.

### References

- CHARRON F., PETITTO L.A., 1991 : Les premiers signes acquis par des enfants sourds en langues des signes québécoise (LSQ) : Comparaison avec les premiers mots. *Revue Québécoise de linguistique théorique et appliquée*, 10 : 1, 71-122.
- LOCKE J., 1983 : *Phonological acquisition and change*. New York : Academic Press.
- MACNEILAGE P.P., DAVIS B., 1990 : Acquisition of speech production : Frames, then content. In : Jeannerod (Ed.) *Attention & Performance XII: Motor Representation & Control*. Hillsdale, N.J. Lawrence Erlbaum Associates. 453-476.
- MACNEILAGE P.F. STUDDERT-KENNEDY M.G, LINDBLOMB., 1985 : Planning and production of speech : An overview. In : J. Lauter (Ed.), *Proceedings of the conference of planning and production of speech by normally hearing and deaf people*. American Speech and Hearing Reports.
- NEWPORT E., MEIER R, 1985 : The acquisition of American Sign Language. In : D.I. Slobin (Ed.), *The crosslinguistic study of language acquisition*, Volume I: The data Hillsdale, N.J. : Lawrence Erlbaum Associates. 881-938.
- PETITTO L.A., 1997 : In the Beginning ; On the genetic and environmental factors that make early language acquisition possible. In M. Gopnik (Ed.) *The inheritance and innateness of grammars*. Oxford, England ; Oxford University Press, 45-69.
- PETITTO L.A., 1994 : On the equipotentiality of signed and spoken language in early language ontogeny. In : B. Snider (Ed.), *Post-Milan ASL and English literacy. Issues, trends, and research*. Washington, D.C. : Gallaudet University Press. 195-223.
- PETITTO L.A. : 1993 ; On the ontogenetic requirements for early language acquisition. In B. de Boysson-Bardies, S. de Schonen, P. Jusczyk, P. MacNeilage, & J. Morton (Eds.), *Developmental neurocognition : Speech and face processing in the first year of life*. Dordrecht, The Netherlands : Kluwer Academic Press. 365-383.
- PETITTO L.A. : 1992 : Modularity and constraints in early lexical acquisition : Evidence from children's first words/signs and gestures. In M. Gunnar & M. Maratsos (Eds.) *Modularity and constraints in language and cognition : The Minnesota Symposia on Child Psychology*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 25-58.
- PETITTO L.A., 1988 : "Language" in the pre-linguistic child. In F. Kessel (Ed.), *Development of Language and Language Researchers : Essays in Honor of Roger Brown*. Hillsdale, N.J. : Lawrence Erlbaum Associates, 187-221.
- PETITTO L.A., 1987a : On the autonomy of language and gesture : Evidence from the acquisition of personal pronouns in American Sign Language. *Cognition*, 27:1, 1-52.
- PETITTO L.A., 1987b : "Theoretical and methodological issues in the study of sign language babbling : Preliminary evidence from American Sign Language (ASL) and Langue des Signes Québécoise (LSQ)." Fourth International Symposium on Sign Language Research, Lappeenranta, Finland, July 15-19.
- PETITTO L.A., 1986 : Language versus gesture : Why signed languages are not acquired earlier than spoken languages. *Abstracts from Theoretical Issues in Sign Language Research Conference*. Rochester, New York : Cognitive Science Technical Report. University of Rochester, 32. 30-31.

- PETITTO L.A., 1985 : Are signed languages acquired earlier than spoken languages ? *Society for Research in Child Development Abstracts, Volume 5*. Biennial Meeting. Toronto, Canada, 269.
- PETITTO L.A., 1984 : From gesture to symbol : The relationship between form and meaning in the acquisition of personal pronouns in American Sign Language. Doctoral dissertation. Department of Human Development and Psychology, Harvard University. Cambridge, MA., USA.
- PETITTO L.A., MARENTETTE P., 1991a : Babbling in the manual mode : Evidence for the ontogeny of language. *Science*, 251, 1483-1496.
- PETITTO L.A., MARENTETTE P., 1991b : The timing of linguistic milestones in signed and spoken language acquisition. *Society for Research in Child Development Abstracts, Volume 8*. Biennial Meeting. Seattle, Washington, 145.
- PETITTO L.A., CHARRON F., 1988 : "The acquisition of semantic categories in two sign languages, ASL, & LSQ". *Theoretical Issues in Sign Language Research, II*, Gallaudet University, Wash., D.C., May 18.21.
- PETITTO L.A., COSTOPOULOS N., STEVENS L., (in preparation) – The identity of linguistic milestones in signed and spoken language acquisition : Evidence for a unitary timing mechanism in the ontogeny of language.
- VAN DER STELT J.M., KOOPMANS-VAN BEINUM F.J., 1986 : The onset of babbling related to gross motor development. In : B. Lindblom & Zetterstrom (Eds.) *Precursors of Early Speech*. New York : Stockton Press. 163-173.