THE CRITICAL PERIOD FOR LANGUAGE ACQUISITION AND THE DEAF CHILD'S LANGUAGE COMPREHENSION : A PSYCHOLINGUISTIC APPROACH

Rachel I. MAYBERRY

Montréal
Université McGill - Ecoles des sciences de la communication humaine •
1266 Ouest - Avenue des Pins - Montréal (Québec) H3G 1A8

The critical period for language acquisition and the deaf child's language comprehension : a psycholinguistic approach

The critical period hypothesis for language acquisition (CP) proposes that the outcome of language acquisition is not uniform over the lifespan but rather is best during early childhood. The CP hypothesis was originally proposed for spoken language but recent research has shown that it applies equally to sign language. This paper summarizes a series of experiments designed to investigate whether and how the CP affects the outcome of sign language acquisition. The results show that the CP has robust effects on the development of sign language comprehension. Effects are found at all levels of linguistic structure (phonology, morphology and syntax, the lexicon and semantics) and are greater for first as compared to second language acquisition. In addition, CP effects have been found on all measures of language comprehension examined to date, namely, working memory, narrative comprehension, sentence memory and interpretation, and on-line grammatical processing. The nature of these effects with respect to a model of language comprehension is discussed.

Keywords :
Critical Period - Language - Acquisition/Development - Sign language
Comprehension - Language processing

La période critique pour I'acquisition et la compréhension du langage par I'enfant sourd : approche psycholinguistique

L'hypothèse d'une période critique (PC) pour 1'acquisition du langage suppose que le résultat quant a 1'acquisition du langage n'est pas uniforme pendant toute la durée de la vie mats est le meilleur pendant la petite enfance. L'hypothèse
d'une PC a d'abord été proposée pour la langue orale mais de récentes recherches ont montre qu'elle s'applique également a la langue des signes. Cette communication présente le résumé d'une série d'expériences conçues pour rechercher si et comment la PC a des effets robustes sur le développement de la compréhension de la langue des signes. Ces effets sont constates a tous les niveaux des structures linguistiques (phonologique, morphologique et syntaxe, lexique et sémantique) et sont plus marques pour 1'acquisition de la langue des signes comme première langue que comme deuxième langue. De plus, les effets de la PC ont été observes sur toutes les

évaluations de compréhension effectuées jusqu'ici, c'est-à-dire la mémoire de travail, la compréhension d'une histoire, la mémoire et 1'interpretation de phrases et le traitement "on-line" de la grammaire. La nature de ces effets par rapport a un modèle de compréhension de la langue seront discutes.

Mots-clés :
Période critique - Acquisition/développement du langage - Langue des signes
Comprehension - Traitement du langage

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Introduction :

The director of a well known oral school for the deaf gave a lecture in one of my university classes. When one student asked why his school did not use sign language with young deaf children, he answered was that speech must be learned at a very young age if it is to be learned by the deaf child but that sign language could be easily learned by any person at any age. This reasoning summarizes the basic assumptions many people have held about the relationship of age to language acquisition. Age constraints on language acquisition do not apply to sign language, either because sign language is not thought to be language, or, alternatively, because sign language is not spoken. Recent research has demonstrated that sign languages are real languages (e.g., Klima & Bellugi, 1979). Therefore, if there are age constraints on language acquisition, then sign languages should be as easy or as hard to learn at older ages as are spoken languages. The purpose of this paper is to summarize a series of studies that I and my students have conducted to investigate the "critical period for language acquisition" using sign language as the test case. Because the details of these experiments are important to the conclusions that are drawn, they are also summarized here. The primarily finding of these studies is, contrary to that one lecture by the head of a school for the deaf, that age constraints apply to sign language acquisition in complex ways that reveal a great deal about how the human mind develops linguistic capacity in response its early environment.

Is Sign Language Easy to Learn ?

Our first studies were attempts to determine whether there was variation in sign language comprehension among deaf individuals for whom sign language is a primary language that was related to their prior experience with it. In one study, we asked two groups of deaf signers to watch videotaped stories given in American Sign Language (ASL) and Pidgin Sign English

(PSE) - an English- like dialect of ASL often used in educational settings - and to simultaneously copy them into sign language. After completing the task, we asked the subjects a series of comprehension questions (Mayberry & Fischer, 1989).

One group of subjects were native learners of ASL, which means that they had deaf parents who talked with them in sign language beginning when they were babies. The second group of subjects were normative learners of ASL, which means that they had normally hearing parents who knew no sign language; these subjects began to learn sign language between 9 and 16 years of age in school.

There were very large and striking performance differences between the two groups, with the native learners significantly outperforming the normative learners. In addition, the accuracy with which the subjects could copy the stories in sign language was highly correlated with their ability to answer questions about the stories (Mayberry & Fischer, 1989).

These results suggested that sign language was not so easy to learn, so we conducted a second study with 55 deaf subjects divided into 5 groups as a function of when they first learned to sign: Native signers, and subjects who first learned to sign at the ages of 5, 9, 14, and 19 years, all when they first attended a school for the deaf where sign language was used. Because all the subjects were approximately the same chronological age at the time of the study, 20 to 24 years old, the amount of experience they had with sign language was inversely related to and confounded with the age at which they had first learned to sign (Mayberry & Fischer, 1989).

For this study, we asked the subjects to watch videotaped ASL sentences and to copy them simultaneously while watching and, in a second task, to watch the sentences and then repeat the signed sentences from memory. The results were again very striking : performance accuracy declined for both tasks as a linear function of the prior experience and the age at which sign language was first learned (Mayberry & Fischer, 1989).

The results of these experiments suggested that sign language is not particularly easy to learn, or, alternatively, that it takes an very long time to learn sign language well. The important question is whether there is a CRITICAL PERIOD FOR LANGUAGE ACQUISITION that may be contributing to the striking regularity of these trends.

What is the Critical Period for Language Acquisition?

The critical period for language acquisition is the hypothesis that language is acquired best in early childhood and is more difficult to learn at older ages. The idea has been around for a at least 100 years, but Wilder Penfield, a Montreal neurologist, was one of the first scientists to purpose that the superiority for language acquisition shown by young children is due to neuroplasticity (Penfield & Roberts, 1959). Later, Lenneberg (1967), in his revolutionary book. *The Biological Foundations of Language*, greatly elaborated this proposal by gathering a variety of evidence from studies of brain growth and clinical studies of cases of brain damage, mental retardation, and deafness to support the hypothesis that there are age constraints on language acquisition caused by brain maturation.

Most of the empirical evidence for critical periods in development come from studies of the visual system in animals rather than from language studies with humans. When mammals are prevented from using their vision in early life, the result is a permanent inability to see. Similar effects have been documented in humans who are born with visual impairments, such as congenital cataracts, that remain uncorrected during childhood. Sacks (1993) describes one such

a case, where a grown man was unable to develop functional sight after cataract surgery although he was technically able to see. He was unable to recognize his dog without touching it, nor was he able to make his way from the front of his house to the back using only his eyes. Because his brain had not received the necessary visual input at just the right moments in development, it had never learned "to see." This remained true even in adulthood because the critical period for the development of this man's visual system had passed long ago. Whether a critical period also guides language acquisition has been more difficult to ascertain. There are no animals models to study and all human babies born with normal hearing are immersed in spoken language from the moment they are born. In contrast to the situation for babies who hear normally, the situation is radically different for human babies who are born deaf. Unable to hear, they are isolated from the spoken language that surrounds them, if their parents are normally hearing and speak to them. If they are born to parents who use sign language, then the situation is comparable to that of the hearing child in the sense mat the child is able to "see" language from birth in an analogous fashion to the way in which normally hearing children "hear" language from birth. However, for deaf children who use sign language as a primary means of communication, the age at which they are first exposed to it is highly variable due to environmental circumstances. Sign language is absent from the early home environments of most deaf children. They are able to learn it primarily at older ages when they first enroll in a school where sign language is used. We use this environmentally induced variation in age of first sign language learning to investigate the critical period for language acquisition.

We have designed our work to answer several basic questions about the critical period for language acquisition and its possible effect on sign language acquisition. These questions are as follows: (1) Is there a critical period for language acquisition? (2) If so, how does the critical period for language acquisition affect language processing in adulthood? In order to answer this question, we must also ask the next question. (3) How is sign language processed in comparison to spoken language? (4) Are the effects of the critical period the same for first as compared to second language acquisition?

Long-Lasting Effects of the Critical Period on Sign Language Ability

In our next experiment we determined whether there are critical period effects on sign language acquisition that are apparent in later adulthood after a lifetime of using it. The sign language we tested was ASL. Forty-nine deaf, adult subjects participated in the study; each person had been using ASL for a minimum of 20 continuous years after first learning it. One group was native learners; the second group first learned ASL between the ages of 5 and 8; the third group first learned ASL at age 11. There were no significant differences in chronological age among the groups and no differences in length of sign experience so that age of ASL acquisition was the primary factor on which the groups differed (Mayberry & Eichen, 1991).

The subjects watched 30 long and complex, videotaped ASL sentences; half were presented at a normal rate and half were presented at a rate that was 68 faster. Even after 20 or more years of continuous experience with ASL, the normative learners performed less well than the native learners. Performance accuracy declined as a linear function of age of acquisition. The speeded condition was more difficult for the native and childhood learners than the normal -rate condition. This was not true for the adolescent learners who performed equally poorly on ASL sentences given at the speeded and normal rate. Next we also examined how the subjects

processed the grammatical morphology that was included in the ASL sentences (Mayberry & Eichen, 1991).

The native learners were far more likely than the childhood and adolescent learners to produce grammatical morphology. The error patterns of all the groups were especially revealing and showed that the older learners were as analytic when it comes to morphology as were the native learners, but not in the same way. When the native learners made errors involving grammatical morphology, they tended to replace, or alter the morphemes and rarely deleted them altogether. The tendency to delete, or strip, grammatical morphology from lexical stems increased as age of acquisition increased. This means that the morphological distinction of *inflection versus lexical stem* is respected in the processing of all signers, regardless of age of acquisition. However, accuracy and error patterns vary systematically with age of acquisition (Mayberry & Eichen, 1991).

Very different error patterns arose for lexical stems. These errors tended to be one of two types, meaningful errors, or conversely, non-meaningful errors that were related to surface phonological form independent from sentence meaning. The subjects' tendency to make meaningful, or semantic, errors as compared to phonological errors was directly related to the age at which they first learned ASL. The native learners primarily made lexical stem errors associated withlexical meaning and syntactic structure independent of phonological form. As age of acquisition increased, these kind of errors decrease and there was a concomitant increase in errors that are related to the surface, phonological form of the stimulus (Mayberry, 1994; 1995). Thus, we see different error inventories in sign language processing for lexical stems as compared to grammatical morphology. The same is true for spoken language processing. Here we have evidence that lexical stems and grammatical morphology are processed differently in sign language as they are in spoken language. Learning sign language at older ages does not affect this basic processing distinction.

Linguistic Loci of Critical Period Effects in Language Processing

What are the effects of the critical period on the processing of linguistic structure? There have been numerous speculations in the literature. For example, Newport (1984) has proposed that the critical period affects morphological knowledge and processing, such that early learners treat morphology analytically whereas older learners treat it holistically. Coppieters (1987) has proposed that lexical knowledge is specifically affected by the critical period such that older learners know less about the details of lexical items than do early learners. A more common proposal, suggested by Bley-Vorman (1989) and Johnson and Newport (1989), among others, is that syntactic knowledge and skill are specifically affected by the critical period, so that early learners are grammatical but older learners are not. Finally, Flege (1987) and Scovel (1989), among others, have proposed that phonological production (and perception) are especially affected by the critical period so that older learners always have accents and often misperceive phonetic features.

What do the sign language data tell us about the effects of the critical period on linguistic processing? First, there are specific effects on grammatical morphology : childhood learners are analytic and alter grammatical morphology; late learners are also analytic but tend to strip grammatical morphology. Next, there are lexical effects. The lexical mistakes of childhood learners are based in sentence meaning whereas those of late learners are based in surface level properties, i.e., phonological form independent of sentence meaning. Syntactically, childhood

learners produce grammatical utterances whereas late learners are often ungrammatical. Finally, childhood learners paraphrase sentence meaning whereas late learners tend to misunderstand or forget sentence meaning.

Critical Period Effects for a First Compared to a Second Language

The magnitude of me critical period effects in these studies was large, m these studies, age of sign language acquisition accounts for 40 to 60 percent of the variation in deaf subjects' performance. This led us to speculate as to whether there was something special about the critical period effects in sign language. One major difference between the subjects of our studies and the subjects of critical period effect studies on second-language learning, is that second language learners have always previously acquired a FIRST language during early childhood. By contrast, many of our deaf subjects had acquired very little language prior to learning sign language. Our impression was that many of our subjects were not learning a second language after childhood; they were learning their FIRST language after childhood.

It is impossible to ask whether the critical period has greater effects on first as compared to second language acquisition by studying only the normally hearing population. However, it is possible to do so with the deaf population. While the majority of individuals who are severely and profoundly deaf are deaf from birth, some very rare individuals are born with normal hearing which they suddenly lose at older ages. When such individuals learn sign language, they are genuine second language learners of sign who are, in addition, are deaf. We turned to such rare individuals to help us determine whether the critical period has greater effects on first as compared to second language acquisition.

To ascertain whether the critical period has differential effects on first as compared with second-language acquisition of sign language, we conducted a matched-pairs study. We recruited nine individuals who were not born deaf but rather lost their hearing between the ages of 8 and 12; primarily due to meningitis. Because they had normal hearing throughout childhood, they were native speakers of English. After becoming deaf, they were educated with deaf children and learned to sign from them in schools for the deaf. ASL was a second language for these subjects. We then matched these subjects by age and sex to nine other subjects who were born profoundly deaf but learned little or no language during childhood before learning ASL between the ages of 9 and 13. In addition, we tested one group of childhood learners of ASL and a native control group who were matched by age and as closely as possible by sex to the other two groups. The subjects performed a sentence recall task (Mayberry, 1993).

The results clearly showed that the critical period has much greater effects on first than second language acquisition. Despite the fact that the two groups of late learners both learned ASL at the identical ages, each second-language learner significantly out-performed each late-first language learner. These results were generally consistent across the various syntactic structures of the sentences. Thus, we see the same effects for the simple sentences as compared to the complex ones. The one exception is case of the the two separate sentences (Mayberry, 1993). These findings suggest that the sign language processing of deaf people who did not acquire language in early childhood is not the same as that of second language learners. This is the empirical question that motivated our final study.

Grammatical Processing in a Second Language vs. a Late-First Language

Are there special effects of learning a first language after childhood that make grammatical processing different from what would be observed in someone learning a second-language after childhood? To answer this question, we tested the grammatical processing in English of four groups of subjects, two were deaf and two were normally hearing. The first group of hearing subjects was native learners of English. The second group was hearing, second-language learners of English; they each began to learn English between the ages of 6 and 11 in school. Their native languages were French, Italian, German, Persian and Urdu. The third group consisted of deaf, native learners of ASL; each subject began learning English in school as a second language between the ages of 5 and 6. These subjects are deaf, second-language learners, and we hypothesized that their performance would be similar to that of the hearing, second-language learners. The fourth group consisted of deaf individuals who learned little or no language during early childhood before going to a school for the deaf that used sign language between the ages of 6 and 13. At school, they learned both ASL and English at the same time, ASL from their deaf peers and English in the classroom (Mayberry & Lock, 1997; Lock, 1996)

In order to demonstrate that the deaf late learners of ASL knew it less well than the native learners, we gave them an ASL comprehension test. The test consisted of 20 ASL sentences of 4 different syntactic types using a sentence- picture matching task. The examiner signed the ASL sentence and the subject selected one picture from among three that showed the ASL sentence meaning. The late learners of ASL, as expected, performed much more poorly on this task as compared to the native ASL learners, who made no mistakes (Mayberry & Lock, 1997; Lock, 1996).

We measured syntactic processing in English with a grammatical judgement task. Short, English sentences were presented one at a time on a computer screen; the subject's task was to decide whether the sentence was grammatical or not. The stimuli for the grammatical judgement task were 72 grammatical and 72 ungrammatical English sentences of five syntactic types which varied from early to late developing in young children acquiring English as a native language. These syntactic structures ranged from simple sentences, such as, "The girl is playing in the water," to complex ones such as, "The boy who is chasing the girl is happy."

Confirming our hypothesis that late-first language acquisition is not the same as second-language learning, we found that the deaf subjects who learned little or no language prior to learning both English and ASL at the same age after childhood performed significantly more poorly on the grammatical judgement task than all three other groups (native speakers of English, second-language speakers of English, and native signers of ASL/second-language learners of English). In direct contrast, the deaf subjects who were native learners of ASL and second-language learners of English performed as well as both the native speakers of English and the second-language speakers of English. The same pattern of results characterized the groups' performance on the syntactic comprehension task. Here the subject read the English sentence and pointed to the one picture from among three that displayed its meaning. The deaf subjects who acquired little or no language during early childhood before going to school between the ages of 5 and 7 and learning both English and ASL at the same time performed much more poorly than the other three groups, especially for the more complex structures, namely, the dative, passive, and relative clauses structures. The three other groups, all of whom acquired a language natively in early childhood, the native speakers of English, the second-language speakers of English, and the deaf, native signers of ASL/second-language learners of English, all comprehended all the syntactic structures nearly perfectly.

The Critical Period and Deaf Children's Language Acquisition

We believe that the results of these studies provide compelling insights into the nature of the critical period for language acquisition and thus also give us insights into the severe language comprehension problems frequently observed in large numbers of deaf children worldwide. First, there is very clear evidence for a critical period for sign language acquisition. Second, the effects of the critical period on sign language acquisition are robust and large. Third, critical period effects are strongest for 1st language acquisition and weaker for 2nd language acquisition. Fourth, critical period effects are apparent at all levels of linguistic structure, namely, phonology, morphology, the lexicon, syntax, and semantics. Fifth, the critical period affects the processing of both simple and complex syntactic structures by late language learners. Sixth, critical period effects are apparent on all language processing tasks tested to date, namely, sentence and story memory and shadowing, sentence and story comprehension, and grammatical judgement tasks.
Finally, the effects of the critical period on first-language acquisition are permanent. In conclusion, the results of these studies suggest that there are strong parallels between the critical period for the development of the visual system and the development of the linguistic system. Individuals born with congenital cataracts that prevent mem from obtaining visual experience in early childhood grow up to be functionally blind, even after the cataracts are successfully removed (e.g.. Sacks, 1993). Our research shows that individuals who are born deaf and isolated from language during early childhood grow up being linguistically disfunctional (Mayberry, 1992, 1994).

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