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First-Language Acquisition in Adolescence: Evidence for a Critical Period for Verbal Language Development

Gina M. Grimshaw, Ana Adelstein, M. Philip Bryden,† and G. E. MacKinnon

University of Waterloo, Waterloo, Ontario, Canada

It has been hypothesized that there is a critical period for first-language acquisition that extends into late childhood and possibly until puberty. The hypothesis is difficult to test directly because cases of linguistic deprivation during childhood are fortunately rare. We present here the case of E.M., a young man who has been profoundly deaf since birth and grew up in a rural area where he received no formal education and had no contact with the deaf community. At the age of 15, E.M. was fitted with hearing aids that corrected his hearing loss to 35 dB, and he began to learn verbal Spanish. We describe his language development over the 4-year period since his acquisition of hearing aids and conclude that he demonstrates severe deficits in verbal comprehension and production that support the critical period hypothesis.

Many researchers have hypothesized that young children are predisposed to the acquisition of language (Chomsky, 1959; Lenneberg, 1967; Newport, 1990) and further that this disposition is unique to childhood. Lenneberg (1967) formally proposed a critical period for language acquisition that extends from infancy until puberty. Although the exact timing (Johnson & Newport, 1989; Krashen, 1973; Lenneberg, 1967) and nature (Lenneberg,

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Address correspondence and reprint requests to Gina Grimshaw, Department of Psychology, California State University, San Marcos, San Marcos, CA, 92096. E-mail: grimshaw@csusm.edu.

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1967; Newport, 1990) of the critical period are matters of debate, there is a great deal of indirect evidence to support the hypothesis (Basser, 1962; Hécaen, 1976; Johnson & Newport, 1989, 1991; Lenneberg, 1967). Direct evidence, in the form of individuals who were deprived of linguistic input during the proposed critical period, is more rare, and the interpretation of these cases is often ambiguous (Curtiss, 1977; Mayberry & Eichen, 1991; Skuse, 1993). We present here a case of linguistic isolation during childhood followed by acquisition of a verbal first language in adolescence that may help to clarify some issues about the critical period.

Evidence in Support of the Critical Period

Childhood aphasia. Most tests of the critical period hypothesis have relied on indirect methods. Lenneberg based his hypothesis largely on evidence that children with unilateral lesions recover language functions more successfully than do similarly afflicted adults (Basser, 1962; Lenneberg, 1967). Lenneberg proposed a mechanism for the critical period based on an initial state of equipotentiality followed by the gradual establishment of left-hemisphere language specialization. This mechanism has been disputed (see Segalowitz & Berge, 1995, for a review of the evidence that the left hemisphere is specialized for language processing at birth), leading some to question the critical period itself (St. James-Roberts, 1981). However, studies of language development in cases of neurological insult are not a true test of the hypothesis. These findings reflect the potential for nonlanguage areas of the brain (either in the right or left hemisphere) to take over language functions after insult, and the time-limited nature of this recovery. They do not address the existence of a critical period during which normal dedicated language areas of the left hemisphere are predisposed to the acquisition of language.

Second-language acquisition. We turn therefore to the study of language acquisition in the intact brain. One area in which there is a great deal of data available on which to compare children and adults is that of second-language acquisition. Studies typically find that, although adults demonstrate an initial advantage over children, long-term mastery of the second language decreases with increasing age of acquisition (Johnson & Newport, 1989, 1991; Oyama, 1978), with performance decreasing linearly after the age of 7 (Johnson & Newport, 1989). This relationship exists both for language-specific and universal syntactic structures (Johnson & Newport, 1991). However, the relationship between first- and second-language acquisition is uncertain (Clahsen & Muysken, 1986; Epstein et al., in press) and so these findings may not be applicable to questions about first-language acquisition.

Extreme deprivation. Direct tests of the critical period hypothesis involve an examination of first-language acquisition beyond the critical period, in the absence of neurological insult. Such cases are, of course, very rare. This literature has been recently reviewed by Skuse (1993), who describes 10 cases of extreme deprivation in early childhood. Most cases are very poorly

documented, and the degree of linguistic deprivation is often questionable. In cases where the child was under the age of 7 at discovery, great gains were made in cognitive and language development. However, the only well-documented case of total isolation throughout childhood is that of Genie (Curtiss, 1977), a young girl who was kept locked in her room and deprived of human contact or any form of stimulation between the ages of 20 months and 13 years. Although Genie's initial progress in semantic development was promising (Fromkin, Curtiss, Krashen, Rigler, & Rigler, 1974), Curtiss (1977) concludes that Genie's language was atypical in several ways. Despite intensive educational and therapeutic intervention, her syntactic development lagged significantly behind her semantic growth, and she had particular difficulty with verb tense, word order, prepositions, and pronouns. There was also an unusually large discrepancy between her production and comprehension. Genie's case is considered to be consistent with at least a weak form of the critical period hypothesis, in that first-language development in adolescence is atypical, if not impossible. However, Genie's childhood was atypical in so many ways that it is impossible to know if her language deficits reflect a critical period mechanism, or are the result of her tragic background.

Deaf children of hearing parents. A group of individuals who regularly experience linguistic isolation in the context of normal development are deaf children of hearing parents. These children have great difficulty learning spoken language and typically do not learn sign language until they enter a residential school for the deaf. Several researchers have observed an inverse relationship between age of acquisition and long-term proficiency in sign language, consistent with a critical period hypothesis (Emmorey, Bellugi, Friederici & Horn, 1995; Mayberry & Fischer, 1989; Mayberry & Eichen, 1991, Newport, 1990). It is interesting to note that these individuals all achieve some degree of proficiency in sign. For example, in the study reported by Mayberry and Eichen (1991), long-term proficiency in American Sign Language (ASL) was examined as a function of age of acquisition, with individuals having learned ASL between infancy (native learners) and age 13 (adolescent learners). Subjects had all been exposed to ASL for a minimum of 20 years. Although native learners outperformed adolescent learners (in support of a critical period hypothesis), the older learners were not linguistically incompetent (although the authors do not present individual subject data, so it is impossible to determine if there were any severely impaired individuals). Critical period effects were observed on a difficult recall task using test sentences that were 12 to 15 signs in length and presented at a speeded rate. Even under these unfavorable conditions, late learners were able to identify over 50% of both word stems and bound morphemes (compared to over 80% for native signers). This finding seems to support a weak form of the critical period hypothesis, that is, that children are better language learners than adults, but does not support the claim that language *must* be learned in childhood.

Differences between Genie and Late Learners of Sign Language

The difference between the poor performance of Genie and the competence of adolescents learning sign language is striking. Five hypotheses are proposed to account for this discrepancy.

1. Genie is atypical because of her background. Severe emotional and physical abuse may have prevented Genie from acquiring language, especially because she was beaten when she produced any form of vocalization (Curtiss, 1977). Similarly, the lack of cognitive stimulation in her environment may have produced permanent cognitive or even neurological damage. Finally, Genie was diagnosed as mentally retarded at the age of 14 months (on admittedly scant evidence), and it is possible that she suffered from a preexisting neurological deficit (Skuse, 1993).

2. The differences reflect short-term vs. long term acquisition. Genie's progress is reported for only the first 5 years after her discovery, whereas reports of late-learners of sign report competence after decades of exposure. It is possible that Genie's language is delayed, but not deviant. According to Rymer's (1993) biography, Genie was institutionalized in adulthood, and her linguistic skills are still very poor. However, no data exist regarding Genie's long-term outcome.

3. Deaf subjects did not experience the same degree of linguistic isolation as Genie. In reported studies of late-learners of sign, age of acquisition is defined as the age at which subjects entered residential schools for the deaf. However, most subjects had previous schooling, either in the regular school system or in day classes for the deaf. These subjects may therefore have acquired some level of linguistic competence, either through direct training in spoken language, or through interactions with other deaf students. Findings in these subjects may therefore reflect second-language acquisition and not delayed first-language acquisition.

4. Deaf subjects communicate with homesign. Even if one accepts the strong argument that the deaf children of hearing parents received no formal linguistic input prior to their enrollment in residential school, they were not without communication during this time. Whereas Genie was completely isolated and had no human interaction during her confinement, the deaf children grew up in normal homes where communication was a necessary part of daily life. Such children typically develop their own gestural communication systems, or homesign. Homesign has been extensively studied by Goldin-Meadow and colleagues (Goldin-Meadow, Butcher, Mylander & Dodge, 1994; Goldin-Meadow & Feldman, 1975; Goldin-Meadow & Mylander, 1984, 1990) and has been found to be a highly iconic and mimetic individual gestural system that consist of a series of pointing gestures (to represent agents and objects) linked by action gestures. Most homesign systems do have some linguistic properties, such as well-formedness and a consistent word order, but they lack many other properties of natural languages such

as a productive morphology. Interestingly, deaf children use their homesigns more consistently and more fluently than do their hearing parents, suggesting that any linguistic structure is generated by the child and not by the parent (Goldin-Meadow & Mylander, 1984). It has been reported that when deaf children of hearing parents come in contact with other signing individuals, the homesign is rapidly replaced by sign language (Emmorey, Grant, & Ewan, 1994). It is possible that the relative success of late learners of ASL reflects the language foundation that has been established through homesign.

5. The critical period places greater constraints on the acquisition of spoken vs. signed languages (Scovel, 1989). This effect could arise in two ways. First, there may be severe timing constraints on the development of acoustic phonological processing that would limit the acquisition of spoken but not signed language. If so, one might expect that Genie would have had greater success with a signed language. Curtiss (1977) reports that attempts were made to teach Genie sign language, but unfortunately the results of this project are not reported. Second, it is possible that homesign provides a stronger basis for the development of sign language than for spoken language. Homesigns bear some similarity to sign languages such as ASL, which is not surprising given that natural sign languages probably develop when individual homesigners come together into a deaf community (see Senghas, 1995, for a discussion of the emergence of a sign language from individual homesigns within a single generation).

We present here a case study that may clarify some of these issues. E.M. is a young man who has been profoundly deaf since birth. He has had little formal education and had no contact with the deaf community before the age of 12. At the age of 15, E.M. was fitted with aids that corrected his hearing loss to 35 dB. He is therefore able to hear speech spoken at a conversational level, and for the past 4 years has been learning verbal Spanish. Thus, like Genie, he experienced an extended period of linguistic isolation and began to learn a spoken language in adolescence. However, like other deaf children of hearing parents, E.M. experienced linguistic isolation in the context of normal social and cognitive development. Furthermore, E.M. has developed a homesign system, and so we are able to observe the role that his homesign plays in his subsequent verbal language development. Finally, because of E.M.'s cultural and social situation, we feel he experienced greater linguistic isolation than late-learners of sign who have been described. We report here on the development of E.M.'s verbal comprehension and production in the 48 months since his acquisition of hearing aids.

CASE REPORT

History

E.M. is an 19-year-old male from rural Mexico. His family reports that he has been profoundly deaf since birth, and the first medical report of his

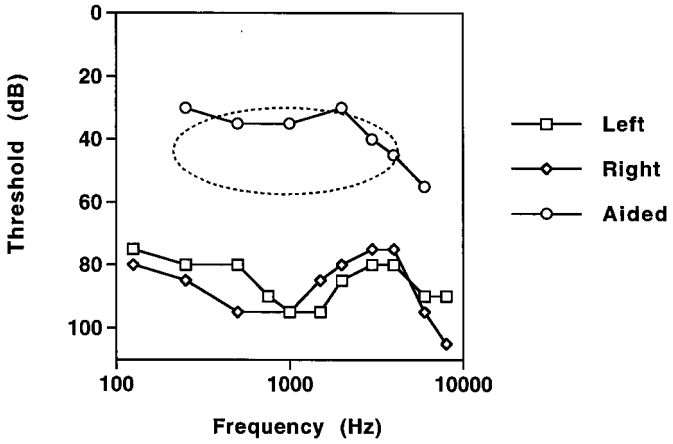

FIG. 1. Aided and unaided auditory thresholds. The oval area reflects the intensity of conversational speech.

hearing loss was obtained at age 3. Audiograms obtained at ages 6, 8, 16, and 18 are consistent with a 90 dB hearing loss in the right ear, and a 100 dB hearing loss in the left ear (see Fig. 1). Attempts were made to fit E.M. with hearing aids at ages 6 and 8; however, these aids were unsuccessful and he did not wear them. On the basis of his family history, he has been diagnosed with Waardenburg syndrome, a dominant genetic disorder that is characterized by anomalies in skin pigmentation and that occassionally results in deafness. The family reports that E.M.'s paternal great aunt was also deaf, although E.M. had no contact with her. He is the eldest of four children, and his youngest sister (age 12) is also deaf. She did not receive any formal education until after E.M. left the family home at age 15, at which point she briefly attended a day school for the deaf where oral training was stressed.

E.M.'s education consisted of approximately 1 year spent in the regular school system at age 9, where an attempt was made to teach him to read, and several months spent in a day school for the deaf at age 12, where oral training was provided. Today E.M. is able to read and spell isolated written words, but does not read with comprehension (see below). Aside from his time in the school for the deaf, his family reports that he had no contact with other deaf individuals.

At the age of 15 years, 9 months, E.M. came to Canada to stay with relatives. He was fitted with binaural hearing aids that corrected his hearing loss to 35 dB, a level that allows him to hear spoken conversation (see Fig. 1). Since that time, E.M. has been hearing and learning verbal Spanish within the family home. He has not received any formal language instruction during this time and has not attended school. His language input is therefore similar

to that of a young child who learns language naturally at home. E.M. spends 6 months of the year with his family in Mexico and 6 months of the year with relatives in Canada who do not know his homesign and communicate with him verbally.

Cognitive Ability

Assessments performed in Mexico at ages 8 and 10 estimated E.M.'s full-scale IQ to be 82 and 92, respectively. At age 16, his IQ was estimated to be 83 with the Test of Nonverbal Intelligence II (TONI-II) and 88 with the Performance Scale of the Wechsler Intelligence Scale for Children-Revised (WISC-R). On the WISC-R his performance was variable, with above average performance on Object Assembly, but severe deficits in Coding and Picture Arrangement. This pattern of strengths and weaknesses is not atypical in deaf populations (for a review see Mayberry, 1992). Auditory Digit Span was also assessed, and found to be very poor (scale score = 1, with a forward digit span of 2 items). Reassessment with the Wechsler Adult Intelligence Scale—Revised (WAIS-R) at age 19 was consistent with this evaluation, producing a Performance IQ of 85. Again, E.M. demonstrated strengths in Object Assembly and weaknesses in Picture Arrangement and auditory Digit Span. Estimates of intelligence are presumed to be low, given that no verbal instruction could be provided, and E.M.'s cultural background did not prepare him for testing situations. We conclude, therefore, that E.M. has demonstrated a low-average level of intelligence throughout his development, and that his nonverbal cognitive development has not been inhibited by his lack of linguistic development.

Homesign

Although E.M. has not experienced formal language, he has not been deprived of communication. He and his family use a homesign, a system of iconic gestures that allows them to communicate. The linguistic nature of E.M.'s homesign is a matter of ongoing investigation (Grant & Emmorey, 1994; Jakubecy & Emmorey, 1995); however, preliminary analyses of E.M.'s homesign are consistent with the findings for other deaf children of hearing parents (Goldin-Meadow & Mylander, 1984, 1990), although E.M.'s system seems to be much more elaborate than that described in younger children (e.g., Goldin-Meadow & Mylander, 1984). The system consists largely of gestures for actions, linked by points (E.M. points to a position in space to represent an object) and structures that seem to function as pronouns or classifiers. Classifiers are typical in many sign languages, and are consistent lexical items that are used to represent a class of object in an action gesture. For example, E.M.'s sign for ''the dog jumped over the bed'' consists of a classifier for animal (a four-legged sign produced with the right hand) jumping over the classifier for flat object (a flat left hand, palm down).

It is the use of classifiers that distinguishes E.M.'s homesign from the more simplistic systems observed in younger children (Goldin-Meadow & Mylander, 1990). E.M.'s classifiers differ from those in native sign languages, however, in that they do not appear to have a rich morphological structure.

Language Production

E.M. has great difficulty with articulation, and seldom speaks spontaneously. After 34 months of aided hearing, a formal attempt was made to elicit speech. He was asked to describe a seven-minute cartoon (Sylvester and Tweety; McNeill, 1992) with which he was familiar. Verbally, he was able to produce one word—*gato* (*cat*). He was then left with a pad of paper and the remote control for a period of 15 min, because it was possible that E.M.'s poor articulation was inhibiting his language production. He wrote four Spanish words—*cat, coins, monkey, and telephone.* Although these words were appropriate to the story, they could hardly be considered a narrative. We are confident that E.M. understood the nature of the task, as he had previously produced gestures to the same cartoon that, while impoverished, conveyed the essence of the story.

After 48 months, it became apparent that E.M. was still relying heavily on gesture for communication. However, his gesture had changed to incorporate the verbal productions that he had learned. Although all attempts to encourage E.M. to speak ''without his hands'' were met with flat refusal, he was quite willing to communicate in a combination of speech and gesture. This new mode of communication was formally assessed at 48 months with the Verbs of Motion Morphology Production subtest of the Test Battery for American Sign Language Morphology and Production (Supalla, Newport, Singleton, Supalla, Coulter, & Metlay, in press). This test is designed for the elicitation of sign and consists of 40 short (3 s) video clips that depict the movement of an object from one location to another, often in relation to a second object. Objects are repeated throughout the test to provide a measure of consistency in lexical use. E.M. was asked to describe each scene using as much speech as possible, although he could use gesture if he needed it to make himself clear. This same subtest had been administered to E.M. at 16 months of aided hearing, at which point he exclusively produced homesign responses. The comparison between the two assessments allows us to examine the possible contribution of homesign to verbal language production, and the manner in which speech and gesture are integrated.

At the 16-month assessment, E.M. produced gestural responses for all 40 video clips. Gestures were of the form described above, and usually consisted of the movement of classifier signs, sometimes in relation to a second classifier. Of the 60 nouns that were present in the items, only 16 were explicitly identified, and these consisted of only 8 unique nouns (tree, airplane, chicken,

porcupine, shirt, swing, cactus, and gun). At the 48-month assessment, E.M. again produced utterances for all 40 items, except that they now consisted of a combination of speech and sign. Speech was incorporated into 18 of the utterances. Sixteen of these involved a typical homesign gesture, accompanied by a verbal identification of the subject noun. For example, for the item ''a boy jumps into a circle,'' E.M. produced the classifier for person (2 fingers walking) with his right hand, jumping into a circle formed with the thumb and forefinger of his left hand, accompanied by the verbal noun ''*nino*'' (boy). In most instances the verbal noun represented an object that had not previously been identified explicitly in homesign. Speech was not used redundantly with gesture. Thus, verbal speech had added a new dimension to E.M.'s communication (noun identification). There were several instances, as well, where the incorporation of speech changed the homesign. For instance, four of the items involve an airplane. In his original homesign, E.M. used a detailed classifier to represent the airplane in the action gesture (right-handed fist with thumb and fifth finger extended to represent wings). When the verbal noun ''airplane'' was incorporated into the utterance, the airplane was represented by a very general classifier (a nondescript, open handshape). It seemed that a specific classifier was no longer deemed necessary. This is an example of verbal speech replacing some aspect of sign. E.M. used one verb in combination with a verbal noun, ''*airplane stop*.'' This is the only known example of a two-word utterance in E.M.'s verbal production.

Language Comprehension

In order to examine E.M.'s comprehension of syntax, we administered Spanish-language adaptations of the language comprehension tests that Curtiss (1977) administered to Genie. Tests were administered by a native speaker of Spanish (A.A.). These tests were used to allow direct comparisons between Genie and E.M. Assessments were administered at 8, 12, 16, 20, 24, and 34 months after the initiation of hearing aid use. All language tests followed the same format, similar to a token test. E.M. was required to make some form of manual response to a verbal instruction. First, the vocabulary to be used in the subtest was tested (e.g., *point to the circle*). Then, the specific syntactic structure of interest was tested (e.g., *point to the big blue circle*). Trials on which E.M. made a vocabulary error were not scored. At the first four assessments the test was discontinued if E.M. failed four consecutive items. If E.M. attempted all items, they were repeated, in a different order. At the 24- and 34-month assessments, all items were administered twice regardless of accuracy, in order to obtain an estimate of performance based on the complete test. This may have resulted in a lower level of performance at these assessments, both because of motivational factors and a re-

duced opportunity to capitalize on chance with the longer assessment. However, the 24-month and 34-month assessments are directly comparable to each other. At the 34-month assessment, an additional variation was added. We suspected that E.M. might have less than perfect performance, even on tasks he appeared to understand, because he occassionally didn't hear the verbal instruction. Therefore, on the first pass through each subtest, verbal instructions were provided. On the second pass, written instructions were provided. E.M. read each instruction aloud before completing each item.

Overall performance is summarized in Table 1. Descriptions of the language subtests, patterns of errors, and comparisons with Genie are discussed below. All reports of Genie's performance are taken from Curtiss (1977).

Simple and complex modification. E.M. was presented with circles, triangles, and squares in two sizes (simple modification) and three colors (complex modification). Instructions were of the form:

Enseñamé el cuadro chiquito azul.
Show me the small blue square.

Performance on both simple and complex modification tasks was above chance but imperfect from the earliest assessment. E.M. made more errors in complex modification (two adjectives) than in simple modification (one adjective). Almost all errors involved a failure to identify the correct shape—the modifiers were always correct. Given that word order in Spanish is such that the noun is followed by the modifiers, it is possible that these problems reflect a short-term memory deficit, which is consistent with his poor performance on the digit span subtest of the WISC-R and WAIS-R. However, this explanation cannot account for less than perfect performance with the written instructions, as E.M. could refer back to the instructions as often as necessary (although we do not know that he ever used this strategy). Genie appears to have mastered these constructions (with perfect performance) within 2 years.

Singular vs plural. This subtest consisted of eight pairs of pictures, each denoting a singular/plural distinction. Instructions were:

Enseñamé las flores.
Show me the flowers.

It is apparent that E.M. had mastered the distinction at our first, 8-month assessment. Curtiss reports that Genie could not distinguish singular and plural after 2 years, although she mastered the rule after it was taught to her explicitly. It is possible that the two plural markers in Spanish (the article and the plural morpheme ''s'') make the distinction more salient than in English (cf. Goodglass, 1993).

Possessive pronouns. The comprehension of possessive pronouns was examined by having E.M. point to features on his body, the experimenter's body, or to a picture of a boy and a girl. The pronouns *my, your, our, his/*

TABLE 1
Percent Accuracy on Language Comprehension Subtests

Subtest	Chance	Months of corrected hearing						
		8	12	16	20	24	34a	34b
Simple modification	11	66*	83*	92*	75*	68*	67*	83*
Complex modification	5	44*	50*	67*	100*	71*	59*	50*
Singular/Plural	50	87*	87*	83*	94*	82*	72	87*
Possessives	20	50*	57*	50*	64*	43*	36	57*
Comparatives	50	100*	50	100*	—	92*	84*	—
Conjunctions	50	78	60	100*	55	25	40	50
Verb tense	33	47	—	73*	—	57*	25	30
Before/After	50	43	—	20	—	46	29	—
Some/One/All	33	25	33	62*	—	—	25	50
Pronouns	14	22	—	27	—	—	19	44*
Spatial prepositions	14	33	40	40*	31	0	36*	27
Simple negation	50	33	57	54	45	66	66	33

Note. The 34-month assessment includes both verbal instructions (34a) and written instructions (34b).
* Performance differs from chance, $p < .05$.

her, and *their* were examined (note that *his* and *her* are not distinguished in Spanish). Instructions were of the form:

Enseñamé tu naríz.
Show me your nose.

E.M.'s performance on this task rose above chance at the 34-month assessment. Item analysis revealed that E.M. had difficulty only with the plural pronouns *our* and *their* for which he would answer inconsistently. Genie appeared to comprehend *my* and *your,* but had difficulty with all other possessives.

Comparative and superlative. Stimuli were buttons and strips of paper of varying sizes (two sizes for comparative, five sizes for superlative). E.M. was instructed to point to the appropriate object:

¿Cual botón es Más chiquito?
Which button is smaller?

After the 16-month assessment, E.M. appeared to understand these constructions. Genie did not fully master the superlative, but again the distinction between Spanish and English may be responsible. In English, they are distinguished only by the bound morphemes ''er'' and ''est,'' whereas in Spanish, they are indicated by the modifiers más (comparative) and el más (superlative).

Conjunctions. E.M. was presented with a series of common objects and instructed to point out conjunctions or disjunctions. For example:

Enseñamé el reloj o el botón.
Show me the watch or the button.

At the 34-month assessment, it was observed that E.M. sometimes substituted *and* for *or,* but never *or* for *and.* E.M.'s perfect performance on this subtest at the 16-month assessment and his poor performance at later assessments is an example of variability over time. Similar variability was observed in Genie's performance over time.

Verb tense. Four pictorial stories were used that consisted of three scenes that indicated past, present, and future tense. Instructions were of the form:

Enseñamé los niños comerán chorisos.
Show me, the children will eat sausages.

The present progressive, simple future, future infinitive, preterite indicative, and past infinitive tenses were examined. Although performance rose above chance at the later assessments, item analysis revealed no consistent pattern of errors on this subtest, except that E.M. had a bias toward responses in the present tense. This bias is expected if he is relying on semantic knowledge whenever he is unsure of verb tense. For example, the pictures for the sausage story (which assesses knowledge of the verb *to eat*) show children cooking

sausages, followed by children eating sausages, followed by children holding their full tummies. It is only in the present tense that ''*eating*'' is actually taking place. E.M. did not have complete mastery of any single tense. Genie showed initial comprehension of the future infinitive (e.g., *the boys are going to eat sausages*), but appeared to lose this comprehension at later assessments. The only tense that Genie had any long-term success with was the past with *finish* (e.g. *the boys finished eating sausages*). Curtiss interprets this success in terms of Genie's semantic understanding of the past marker ''*finish*'' combined with her failure to recognize other tense markings. We used a similar Spanish construction (*finish* + infinitive; *los ninos acabaron de comer chorisos*), but E.M. often confused this with the present tense.

Before/after word order. E.M.'s reliance on word order was examined by using a before/after construction. Instructions were of the form:

Tócate tu nariz despues que tocas tu barba.
Touch your nose after you touch your head.

E.M.'s performance never rose above chance on this subtest, and it was often below chance. Item analysis revealed that E.M.'s errors are not the result of his relying on word order in performing the tasks. However, his performance was better (but not perfect) when the subordinate clause followed the main clause (see example above) than when it preceeded the main clause (e.g., *after you touch your ear, touch your chin*).

Some/one/all. These constructions were examined by having E.M. place some, one, or all objects (buttons and coins) in a box. At the 24-month assessment, E.M. appeared to have mastered *one,* but used both *some* and *all* to mean all (Genie made similar errors). At the 34-month assessment, E.M. placed just one object in the cup in response to all instructions, demonstrating no differentiation among terms. This is another example of an ability that seems to have come and gone.

Pronouns. This subtest examined E.M.'s comprehension of pronouns as agent, object, or reflexive. A series of pictures was presented that depicted boys and girls feeding each other and themselves. Instructions were of the form:

Enseñamé, ella lo está alimentando.
Show me, she is feeding him.

E.M.'s performance rose above chance on the written form of this subtest at the 34-month assessment. Item analysis revealed that he used pronouns correctly when there was only one in the sentence (e.g., *the girl is feeding him,* or *she is feeding the boy*), but not when there were two pronouns (*he is feeding her*). There was no discernable pattern to the errors in the two-pronoun case. Use of the reflexive (*she is feeding herself*) was still inconsistent at the 34-month assessment. Genie had similar difficulties with this construction.

Spatial prepositions. Stimuli were four stacking boxes in different colors. E.M. was instructed to take two of the boxes and place them in some spatial relationship. Relationships that were examined were in, on, under, over, beside, behind, and in front of.

Pón la caja verde dentro de la caja azúl.
Put the green box in the blue box.

E.M. had great difficulty with this task. Item analysis revealed that, even at the 34-month assessment, he had not mastered one of these prepositions, nor were his errors limited to related pairs (under vs. over, in front of vs. behind). His general strategy when performing this subtest was to pick up the two appropriate objects and move them through a variety of spatial arrangements, watching the examiner for clues as to which was correct. Genie made predictable errors on this task, confusing under/over, and in front/behind. This may reflect a difference in testing procedures. For the first 3 years of testing with Genie, different subtests were used for different relations; for example, pictures of a house either in front of or behind a tree were used to test the in front/behind relation. Genie may have learned the pairwise association of prepositions during this phase. When Genie's tests were changed to use stacking cups (with no obvious spatial relationship to each other), these pairwise confusions continued.

Simple negation. Three pairs of pictures were presented, each pair denoting a presence/absence relationship. E.M. was required to point to the indicated picture.

Enseñamé el conejo no tiene zanahoria.
Show me, The rabbit does not have a carrot.

E.M.'s performance never rose above chance on this task, in contrast to Genie who demonstrated perfect performance with this construction even at her earliest testing sessions.

DISCUSSION

Our assessment of E.M.'s verbal production and comprehension suggests that he has severe linguistic deficits that are comparable to those observed in Genie in the years following her discovery. The similarities to Genie are striking, given the great differences in their histories. E.M. did not experience the severe abuse and deprivation that Genie did, nor did he have the benefit of intensive educational remediation when he started to learn language. Genie and E.M. were exposed to different languages in different contexts, and yet both seem to suffer from similar linguistic impairments. E.M.'s case, therefore, suggests that Genie's abusive background is not likely to be the only cause of her language impairments and provides converging evidence for the existence of a critical period for first-language acquisition.

E.M.'s poor language performance can be compared to the relative compe-

tence of late-learners of ASL. This discrepancy may reflect short-term vs long-term outcome, and only the passage of time will allow us to assess this possibility. Very little is known about the development of ASL in cases of late acquisition, as most studies have looked only at long-term outcome. However, Emmorey et al. (1994) report the case of Anna, a homesigner from Guatemala with a history similar to that of E.M., including a comparable degree of linguistic isolation. Anna began to learn ASL at the age of 16. Her homesign was comparable to E.M.'s in that it was more sophisticated than that documented in young homesigners (Goldin-Meadow & Mylander, 1984). Specifically, it consisted of fewer points and more characterizing gestures (including classifiers), although nouns were rarely expressed explicitly. Interestingly, when Anna began to incorporate ASL signs into her gestures (after only 6 weeks of exposure), she used ASL signs for the nouns that her gesture system did not make explicit. This parallels the integration of speech into E.M.'s homesign. Within 6 months of exposure to ASL, over 75% of Anna's productions were ASL gestures, although she continued to demonstrate syntactic deficits. Her rapid transition from homesign to ASL suggests that E.M.'s linguistic deficits are specific to verbal language. This hypothesis could be tested if E.M. were also to learn a sign language (probably Mexico City Sign). However, because E.M. lives with his hearing family in a rural area of Mexico with no Deaf community, he and his family have decided against his learning sign language, and have focused all energies on verbal acquisition.

There are two possible hypotheses about why the critical period may more seriously constrain the development of verbal as opposed to manual languages. The first is that the critical period is specific to some low-level auditory/phonological process, and that deficits in this system produce further deficts upstream. Given E.M.'s auditory deprivation, deficits in auditory speech perception and production mechanisms are possible (if not likely), and they may be the source of higher-level language deficits. Furthermore, E.M.'s hearing aids do not fully correct his hearing loss, and he therefore experiences impoverished auditory input. Failures in simple auditory processing cannot be solely responsible for E.M.'s comprehension deficits, however, as similar performance is observed in response to written stimuli.

A second possibility is that homesign provides a better foundation for the acquisition of manual as opposed to verbal language. Certainly signers do not face the same physical challenges to language perception and production that E.M. does. But further, there are parallels between the syntactic structures of homesign (such that it is) and ASL that may allow the acquistion of ASL to more closely resemble late acquisition of a second as opposed to a first language.

Comparisons to Normal Language Development

The conclusion that E.M.'s language development is atypical warrants a comparison to normal verbal language development. There is some question

as to the appropriate control group to which E.M. should be compared. On the basis of length of exposure to verbal language, E.M. could be compared to a 3-year-old child (for the language comprehension tests) or a 4-year-old-child (for the language production tests). This comparison is a conservative one for several reasons. First, E.M.'s cognitive and communicative skills when he first began to learn language far surpassed those of an infant. Furthermore, E.M. began to learn vocabulary within days of auditory exposure, and demonstrated knowledge of some syntactic structures (e.g., singular/plural) after only 8 months. Finally, it seems reasonable to assume that E.M.'s homesign might provide some basis for verbal language development; for example, he already had some form of representation for spatial prepositions.

One might argue that E.M.'s deficits in syntactic comprehension are not atypical for a 3-year-old child. Unfortunately, normative data are not available on the Curtiss (1977) language tests nor on our Spanish adaptations, and so we must rely on other sources. Most studies of child language acquisition have concentrated on production, which can be assumed to lag behind comprehension. Thus, some 3-year-olds may have difficulty in producing the same structures that E.M. has difficulty comprehending, such as before/after, or some possessive pronouns. However, we conclude that E.M.'s syntactic development is atypical in several ways. First, development is protracted. As noted above, E.M. showed comprehension of some structures after only 8 months of language exposure (e.g., singular vs plural, and comparatives and superlatives), but still did not comprehend verb tense, negation, pronouns, or prepositions at 34 months. Most notably, E.M. did not demonstrate significant improvement on a single subtest over the 2-year period of our assessment. Second, E.M. exhibits specific failures that are not seen in normal language development. For example, after 34 months he does not comprehend simple negation, a structure that is observed in children's language production by 26 months, and in comprehension before that (Brown, 1973). Third, E.M. exhibits tremendous variability in performance, both between sessions and across items. Even for structures that E.M. appears to have mastered (e.g., singular vs plural) performance is never perfect. Variability across sessions does not appear to be related to any systematic process, such as generalization.

But it is in verbal production that E.M.'s deficits are most apparent. After 48 months of language exposure, E.M. has a mean length of utterance (MLU) of less than 2. Normal children reach this stage at an average age of 20 months, and by age 4 have a MLU of 4.4 (Brown, 1973). E.M. never went through a babbling stage and has never been heard to experiment with language sounds. Babbling and experimentation are thought to be important contributors to the development of speech-production mechanisms. Anecdotal reports from E.M.'s family suggest that he does not participate in language acquisition the way that young children do—he does not mimic and

he does not ask questions. One could argue that E.M. has a functional homesign and thus has little motivation for verbal production. However, when E.M. is in Canada he stays with relatives who do not know his homesign, and encourage verbal communication at all times.

CONCLUSIONS

We have presented here a case of linguistic isolation in the context of normal cognitive and emotional development. E.M.'s case is consistent with the hypothesis that there is a critical period for first-language acquisition that ends at puberty, if not before. Unfortunately, we have no data that can address the nature of the critical period. Although critical period hypotheses have usually been associated with ideas of biological determinism, this need not be the case. We have provided the *observation* that first-language acquisition in puberty is atypical in many ways. This may reflect a loss of neural plasticity (e.g., Lenneberg, 1967) or the development of cognitive processes that inhibit language acquisition (Newport, 1990), or some interaction between the two. It is likely that language acquisition involves a set of innate constraints that dictate the processing of linguistic input as it is provided by the environment (e.g., Karmiloff-Smith, 1993). These constraints normally act early in childhood, producing predictable patterns of language development. However, as the individual develops, neural and cognitive structures change, both through maturation and environmental stimulation, resulting in associated changes in the constraints on language acquisition. The nature of language thus depends on the state of the neural and cognitive structures upon which it is instantiated, and it is these that change with time.

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