*ITL: Review of Applied Linguistics 39 -40. pp 23-37*
*1978*

# LANGUAGE DEVELOPMENT IN THE MATURE (MINOR) RIGHT HEMISPHERE*

Susan Curtiss and Victoria A. Fromkin
*Department of Linguistics, UCLA*

Stephen D. Krashen
*Department of Linguistics, USC*

This paper is a report about Genie, a girl who experienced a degree of isolation and deprivation greater than any case previously documented. Genie's case history has been described in detail elsewhere (Curtiss, Fromkin, Krashen, Rigler, and Rigler, 1974; Fromkin, Krashen, Curtiss, Rigler, and Rigler, 1974; Curtiss, 1977). Her story will be briefly summarized here for those who are unfamiliar with it.

Genie was born in 1957. From 4 to 11 months of age she wore a Frejka splint for a congenital hip dislocation. At 14 months she became acutely ill and listless. The physician warned the parents that her listlessness could possibly be a sign of retardation. The father misunderstood this warning and decided that Genie was indeed retarded. He confined her to a small bedroom. There she was physically harnassed to an infant's potty seat by day and often by night as well. She was otherwise confined in a homemade sleeping bag in a crib with wire mesh on all sides and a wire mesh cover overhead.

Genie received only minimal care and received little sensory input or stimulation of any kind. She was fed only infant food and periods of human contact with her were extremely limited. In addition, her father had an intolerance for noise; there was no radio or TV in the house, and Genie was punished severely for making any noise whatever.

---

* Partial support for this research was provided by National Science Foundation Grant #76-83072.

She was discovered when she was 13 years 7 months of age, a pitiful creature - painfully small, thin - more like a child of 6 or 7 than a teenager. She could not stand erect, could not chew food, and was not toilet trained. She maintained an eerie silence.

Genie's use of language has changed dramatically in the six years we have known her. She has gone from a non-comprehending, non-speaking human being to one who understands most of what is spoken to her, and who can speak to voice her thoughts, wants, and needs (For a complete report of her linguistic competence, see Curtiss et al, 1974 and Curtiss, 1977).

This report is devoted to the examination of just one unusual aspect of this already unusual case. In previous reports (Fromkin et al, 1974; Krashen, 1973), evidence was presented to support two related hypotheses concerning the representation of language in Genie's brain :

I. She appears to be processing language, as well as certain non-verbal functions, in her right hemisphere, rather than in her left hemisphere; she may, in fact, be utilizing the right side for all higher cortical functions.

II. Genie is relatively more proficient in "appositional" tasks than she is in "propositional" tasks (terminology from Bogen, 1969) : That is, she does better in what in right-handed normals are abilities purported to be localized in the right side of the brain.

Our original data supporting hypothesis I came from dichotic listening studies (Fromkin et al, 1974). When simultaneous competing verbal stimuli are presented to normal right-handed subjects, a slight but significant right ear advantage is found which is hypothesized to reflect left hemisphere processing. Normals show a left ear advantage for dichotically presented nonverbal stimuli processed by the right hemisphere, such as environmental sounds (Curry, 1967). Genie showed the expected slight left ear advantage for dichotic environmental sounds, but has shown a huge left ear advantage for verbal stimuli, her right ear performing at a chance level. To



account for such an unusual degree and direction of ear advantage (Genie is right-handed), we have hypothesized that Genie is processing language with her mature right hemisphere. Stimuli arriving at the right ear in dichotic listening are blocked en route to the right hemisphere, possibly by the "original" language areas in the left hemisphere that are now unable to do linguistic processing. Non-linguistic sounds arriving at the right ear are able to pass through to the right hemisphere.

Recent investigations of the localization of linguistic functions in Genie have confirmed hypothesis I. Brown and Mar at the UCLA Brain Research Institute, have found evidence of right hemisphere processing in Genie using the evoked response technique. Evoked response is the brain's electrical reaction to a single stimulus. In evoked response (as contrasted with EEG), stimuli are fairly short and are repeated several times : the responses are then averaged. Brown, Marsh, and Smith (1973) have used evoked response to study cerebral asymmetry and the representation of language in the brain. Their particular contribution has been the demonstration that the evoked response is different for the same word used in different grammatical contexts : for example, *fire* in "fire is hot" and "fire the gun". Response differences between the two meanings of such homophones are greater in the left hemisphere, particularly around Broca's area. The probability that their technique detects language lateralization is strengthened by their recent replication of results that were originally found using dichotic listening : the findings that stutterers show less lateralization than non-stutterers (Ponsford, Brown, Marsh, and Travis, 1975), that the development of cerebral dominance is complete by around age five (Krashen, 1973), and that males show greater lateralization than females (Remington, Krashen, and Harshman, 1974; Harshman and Remington, 1976).

Pilot data for Genie have been analyzed by Brown and Marsh and indicate greater right hemisphere involvement than left hemisphere involvement in language processing, specifically

in the anterior portion of the cortex. The evoked potential results, then, are consistent with our dichotic listening results, and our hypothesis that Genie is primarily using her right hemisphere. Our current work is to compare the development of her language with other cases of right hemisphere language.

Studies with split-brain patients have revealed that the right hemisphere has some capacity for creative language. Gazzaniga and Sperry (1967) found that when split-brain subjects were allowed to respond non-verbally (by pointing with the right-hemisphere controlled left hand), they could retrieve items corresponding to short words flashed to the right hemisphere (via tachistoscopic exposure to the left visual field), and spell simple words using manually palpated letters with the left hand. (The left hemisphere-right hand was unable to respond to these stimuli). Gazzaniga (1971) reported that there were definite limitations on right hemisphere linguistic competence; for example, the right hemisphere was unable to discriminate reversible active subject-verb-object sentences (such as "the boy kissed the girl" from "the girl kissed the boy"), could not discriminate singular from plural nouns, or the future from the present progressive tense. It could, however, distinguish negative from affirmative sentences. Gazzaniga and Hillyard (1971) concluded that the right hemisphere may be skilled mainly at attaching labels to pictures and objects, a hypothesis that is consistent with reports of high vocabulary competence in the right hemisphere. Zaidel (1973), using a device that allows free scanning using just one visual field, gave the Peabody Picture Vocabulary Test (PPVT) to two split-brain subjects and found their right hemisphere scores to be only slightly below left hemisphere scores. This surprisingly high performance on vocabulary contrasts with Zaidel's findings that the same split-brain subjects' right hemispheres do relatively worse on the Token test, a measure of the ability to understand nonredundant spoken commands. While the "average" right hemisphere performed above the 11 year old level on the PPVT, the average



right hemisphere Token test level was about age four.

We have very little knowledge of the syntactic competence of the right hemisphere. Zaidel's work is actually the first detailed look at the syntactic abilities of the mature right hemisphere, as the Gazzaniga et al studies were limited to stimuli that could be examined by the subject in a very short time span. Zaidel has compared his splitbrain results on the Token test to aphasic results, the latter presumably reflecting either the competence of the damaged left hemisphere with possibly a right hemisphere contribution or more direct right hemisphere abilities (see Kinsbourne, 1971; Moore and Weidner, 1975; Zaidel, 1977). He found a significant but modest correlation for difficulty order for the two groups. The difference in error patterns were small but interesting. If Genie turns out to be more similar to the split-brain results, this would also confirm our hypothesis of right hemisphere language for her.

Relatively higher vocabulary than syntax competence has also been found in cases where the right hemisphere has been left on its own to acquire language in adulthood or after completion of the development of cerebral dominance (somewhere around age five; Krashen, 1973). While extensive descriptions have been lacking, all three cases of left hemispherectomy in the literature for lesions incurred during adulthood were reportedly able to acquire (or re-acquire) vocabulary with greater ease than grammar (Hillier, 1954; Zollinger, 1935; Smith, 1966). Smith (1966) reported the growth of some propositional speech in one left hemispherectomized adult, but does not give details. Hillier's subject also reportedly made some small progress in syntax for a short time.

Zaidel (1973) administered the Peabody and the Token test to another left hemispherectomy (symptoms at 8 and surgery at 10). Her score on the PPVT (she was 13 at the time of testing) far exceeded her performance on the Token test - scoring at the level of 8.1 years and 3.0 years respectively.

In recent work, Dennis and Whitaker (1976) examined three cases of child hemispherectomy, one right and two left.

While general observations of spontaneous speech indicated no apparent differences in linguistic performance, detailed linguistic testing did reveal systematic differences in syntactic competence of the two hemispheres, with the left hemisphere outperforming the right in every instance of significant differential ability. All three cases, however, achieved comparable scores on the Peabody Picture Vocabulary Test.

There are interesting parallels between Genie and the adult left hemispherectomies, split-brains, and childhood left hemispherectomies. Genie's vocabulary exceeds many aspects of her syntactic ability. Like the adult right hemispheres, Genie has far better comprehension than speech (Zaidel, 1973, Curtiss, 1977). Like the right hemispheres acquiring language since infancy, Genie displays word order comprehension difficulties and better receptive semantic than syntactic abilities. Although she still shows a low level of performance on the PPVT (table one), her level as of 1/76 (MA = 5.10) is more advanced than all aspects of her grammatical performance, and in this respect she resembles both split-brains and all left hemispherectomies.

Table One

Peabody Picture Vocabulary Test Scores for Right Hemisphere Language

| Genie | date tested | total raw score | mental age |
|---|---|---|---|
| | 3/5/71 | - | |
| | 4/9/71 | - | |
| | 4/22/72 | 41 | 3.11 |
| | 9/17/72 | 46 | 4.7 |
| | 5/8/73 | 44 | 4.4 |
| | 2/74 | 53 | 5.7 |
| | 1/76 | 54 | 5.10 |



| | | | |
|---|---|---|---|
| split-brain : (Zaidel, 1977) | | | |
| L.B. | right hemisphere | 103 | 16.3 |
| | left hemisphere | 115 | 18+ |
| N.G. | right hemisphere | 82 | 11.0 |
| | left hemisphere | 87 | 12.5 |
| left hemispherectomy : (Smith, 1966) | | | |
| E.C. | | 85 | 12.1 |
| aphasics in general | | 98 | |
| global aphasics | | 68 | |

A major and striking contrast, however, exists between Genie and the childhood right hemispheres. The speech of the two left hemidecordicates (Dennis and Whitaker, 1976) appears normal - fluent, and fully elaborated phonologically, semantically, and syntactically. Genie's speech is syntactically primitive and undeveloped[1]. To illustrate, we now describe a few aspects of her spontaneous speech, all of which lag behind her current vocabulary level.

1. Grammatical morphemes : Brown (1973) describes stage II in the acquisition of English as a first language as the introduction of grammatical morphemes in a more or less invariant order. His three subjects began this stage at 2.6, 2.10, and 1.9 years and completed acquisition of all 14 morphemes studied by 3.6., 4.0, and 2.3 years respectively. Genie appears to be acquiring these morphemes in an order not totally unlike first language acquirers (rho : .6) and not surprisingly, her order of acquisition looks more like first than second language acquisition (Krashen, Madden, and Bailey, 1975; Krashen, 1977). While she has made progress in morphology (table two), she has not yet completed full acquisition of most of these fourteen morphemes.

Tabel Two

Order of Acquisition of Grammatical Morphemes

| | |
|---|---|
| 1. article | 6. irregular past |
| 2. ing | 6. contractable copula |
| 3.5 plural | 8.5 III singular |
| 3.5 possessive | 8.5 auxiliary |
| 6. regular past | |

2. Negation : Klima and Bellugi (1966) have claimed that normal children typically reveal a specific developmental sequence in the acquisition of the syntax of basic negation. They claim that fairly rapidly (over a period of perhaps one to one-and-one half years) the negative sentences of normal children change from (1) sentence external negation (e.g. "no want milk"), where the negative particle is appended to the sentence, usually at the beginning, to (2) sentence internal negation (e.g. "I not want milk"), where the negative particle is embedded in the sentence rather than attached externally, to (3) use of "do-support" ("I do not want milk") - where the auxiliary "do" is added to express the tense of the sentence. At this point, contraction of the negative particle is also found ("He isn't drinking milk").
Genie's negative structures remained unchanged for close to three years, all being of form (1) ("not having floating chair", "not like school"). While Genie was able to express a great deal of semantic complexity in her negative sentences, from the first expressing a wide range of meaning (denial, rejection, non-existence, etc.), the syntax of her negative sentences remained at the most primitive level. Recently, Genie has begun to use negative sentences which appear to be form (2) and (3) such as "You no have book", "I do not have red pail" (5/75), but her acquisition of negation, with respect to syntax, remains relatively less developed than her vocabulary, in parallel with her development of grammatical morphemes[2].

3. Questions. Normal children begin asking questions almost as soon as they utter their first words. First, through use of intonation, then, through use of question words, and finally through syntactic operations, children formulate interrogatives and are able to ask questions. Not all question words appear at the same time, however : WHO, WHAT, and WHERE questions appear first, WHY, WHEN and HOW later. In comprehension of questions the difference between a child's understanding of the different question words becomes even clearer. A normal child understands WHO, WHAT,



and WHERE questions long before WHY, WHEN and HOW questions. The semantic complexity of the particular question words appears to make the difference, since the syntactic form of the question remains identical.
Unlike normals, Genie has never asked a linguistically marked question. She has not been able to control pitch sufficiently to use intonation to ask questions. More surprisingly, however, she uses no question words spontaneously and has never formed a spontaneous WH- question[3]. In striking contrast to the complete absence of questions in her speech, Genie comprehends all the question words and has done so for almost five years ! From the earliest point on record where we have data on all of the different question types (1/72), Genie shows clear comprehension of WHO, WHAT, WHERE, WHICH, WHOSE, WHEN, WHY, and HOW as well as yes/no questions, suggesting highly advanced receptive competence in this area.
In October, 1975, we administered Fathman's SLOPE test (Fathman, 1975), an oral production test involving 20 structures in English. While difficulty order of her results was encouragingly close to second language learners (rho = .6), her overall score of 12 was below the average score for a child learning English as a second language in the US for one year (IL=26). (It should be noted that Genie may have lost several points due to her tendency to delete ends of words, and plural and possessive markers. Her score may thus be a low estimate of her ability).

4. Semantics. In contrast to her syntax, Genie can understand and produce semantically rich and complex structures. Her comprehension of elaborate instructions, descriptions, and questions, and her use of vocabulary, use of negation, elaboration of NP's, production of sophisticated semantic structures, such as if-then conditionals (see Curtiss, 1977, for examples) all evidence greater semantic than syntactic ability.
To summarize, evoked responses data support our hypothesis that Genie has right hemisphere language. Comparison with other cases of right hemisphere language further supports

this hypothesis. Although different in some specifics, many aspects of her language abilities correspond to the language of the other right hemispheres reported to date. We will continue to compare her proficiency and progress to other right hemisphere cases.

The second part of hypothesis I - that Genie is using her right hemisphere for all higher cortical functions - has also received confirmation. Recall that on our dichotic listening environmental sounds test, Genie showed a left ear advantage, indicating right hemisphere processing. Brown and Marsh, again using evoked potential, have also run a pilot facial recognition test with Genie and they found a greater response difference in Genie's right hemisphere. As before, this result parallels our dichotic listening results and strengthens the position that Genie is using her right hemisphere for all higher cortical functions.

Our second hypothesis - that Genie is more proficient at abilities normally localized in the right hemisphere - has also received confirmation. For the most part, Genie continues to perform well on "appositional" tests, that is, tests that tap *only* the right hemisphere. Her performance on some of these tests is simply sensational. On the Moony Faces test (2/75) she scored far above the responses of a normal child. It is, in fact, to our knowledge the greatest performance reported on this test for child or adult subjects. The Mooney Faces test involves gestalt facial recognition, a task known to be dependent on the right hemisphere in normals. Since our last report we have also tested Genie on other "gestalt"-type tests thought to be dependent on the right hemisphere, and she has consistently performed at above normal levels (the Harshman Figures, 2/75; Thurstone Figures, 3/75). These results correspond with our previous reports of high performance on the Street Test and her relatively superior performance IQ as compared to her verbal IQ.

Her performance on other apparently nonverbal tests has been much worse, and these results are extremely interesting in that they indicate that Genie is not merely proficient in

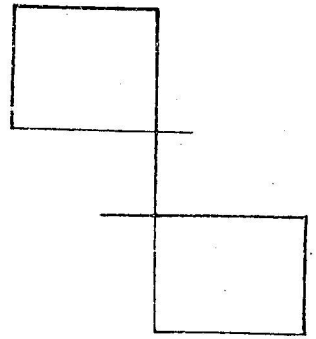


"spatial" or configurational or "nonverbal" tests, but may have a special "appositional" ability, that is, she excells only for functions that generally are localized in the normal right hemisphere. One such test is Graham and Kendall's Memory for Design Test (Graham and Kendall, 1960). This test involves the presentation of simple geometric designs and the reproduction of these designs from immediate memory. In this test the S views a design (such as that presented in figure one) involving straight lines without meaningful associations for five seconds. After the exposure, the design is withdrawn and the S is asked to draw it. There are 15 items on the test and points are subtracted for "easily identifiable errors", with reversal or rotation of the figure being penalized. No penality is given for incomplete or forgotten designs as Graham and Kendall report that such errors were frequent among normals. Orientation errors, however, were frequent in brain-damaged patients. Graham and Kendall claim that the test is very sensitive to presence of organic brain damage, and provide the following interpretation of raw scores for adults :

| | |
|---|---|
| Brain Damage | 12 and up |
| Borderline | 15-11 |
| Normal | 0-4 |

Figure One

Item from the Memory for Design Test



Graham and Kendall suggest that the task may involve skills utilizing both sides of the brain, including the ability to perform a sequence of behaviors, attention to and retention of the pattern, and the reproduction of the pattern via a complex motor act. Consistent with this are results from studies conducted by Ritchie and Butler (1964), who found that performance on the MFD by retardates related to all but two of the 10 subtests of the WAIS as well as the Stanford-Binet IQ test, which involves both verbal (left hemisphere) and performance (right hemisphere) portions. The MFD was administered to Genie on 10/1/75, and her test was independently scored by two raters. Her scores were 9 and 8, placing her in the "borderline" range. If both hemispheres make contributions to the succesful performance of the MFD, Genie's less than spectacular results are quite consistent with our previous findings of relatively good appositional (strictly right hemisphere) skills. It is, in fact, evidence that her special ability should be characterized as right hemisphere or appositional, rather than simply "nonverbal", "visual-spatial", or "configurational". It should be noted that while Genie's score was low, the nature of the errors she made indicates the absence of organic brain-damage.

On a similar test, the Benton Visual Recognition test, and on the Benton et al test of Facial Recognition (Benton et al, 1975), Genie also scored poorly. These tests also appear to involve both hemispheres, as some aphasic populations appear to be impaired on these tasks (e.g. 47 % of post-Rolandic left hemisphere lesions (aphasics) gave a defective performance on the Benton et al test of Facial Recognition; Benton, Van Allen, des Hamsher, and Levin, 1975).

In summary, hypothesis II has also been confirmed thus far. We will continue testing on both "pure" right hemisphere and "bilateral" nonverbal tests. This is a valuable adjunct to our more linguistic studies as it confirms that we are indeed dealing with the mature right hemisphere in isolation.



FOOTNOTES

1. The speech of these left hemidecordicates was only observed impressionistically. It is possible that on closer examination deficits would be found. The differences between these children and Genie would still be marked, however, since even upon casual observation, Genie's speech is belabored and limited.
2. For example, Do-support appears only in the rote phrase "I do not have ...".
3. This is not to say that Genie does not seek information (or make requests). She does indeed - clearly, often, sometimes repetitively. She does so, however, through means such as facial expressions and by pointing. She will also often repeat a word or phrase continuously until someone realizes that her "declarative" utterance is intended as a question and then gives Genie the desired information. These repetitions also are often accompanied by pointing and facial expressions connoting confusion or curiosity.

REFERENCES


Benton, A.L., M.W. Van Allen, K. des Hamsher, and H.S. Levin. Test of Facial Recognition, Revised Manual. Iowa City, Iowa. 1975.

Bogen, J. The other side of the brain II : An appositional mind. Bulletin of the Los Angeles Neurological Society 34, 1969:135-162.

Brown, W., J. Marsh, and J. Smith. Contextual meaning effects on speech-evoked potentials. Behavioral Biology 9, 1973:755-761.

Brown, R., A First Language. Cambridge, Mass:Harvard Press. 1973.

Curry, F. A comparison of left-handed and right-handed subjects on verbal and non-verbal dichotic listening tasks. Cortex 3, 1967:343-352.

Curtiss, S. The Case of Genie : A Modern Day "Wild Child". New York:Academic Press. 1977.

Curtiss, S., V. Fromkin, S. Krashen, D. Rigler, and M. Rigler. The linguistic development of Genie. Language 50, 1974:528-554.

Denniss, M. and H. Whitaker. Language acquisition following hemidecordation : linguistic superiority of the left over the right hemisphere. Brain and Language 3, 1976:404-433.

Fathman, A. The relationship between age and second language productive ability. Language Learning 25, 1975: 245-253.

Fromkin, V., S. Krashen, S. Curtiss, D. Rigler, and M. Rigler. The development of language in Genie : A case of language acquisition beyond the 'critical period'. Brain and Language 1, 1974:81-107.

Gazzaniga, M. The Bisected Brain. New York : Appleton-Century-Croft. 1971.

Gazzaniga, M. and R. Sperry. Language after section of the cerebral commissures. Brain 90, 1967:131-148.

Gazzaniga, M. and S. Hillyard. Language and speech capacity of the right minor hemisphere. Neuropsychologia 9, 1971:273-280.

Graham, F. and B. Kendall. Memory for Designs Test, Revised General Manual. Perceptual and Motor Skills, Monograph Supplement 2 - VIII. 1960.

Harshman, R. and R. Remington. Sex, language, and the brain. UCLA Working Papers in Phonetics. 1976.

Hillier, W. Total left hemispherectomy for malignant glioma. Neurology 4, 1954:718-721.

Kinsbourne, M. The minor cerebral hemisphere as a source of aphasic speech. Archives of Neurology 25, 1971: 302-306.

Klima, E. and U. Bellugi. Syntactic regularities in the speech of children. In J. Lyons and R. Wales (eds.), Psycholinguistics Papers. Edinburgh : Edinburgh University Press, 1966:183-208.

Krashen, S. Lateralization, language learning, and the critical period : Some new evidence. Language Learning 23, 1973:63-74.

Krashen, S. Some issues relating to the monitor model. Paper presented at the 1977 TESOL Conference, Miami, Florida.

Krashen, S., C. Madden, and N. Bailey. Some theoretical aspects of grammatical sequencing. In M. Burt and H. Dulay (eds.) New Directions in Second Language Learning, Teaching, and Bilingual Education : On TESOL '75. Washington, D.C. : TESOL. 1975:44-54.

Mooney, C. Age in the development of closure ability in children. Canadian Journal of Psychology 11, 1957: 219-226.

Moore, W. and W. Weidner. Dichotic word-perception of aphasic and normal subjects. Perceptual and Motor Skills 40, 1975:379-386.

Remington, R., S. Krashen, and R. Harshman. A possible sex difference in degree of lateralization of dichotic stimuli ? Journal of the Acoustical Society of America 55, 1974 :434 (abstract).

Smith, A. Speech and other functions after left (dominant) hemispherectomy. J. Neurol. Neurosurg. Psychiat. 29, 1966:467-471.



Zaidel, E. Unilateral auditory comprehension on the Token test following cerebral commissurotomy and hemispherectomy. Neuropsychologia 15, 1977:1-17.

Zollinger, R. Removal of left cerebral hemisphere. Arch. Neurol. Psychiat. (Chicago). 34, 1935:1055-1064.