tain of these tests, Genie's performance was the highest reported in the literature for either child or adult.

Along the same lines, Genie's performance on tests involving left-hemisphere abilities was below normal (for example, on several tests of sequential order). More problematic, however, was her poor performance on certain tests that have been assumed to tap right-hemisphere skills (for example, facial recognition, memory for designs). The author's explanation of these anomalies is that these particular tasks tap both right- and left-hemisphere abilities and therefore should be difficult for Genie. The argument begins to take on a rather ad hoc quality here. However, in light of Genie's remarkably good performance on certain tasks and poor performance on others, her pattern of abilities might itself be used to generate hypotheses about right as compared to left brain skills.

The data can be interpreted in a still broader context by considering the possibility (not explicitly taken up by Curtiss) that human language acquisition may be constrained not only by the time of acquisition but also by the nature of experience during that time. The literature on the role of linguistic input in language acquisition suggests that certain aspects of language may be sensitive to a finely tuned linguistic environment while others may not. For example, deaf children who have not yet learned oral language and who have not been exposed to a conventional sign language can develop a spontaneous gesture system that has languagelike properties such as ordering rules and recursion (S. Goldin-Meadow and H. Feldman, *Science* **197**, 401 [1977]; H. Feldman, S. Goldin-Meadow, L. Gleitman, in *Action, Gesture and Symbol*, A. Lock, Ed., Academic Press, in press). These properties, developed without a conventional language model, are also found in Genie's postpubertal language. These same deaf children do not develop language properties, such as auxiliary structure, that so far are missing from Genie's language as well. Furthermore, in studies of normal hearing children, the auxiliary is one of the few language properties whose rate of acquisition has been shown to be sensitive to variations in the child's linguistic input (E. L. Newport, H. Gleitman, L. Gleitman, in *Talking to Children*, C. A. Ferguson and C. E. Snow, Eds., Cambridge University Press, 1977). The experience with Genie thus provides further evidence concerning constraints on language development. Some properties of language, such as the auxiliary, may be "fragile," more likely to be developed during the critical period and more likely to be developed with a finely tuned linguistic environment. Other properties, such as ordering rules and recursion, are apparently more "resilient" and can be developed beyond the critical period and with no exposure to a conventional linguistic model.

Several points that highlight the relationship between thought and language are made in the book. When Genie began acquiring speech, she learned many more color words and adjectives expressing size and quality (such as "funny" and "silly") than does a normal child at the earliest stages of language acquisition. Genie's initial two-word phrases reflected this interest in attributes and primarily involved modifications of nouns ("two hand," "lot bread," "fat grandma," "yellow balloon"), as did many of her longer utterances ("small two cup," "little white clear box"). Thus the content of Genie's utterances, while roughly comparable to that of the normal child's, did appear to reflect biases she brought to the language-learning situation (evidently she had a tendency to focus on the physical attributes of the world around her). Moreover, even though Genie was a beginning language-learner, she did not overgeneralize words (that is, use one word such as "bow-wow" to refer to various objects—dog, cow, cat, and so on) as does a normal child. This suggests that certain aspects of normal two-year-old language may reflect properties of the two-year-old mind and not properties of early language learning in general.

Genie's speech also contains references to events that occurred before she possessed language. For example, she described the fact that her father had beaten her during her years of confinement, "Father hit arm. Big wood. Genie cry." As her language improved, she conveyed the same sad tale in single, longer sentences: "Father hit Genie big stick," "Father make me cry." This is a striking example of a human's ability to encode and recall events experienced before the acquisition of language.

The book is sensitively written and manages to convey a sense of Genie both as an individual and as a language user. Genie's story is (we may be thankful) a unique one, from which we can hope to learn much about the resilience of human language-learning capacities. As long as Genie continues to progress, the story is not ended.

SUSAN GOLDIN-MEADOW
Department of Education, University of Chicago, Chicago, Illinois 60637

Asymmetry and the Brain

Lateralization in the Nervous System. STEVEN HARNAD, ROBERT W. DOTY, LEONIDE GOLDSTEIN, JULIAN JAYNES, and GEORGE KRAUTHAMER, Eds. Academic Press, New York, 1977. l, 538 pp., illus. $21.50.

Evolution and Lateralization of the Brain. Papers from a conference, New York, Oct. 1976. STUART J. DIMOND and DAVID A. BLIZARD, Eds. New York Academy of Sciences, New York, 1977. vi, 502 pp., illus. Paper, $40. Annals of the New York Academy of Sciences, vol. 299.

In vertebrates and other bilateria the sensory-central-motor loops that control behavior are bilaterally organized. In contrast, the viscera and their neural control systems depart, often grossly, from bisymmetry. So we look to the behavioral rather than the vegetative needs of the organism for the adaptive rationale for bisymmetry. That the adaptation involved is primarily movement becomes apparent when we consider that it is in motile forms that bisymmetry is most strictly observed, in sessile forms that it is most freely violated. The bisymmetrical organism is rostrocaudally polarized, with distance receptors, organs of prehension, and the major concentration of neurons rostrally located. Because at any instant the organism surveys only a limited section of ambient space, its survival depends on its ability to deploy its sensory-motor equipment in any direction by rapid orientation. By its ability to turn quickly in any direction, the organism becomes functionally circular and prepared for the spatially random incidence of potentially relevant events. Moreover, although unilateral turning would suffice to cover all 360 degrees of arc, a less cumbersome arrangement in fact occurs: an approximately equal balance of opposing right and left turning tendencies, represented at various levels of central nervous organization. Where departures from bisymmetry occur, their implications for the ability to turn freely and quickly to either side are of immediate interest. Do they bias turning? If so, how is the bias counteracted in the natural environment? If not, how is the dissociation achieved?

We may divide asymmetries into those that are species-specific (like human handedness) and those that are consistent within individuals but equiprobably right or left across individuals (like paw preference of many animals). Among the systematic asymmetries, we distinguish the neuromotor, which cause turning bias, the cognitive, which do so only indirectly and minimally, and structural ones that are of trivial or uncertain functional significance. Of each we may ask: Does it bestow adaptive advantage? Does it reflect some superordinate organizational principle, of which it is merely derivative? Or is it due to relaxation of the need for bisymmetry, which perhaps only occurs when specifically programmed?

Of the papers presented in *Lateralization in the Nervous System*, 23 deal with asymmetries from a theoretical, empirical, or methodological standpoint and three with hemisphere interaction. Of those presented in *Evolution and Lateralization of the Brain* 30 deal with issues of asymmetry and nine with other matters pertinent to the evolution of the nervous system. I will consider the papers with respect to questions raised above.

Of the asymmetries discussed in the books the ones most obviously relevant to movement are the rightward turning biases of rats (Glick *et al.*, both volumes), of human infants (Turkewitz, both volumes), and of human adults with lateral cerebral lesions (Heilman and Watson, *Lateralization*). Lateral gaze deviations that accompany the adoption of a particular mental set (Gur and Gur, Anderson, *Lateralization*) are minor reorientations secondary to higher mental activity, and perceptual asymmetries in normal adults (Berlin [auditory], Springer [visual], *Lateralization*) may represent corresponding shifts in attention that are premotor or submotor in nature. Indeed, the event-related electroencephalographic changes studied by Donchin *et al.* and Thatcher (*Lateralization*) do not necessarily represent the cognitive activity in process but could represent lateralized orienting responses in relation to the side of the brain being used. Indeed, this would make it understandable why infants who are quite unable to process speech or music show lateralized EEG response to speech and musical stimuli (Gardner and Walter, *Lateralization*). Stamm *et al.*'s analysis (*Lateralization*) of the functional asymmetry in the monkey's frontal cortex also implicates manual and spatial orientation preferences. Finally, a lively debate on the origins of hand preference (Collins, both volumes; Warren, Morgan, *Lateralization*; Levy, Dewson, Nebes, *Evolution and Lateralization*) bears on the issue of whether this is a component of a species-specific rightward turning bias. If so, this would best be considered as part of a consummatory synergism, initiating manipulation subsequent to effective approach to the object. At this stage, differentiation of manual skills (Wolff, *Evolution and Lateralization*) is consistent with adaptive needs.

It appears that neuromotor asymmetries either do not have implications for turning or, if they do, can be stabilized on the basis of perceptual orientation in normal environments. But are they adaptive in themselves? Perhaps a lateral bias is a point of reference for right-left orientation (Glick *et al.*, *Evolution and Lateralization*).

The most massive lateralization is in humans: the double functional dissociation between left verbal-analytic and right spatial-wholistic processing at the hemispheric—and even the thalamic (Riklan and Cooper, *Lateralization*; Ojemann, *Evolution and Lateralization*)—level.

This asymmetry generates only minimal turning biases. It became possible because the mental processes subserved deal not with the concrete physical environment but with central representations thereof, which, as Levy (both volumes) points out, can be found in either hemisphere as well as across the two. Whether the mental representations that form in the two hemispheres differ qualitatively and how such differences might relate to the presumed unity of consciousness is debated by Eccles, Galin, Gazzaniga, Puccetti, and Whitaker and Ojemann in *Evolution and Lateralization*. The functional advantage, if any, of lateralization is the subject of intriguing speculation by Levy (*Evolution and Lateralization*). But the test case, the left-hander whose cerebral organization is anomalous (mirror image or unlateralized) by reasons of inheritance or early brain damage (Rasmussen and Milner, *Evolution and Lateralization*), proves a disappointment, showing either no deleterious consequences of the anomaly or confusing outcomes (Kocel, Stamm, *Evolution and Lateralization*). Perhaps the variability of lateralization is an example of diversity in human brain organization (Gazzaniga, *Evolution and Lateralization*) with few if any functional implications. If so, it still might have had such implications at the stage in hominoid evolution in which the genetic programs that control it were selected (Levy, *Evolution and Lateralization*).

In contrast to the vitally important lateralized functions in humans are some anatomical asymmetries of brain that, though minor and rather inconstant, appear to be species-specific (Rubens, *Lateralization*; Wada, Witelson, *Evolution and Lateralization*). Their functional significance remains to be determined.

Possible model systems are considered, ranging from heterochely in crustaceans, considered from the viewpoint of asymmetrical neural control (Chapple, both volumes), and positional orientation (Schöne, *Evolution and Lateralization*), through the lateralized control of song in songbirds (Nottebohm, *Lateralization*). In addition, the volumes contain accounts of apparently successful (Stamm *et al.*, *Lateralization*), promising (Dewson, *Lateralization*), or unsuccessful (Hamilton, both volumes) attempts to train monkeys in potentially lateralized skills. Attempts with cats are also reported (Webster, Nelson *et al.*, *Lateralization*).

On reviewing the wealth of information and opinion represented in these two books, one cannot help being tantalized by the fact that, although clues abound, not a single major issue with respect to lateralization has been definitively resolved. No wonder so many of us find this field of scientific endeavor irresistible.

MARCEL KINSBOURNE
Neuropsychology Research Unit,
Hospital for Sick Children,
Toronto, Ontario M5G 1X8, Canada

The Oculomotor System

Control of Gaze by Brain Stem Neurons. Proceedings of a symposium, Paris, July 1977. R. BAKER and A. BERTHOZ, Eds. Elsevier/North-Holland, New York, 1977. xvi, 514 pp., illus. $59.95. Developments in Neuroscience, vol. 1.

Movements of the Eyes. R. H. S. CARPENTER. Pion, London, 1977 (U.S. distributor, Academic Press, New York). xvi, 420 pp., illus. $27.

The Brain and Regulation of Eye Movement. A. R. SHAKHNOVICH. Translated from the Russian edition (Moscow, 1974) by Basil Haigh. Plenum, New York, 1977. x, 190 pp., illus. $25.

If there is any central neural apparatus that should be ready to yield to modern neurobiological probing, it is the mam-