Introduction

John C. Marshall

Sign Aphasia in the Context of Modern Neuropsychology

In an early discussion of the psychobiology of human cognition, Noam Chomsky referred to a language as "a specific sound-meaning correspondence." When asked if he thereby meant to exclude sign languages, he replied: "I mean 'signal.' I should have said 'signal-meaning correspondence.' It is an open question whether the sound part is crucial. It could be but certainly there is little evidence to suggest it is" (Chomsky 1967). At the time there was indeed little evidence on which to base an informed judgment about the linguistic status of sign. True, there had appeared, from Gallaudet College, some preliminary indications of the richness of vocabulary to be found in American Sign Language (Stokoe 1960; Stokoe, Casterline, and Croneberg 1965), but for the rest prejudice ran riot.

It was all too easy for the hearing world "to dismiss the manual communication of deaf people as a mishmash of pantomime and iconic signals, eked out by finger spelling" (Marshall 1986b). Communities of deaf people, accustomed through many generations to using ASL as their primary means of communication for everyday needs, intellectual discussion, and the expression of wit, poetry, and drama, knew better. Yet even there the hostility of the dominant culture sometimes led the deaf themselves to incorporate the hearing world's assessment of their language as a primitive pidgin, a gestural analogue of "You Tarzan, me Jane." The comparison with Yiddish is instructive; there, too, surrounding societies often regarded the language as a degenerate form of German baby talk, an assessment that was sometimes shared by those who wanted to "modernize" the culture of the *shtetl* from within. But deaf "speakers" of ASL suffered additional disadvantages. Communicating in a visual language, quite unrelated to spoken English and expressed in a transitory medium even more difficult to notate than classical ballet, a sign language poet could not hope that his or her work would be printed for posterity. Prior to widespread use of cinematography, the deaf literary artist

was thus deprived of the permanent record of cultural tradition to which a new Peretz, Landau, or Ansky could further contribute.

Happily, ASL is now alive and well, thriving as the living language of a community and as the object of serious scientific investigation. For the latter we are indebted in large part to the work of the Salk Institute and the University of California, San Diego, where Ursula Bellugi, Edward Klima, and Howard Poizner have, with their colleagues and students, revolutionized our understanding of ASL (Klima and Bellugi 1979). We are beginning to see how universal grammatical categories and features are realized in a four-dimensional moving medium that places very different constraints on the overt expression of linguistic form from those found in spoken (or written) languages. ASL, then, is a language, albeit not just a language like any other (in the dismissive sense of that idiom).

Unhappily, deaf signers are no less likely than the hearing to suffer major brain damage, whether from stroke, tumor, or closed head injury. And it is to the important topic of how to describe and explain (and, in the long term, help to remediate) the cognitive deficits consequent on such trauma and disease that Poizner, Klima, and Bellugi have now turned their attention.

The first paradox presented by a natural language expressed in three dimensions of space and one of time goes back to the very foundations of modern neuropsychology. In 1865, Paul Broca convinced the neurological world that the material substrate for (spoken) language was the *left* cerebral hemisphere in the vast majority of right-handed people (see Berker, Berker, and Smith 1986); in 1876, John Hughlings Jackson first produced evidence to suggest that the *right* hemisphere may play a similarly "leading" role with respect to (many) visuospatial abilities (Jackson 1876). Subsequent discoveries have perhaps modified, but never fundamentally contradicted this picture of complementary hemispheric specialization that could be regarded as the central dogma of neuropsychology. But which hemisphere takes precedence when the communication system simultaneously qualifies as both a language and an extremely precise set of gestures executed in space and perceived visually? The clear and unambiguous answer that emerges from these studies by Poizner, Klima, and Bellugi is that language per se is committed to the left hemisphere, irrespective of the modality whereby language is made manifest. It would seem, then, that the biological foundations of grammatical structure are not to be found exclusively in some privileged interaction between cognitive capacity and the auditory-vocal system (Liberman and Mattingly 1985). Neither is the human brain intrinsically specialized for the "what and the where" of objects

in general (Newcombe 1985). Rather, when the objects form part of a linguistic system, their representations are realized by the left hemisphere; when other objects enter into the topographical memory system for place and space, the right hemisphere assumes primary processing responsibility (Landis et al. 1986). In the geography of mind, domain-specific, cognitive computations take precedence over the representation of modality and (purely) physical form (Marshall 1984).

Still more surprisingly, there appear to be strong parallels between the different forms of aphasic impairment in sign and spoken languages, despite the superficial antithesis of the two systems. In spoken languages damage to anterior areas of the left hemisphere often results in a nonfluent aphasia (Grodzinsky 1986): Speech is slow and laborious, often misarticulated; markers of inflectional and derivational processes are simplified or left out; and, in the extreme case, expression may be restricted to major lexical classes (the base forms of nouns, adjectives, and verbs). By contrast, damage to more posterior regions provokes a variety of fluent aphasia: Speech may be fast and flowing until the patient is held up by an inability to retrieve specific lexical items; although mostly produced without apparent effort, speech is contaminated by phonological, morphological, and semantic paraphasias, by copious circumlocation, and by a tendency to "splice together" grammatically incompatible syntactic structures (Butterworth 1985). This basic contrast between two broad classes of aphasic impairment is upheld in the neuronal substrate for sign. Gail D., who suffered an extensive left frontal infarct, was found to have her signing reduced to the production of uninflected, referential open-class signs, stripped of the intricate morphological apparatus of ASL; Paul D., who sustained a subcortical lesion that extended posteriorly to the supramarginal and angular gyri, signed fluently in long, complex sentences, but with numerous inappropriate, even neologistic, jargonlike signs, much lexical and morphological substitution, and erroneous elaboration of sign/inflection combinations. The distinction between frontal "agrammatism" and posterior "paragrammatism" seems to hold good in both signed and spoken languages. Likewise, relatively pure disorders of lexical retrieval are found in both modalities. Karen L., with an infarct centered in the left parietal region, continued to produce a wide range of correct grammatical forms in ASL, but individual lexical items were often semantically underspecified or exhibited sublexical errors analogous to the phonological paraphasias of spoken language impairment.

Although it is far too early for us to have any precise ideas about the extent of neuronal overlap between the physical substrate for

spoken and signed language, these findings do indicate broadly congruent cortical and subcortical areas committed to different aspects of modality-neutral language processing. Further advances will depend on the development of information-processing accounts of language disorder that go beyond the nineteenth-century clinical taxonomy of aphasic disorder (Marshall 1986a) and on more fine-grained architectonic analyses of language-committed cells and pathways (Galaburda 1984). Current in vivo imaging techniques show considerable biological variability in the neuronal representation of spoken languages and many counterexamples to the traditional syndrome/lesion correlations (Basso et al. 1985). Whether this variability is any greater in signed than in spoken languages and whether the new scanning technologies will resolve or further complicate the problems of functional localization are critical topics for the future.

And there are yet other classical controversies that the work of Poizner, Klima, and Bellugi enables us to reopen in new form. For example: In an early attack on the adequacy of the Wernicke-Lichtheim taxonomy of the aphasias, Pierre Marie (1906) suggested that the nonfluent (Broca's) aphasias were merely fluent (Wernicke's) aphasias aggravated by dysarthria. The hypothesis has not fared too well, although it still has its supporters. Studies of the sign aphasias allow us to rephrase the issue in terms of the question, Can nonfluent signing impairment be regarded as Wernicke's aphasia plus dyspraxia? And, more generally, What is the relationship between praxic impairment and linguistic impairment? Although the higher-level (ideational and ideomotor) apraxias are preferentially associated with left-hemisphere damage, current studies show that apraxias and (spoken language) aphasias can be doubly dissociated (Selnes et al. 1982; Basso and Capitani 1985). The results of Poizner, Klima, and Bellugi support this position in a strong form; aphasia and apraxia can dissociate even when both language and skilled action are overtly expressed by motor performance of the upper limbs. Modularity with a vengeance! The conclusion is further reinforced by the dissociations seen after right-hemisphere damage; here also a dramatic impairment in the cognition of spatial topography (objects in extrapersonal space) can coexist with a relatively intact execution of spatially encoded syntactic structures. Once again, the innate specialization of the right hemisphere for manipulating spatial relationships is constrained by the cognitive domain within which particular places, spaces, and movements fall (Bisiach et al. 1981). Space in the service of language falls within the competence of the left hemisphere.

These, then, are just a few of the intellectual treasures revealed in *What the Hands Reveal about the Brain.*

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