Chapter 8
Spatialized Syntax, Spatial Mapping, and Modality

The reports of our intensive analysis of the six deaf, brain-damaged signers are part of a larger ongoing program of study in which we continue to test patients with unilateral brain damage. In this chapter we first provide converging evidence on nonlanguage spatial capacities from additional deaf signers with unilateral brain damage. We then examine syntactic capacity across left- and right-hemisphere-lesioned signers. Finally, we turn to a unique issue in sign language: comparison of two uses of space in ASL, one for syntax and the other for mapping.

As we have discussed, ASL incorporates both complex language structure and complex spatial relations, thereby exhibiting properties for which the hemispheres of hearing people have shown different predominant functioning. Space has more than just a syntactic function in ASL, however; it also functions in a topographic way in ASL. The space within which signs are articulated can be used to describe the layout of objects in space. In such a mapping spatial relations among signs correspond in a topographic manner to actual spatial relations among the objects described. In this concluding chapter we investigate in deaf signers the nature of cerebral specialization of the use of space for the representation of syntactic relations and that of spatial relations.

8.1 Nonlanguage Visuospatial Capacity

In trying to understand the language deficits of brain-lesioned signers, it is important to assess subjects' capacity for nonlanguage spatial cognition. The following discussion includes evidence from not only the six cases we have detailed but also our larger program of study investigating the effects of brain lesions on spatial cognition. Let us look first at the drawing performance of eight brain-lesioned signers on a simple but telling task, the copying of a complex three-dimensional model (figure 8.1). The figure shows eight drawings,

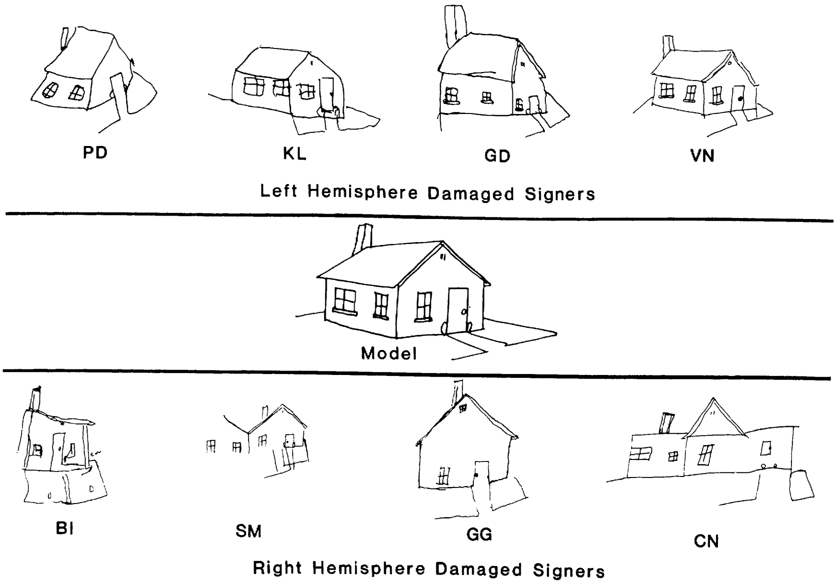


Figure 8.1
Drawings of a house from a model by four left- and four right-lesioned signers. Drawings of the right-lesioned signers show spatial disorganization, left hemispatial neglect, and lack of perspective. (PD, Paul D.; KL, Karen L.; GD, Gail D.; VN, Violet N.; BI, Brenda I.; SM, Sarah M.; GG, Gilbert G.; and CN, Christina N. in this and subsequent figures.)

four by signers with damage to the right hemisphere and four by those with damage to the left. The additional two subjects, one left-lesioned and the other right-lesioned, were selected according to the same criteria as the others—sign language environment, right-handedness, and unilateral brain lesion.

The drawings of the left-lesioned signers (Paul D., Karen L., Gail D., and Violet N.) are recognizable copies, with overall spatial contours and maintenance of perspective. In contrast, the signers with right-hemisphere damage exhibit severe spatial disorganization, left hemispatial neglect, and marked lack of perspective. Severe spatial disorganization is shown, for example, in Christina N.'s house, which has the chimney attached to a dislocated upper wall and the door floating in the middle of the wall. Brenda I.'s house is a distorted rendition of a series of rectangles. The clear left hemispatial neglect can be seen in Sarah M.'s failure to complete lines on the left-hand side of the house; in fact, she failed to indicate most aspects of the left-hand portions of the model. In Gilbert G.'s drawing the left-hand side of the model (wall and roof) are omitted, except for the chimney. Finally, none of the right-lesioned signers is able to indicate perspective. Gilbert G. shows only the front surface of the house, without any indication of the sides or top of the model from which he was copying. (His drawing might be construed as a representation of the house under the condition of a rotation to a head-on view, but even with this interpretation the drawing completely lacks perspective.) Brenda I. shows a similar inability to represent the three-dimensional nature of the model. Christina N.'s drawing also shows profound loss of perspective; she draws the individual components of the house, including the front and side surfaces and roof, but lays them out linearly without any clue to their three-dimensional relationships.

Thus the spatial distortions, the evident left hemispatial neglect, and the lack of perspective in the drawings of the right-lesioned patients are immediately apparent and reflect their dysfunctioning right hemispheres. In contrast, the drawings of the left-lesioned signers, although simplified, have coherent spatial organization.

Figure 8.2 presents the performance of five brain-lesioned signers who took a test of perceptual closure, the Mooney faces test. Unfortunately, the other three patients were not available for this test. The results must be considered as merely suggestive. In this test subjects must discriminate photographs of human faces (top) from photographs of nonfaces (bottom); the photographs have highly exaggerated shadows and highlights. To identify the photographs accurately, the subject must achieve a configurational percept from fragmentary information, an ability that has been associated with intact right-hemisphere functioning (Newcombe and Russell 1969). Figure 8.2 shows that the three right-hemisphere-lesioned signers performed poorly in this task, none above 65 percent correct, and that the two left-hemisphere-lesioned signers were superior to them in performance.

A visuospatial task, the line orientation test, was discussed in chapter 7. In this task patients are asked to match the spatial orientation of partial lines to that of the full-length lines presented in an array (figure 8.3). This task, which taps the orientation aspects of spatial perception, is different from the Mooney faces task, which is more closely linked with figural aspects (shape and form). In this respect, right-lesioned patient Brenda I. shows an interesting contrast. Although she appears able to perceive figural aspects better than the other two right-lesioned patients (as shown by her performance on the Mooney faces test), her ability to perceive orientation aspects (as shown by her performance on the line orientation test) is the most severely impaired and, in fact, grossly impoverished if not nearly nonexistent. With the converging evidence from eight patients on this test, four with left-hemisphere lesions and four with right-

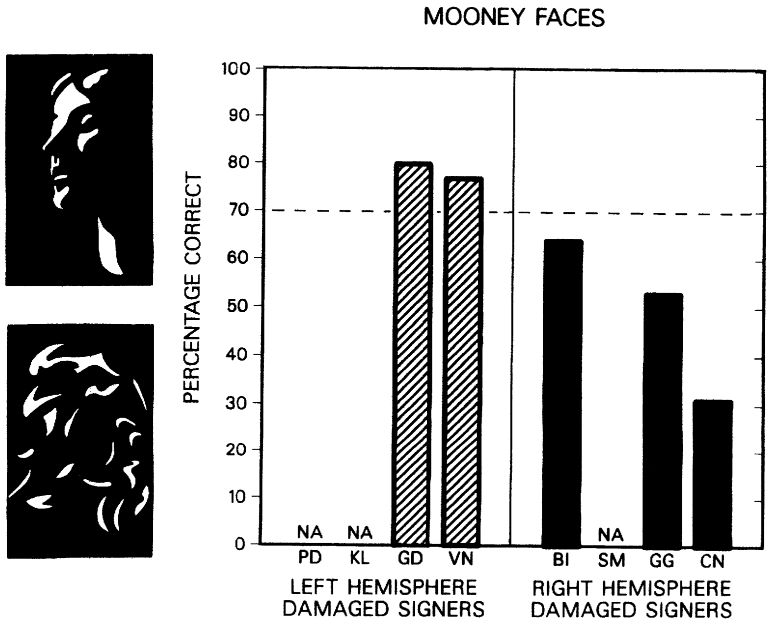


Figure 8.2
Performance on a test of perceptual closure, the Mooney faces test, by left- and right-lesioned signers. Subjects must discriminate photographs of faces from nonfaces, given fragmentary information. Note impairment in right-lesioned signers.

hemisphere lesions, the pattern of relative impairment in deaf signers is now becoming clear, as shown in figure 8.3. In general, left-lesioned signing patients are not impaired, whereas right-lesioned signing patients are severely defective. Scores on the orientation task that are below the dashed line in figure 8.3 are scores exceeded by 98.5 percent of normal hearing controls, after corrections for age and sex to accommodate for the possibility of undiagnosed defects among the population used as controls (Benton et al. 1983).

The data presented here and in chapter 7 demonstrate marked differences in spatial capacity following lesions to the right or the left hemisphere in deaf signers; it seems clear that right-hemisphere lesions (but not left-hemisphere lesions) lead to pronounced spatial disruption. These results are brought out even more strongly by the results of additional tests to more right- and left-brain-lesioned signers. These nonlanguage data show that the right hemisphere in deaf signers develops cerebral specialization for nonlanguage visuospatial functions. A stark contrast helps make the point: Gail D., the left-hemisphere-damaged patient whose language functioning is the

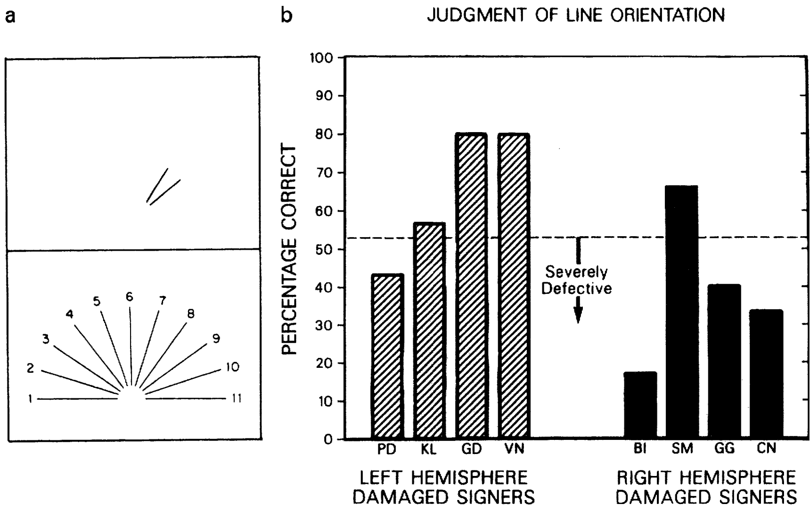


Figure 8.3
Performance on a spatial task, Judgment of Line Orientation, by four left- and four right-lesioned signers. (a) Sample test item. Note depressed performance of most right-lesioned signers (b).

most severely impaired of our subjects, shows highly accurate performance on every one of the visuospatial tests given. These data already strongly suggest that the two cerebral hemispheres in deaf people can show a principled separation between language and nonlanguage functioning, even when both involve visuospatial processing.

8.2 Specialization for Spatial Language Functions

The three left-hemisphere-damaged patients discussed in the preceding chapters are clearly aphasic for sign language; yet their linguistic disorders are different. Their impairments show different patterns, involving disabilities at different structural layers of the language. One left-hemisphere-lesioned patient (Gail D.) is grossly impaired. In sharp contrast to her prestroke signing, her poststroke signing is dysfluent and limited to single sign utterances. Her output is effortful, and she often gropes for the sign. Her difficulties are clearly not due to peripheral motor problems, because she produces the same signs normally in some contexts. There is no trace of the grammatical apparatus of ASL in her signing; signs are made singly and in uninflected form, with selection almost exclusively from referential open-class signs. She produces primarily nouns and some verbs, but with no grammatical inflection, no grammatical use of space, hardly any closed-class items, and none of the spatial apparatus that links signs in sentences. Her language profile is identical with that of markedly impaired hearing Broca's aphasics.

Another left-hemisphere-lesioned patient (Karen L.) has motorically fluent signing and communicates well and freely. She can carry on a conversation with normal rate and flow and can exhibit a full range of grammatical structure. Her deficits in expression are confined primarily to impairment at the *sublexical* level, involving Handshape, Movement, and Place of Articulation substitutions (the equivalent of phonemic errors in spoken language). She shows no tendency to make semantic or grammatical errors in her conversation; indeed, she has relatively preserved grammar (but impaired comprehension). In many ways her signing appears to be the least impaired of the left-hemisphere-lesioned patients; however, she frequently fails to specify the referents of her freely and correctly used indexical pronouns and indexed verbs.

The third left-hemisphere-lesioned signer, Paul D., also retained his motoric fluency after his stroke. He carries on conversations smoothly and with nearly normal rate and flow and does not appear frustrated, although he has occasional sign-finding difficulties. The content of the conversation, however, is revealing. His expressive language deficit is shown primarily in an abundance of paragrammatisms, including semantically bizarre constructions and neologisms. Furthermore, he has a tendency to use morphologically complex forms where simple ones would be appropriate, adding an inflection for temporal aspect or a derivationally complex form. And yet, at the same time, he fails to use the spatialized syntax of ASL (pronominal index and verb agreement markers). His signing is marked by an overabundance of nominals, few pronominal indexes, and failure to mark verb agreement correctly or at all. This appears to be an impairment of spatially organized syntax and discourse.

Thus two left-hemisphere-lesioned patients have primary impairment at the *grammatical* level, the one agrammatic and the other *paragrammatic*. Figure 8.4 shows errors characteristic of each of the three left-hemisphere-damaged patients: articulatory difficulties for the Broca-like patient, Gail D. (figure 8.4a shows articulatory difficulties in making the sign GIRL), errors at the sublexical level for Karen L. (figure 8.4b shows a Handshape substitution and a Movement substitution), and paragrammatisms for Paul D. (figure 8.4c shows the use of a morphologically complex form where a simple one would have been appropriate and the substitution of one morphological form for another).

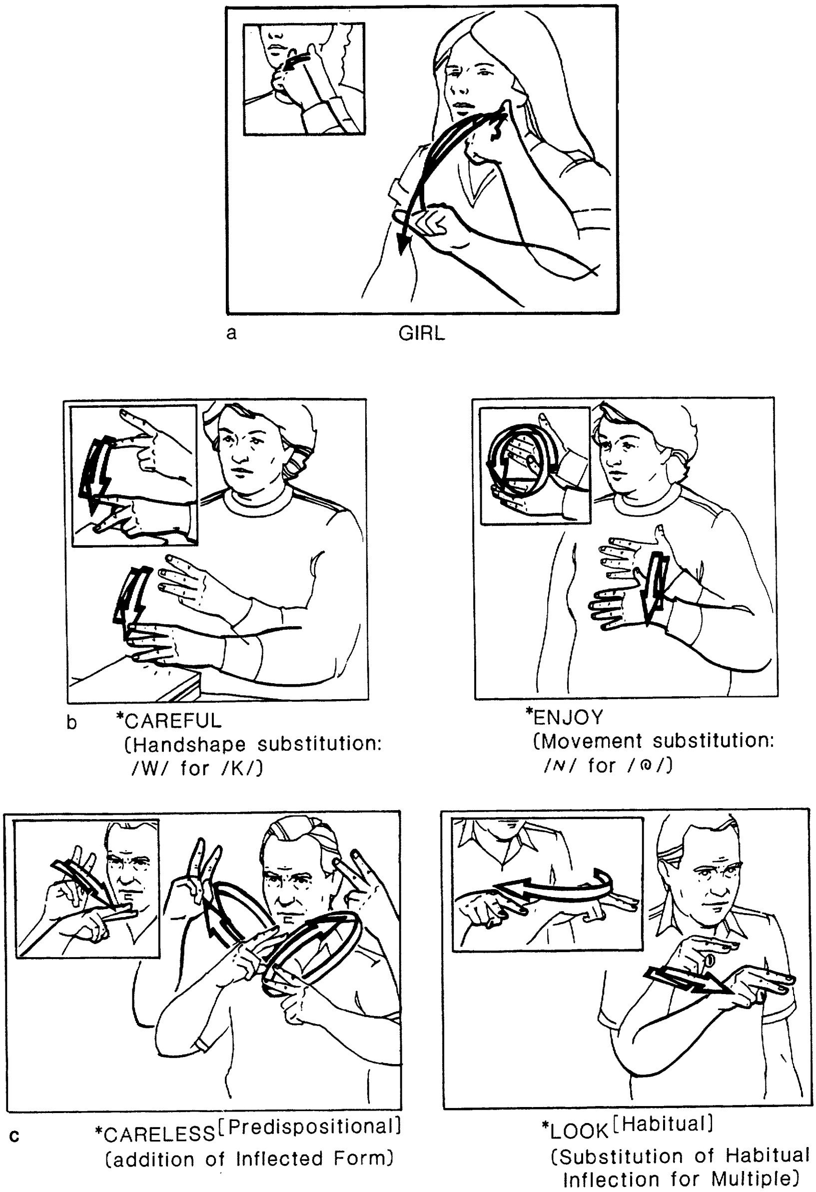


Figure 8.4
Typical errors of left-hemisphere-damaged signers. Correct signs are shown in insets. Note different levels of linguistic deficit across left-lesioned signers. (a) Articulatory difficulty typical of Gail D. (b) Sublexical substitutions of Karen L. (c) Paragrammatisms of Paul D.

In direct contrast, the signers with damage to the right hemisphere are not aphasic for sign language; they exhibit fluent, error-free signing, a good range of grammatical forms, and no signing deficits. Whereas the left-hemisphere-lesioned patients are generally impaired in our tests of ASL structure at different linguistic levels, those with right-hemisphere damage are not. We have focused in this book on the grammatical capacity of these brain-damaged signers because of the central role grammar plays in the human capacity for language. Such an analysis has not been possible in previous studies of deaf signers because the grammatical structure of sign language has only recently been understood. Our results demonstrate that a visuospatial language breaks down as a result of left-hemisphere lesions in deaf signers and that sign language can break down at different structural levels. Our results also demonstrate that signers with lesions in the right hemisphere are, on the whole, not impaired linguistically. To highlight these differing language capacities, we now turn to a linguistic analysis of spatial syntax of left- and right-lesioned signers.

8.3 *Syntactic Capacity across Left- and Right-lesioned Signers*

The most important feature of sign language for revealing the organization of the brain for sign language is the unique role that space plays. Spatial contrast and spatial manipulation figure structurally at all linguistic levels in sign. The spatially realized framework for the syntax and discourse of ASL therefore provides a testing ground for our explanation of the specialization of the two hemispheres.

In ASL the distinction between nouns and pronouns is one between certain content signs and certain function signs. (See our discussion of this measure in chapter 3.) Figure 8.5 shows the ratio of nouns to pronouns for three elderly control signers, for our three signers with left-hemisphere damage, and for our three signers with right-hemisphere damage. These measures are taken from 10-minute samples of free conversation and expository signing from each person.

One might well expect damage to the right hemisphere to impair the spatially realized grammar of sign, but it does not. Remarkably, the three patients with right-hemisphere damage (Brenda I., Sarah M., and Gilbert G.) fall within the range of the controls; they have the normal noun/pronoun ratio of about 2 to 1. In contrast, the three patients with left-hemisphere damage deviate dramatically from this pattern. Gail D., the Broca-like patient, has almost ten times as many nouns as pronouns; this ratio is not surprising in light of her extreme

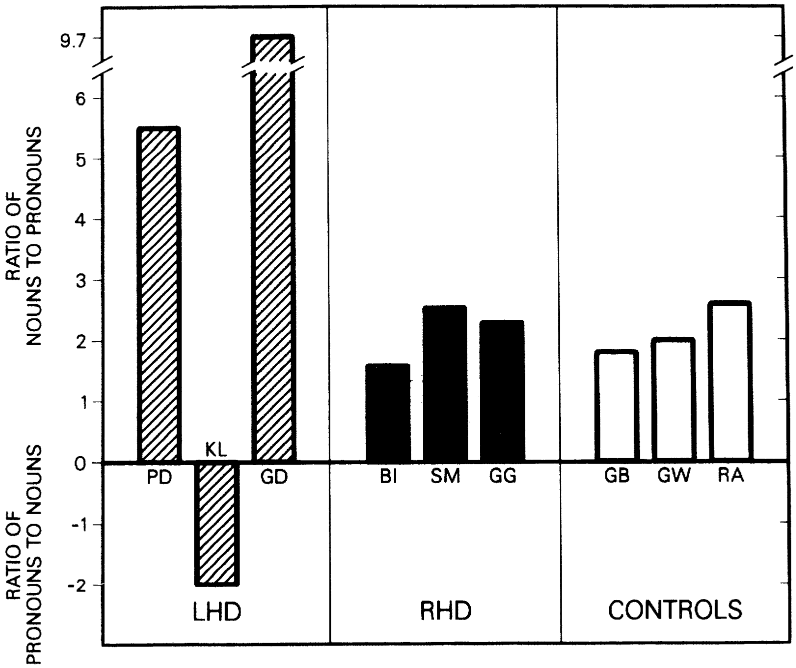


Figure 8.5
Spatialized syntax: ratio of nouns to pronouns in signing. Recall that pronouns in ASL are spatially realized indexes. Ratios greater than zero indicate greater use of nouns than pronouns, whereas ratios less than zero indicate greater use of pronouns than nouns. Note that right-lesioned signers are indistinguishable from controls, whereas all left-lesioned signers are deviant.

dysfluency and almost exclusive use of referential open-class nouns. Far more surprising is the contrast between the two fluent signers with left-hemisphere damage, Paul D. and Karen L. Although both remained fluent, even garrulous, conversationalists after their strokes, they are not only strikingly deviant from the normal pattern but also dramatically different from each other. Karen L. uses only half as many nouns as pronouns, a highly unusual pattern. Her tendency to make free use of pronominal indexes without specifying the associated nominals makes her signing seem vague; this vagueness is associated with the low information content of her signing. Paul D.'s pattern is the reverse of Karen L.'s, with more than five times as many nouns as pronouns, but, unlike Gail D., his fluent signing exploits the full range of grammatical categories. His overuse of nouns indeed appears to be a means to avoid using pronouns, which are spatially realized in ASL. All three patients with left-hemisphere damage show deviant patterns in this respect, whereas none of the patients with right-hemisphere damage is at all deviant.

In ASL the pronominal indexes are just one element of the framework on which spatialized syntax is realized. Another essential element is the system of verb agreement—the network of grammatical relations specifying the movements of verbs between spatial points. We examined every mutable verb in the same 10-minute videotaped samples of discourse for each patient and control subject. Each verb was analyzed to determine whether it had been indexed with respect to space and if such indexing was necessary. Then we computed the percentage of errors, whether failures of omission (verbs without an index in a linguistic context that required it) or errors of commission (verbs indexed incorrectly). The verb agreement errors for patients with left-hemisphere damage and for those with right-hemisphere damage are shown in figure 8.6.

The massive left hemispatial neglect and severe overall distortions shown by the signers with right-hemisphere lesions might lead one to expect that their signing would be noticeably affected, especially because syntax in ASL is highly dependent on spatial relations. Therefore we examined their signing closely to observe its spatialized syntax and discourse (the various reflections of pronouns, indexed verbs, and their spatial arrangements). First, because both Sarah M. and Brenda I. have immobile left arms and consequently right-

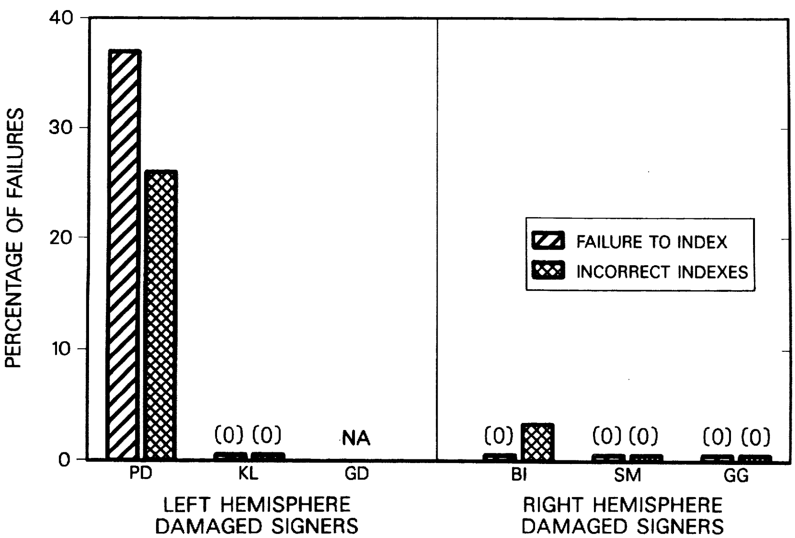


Figure 8.6
Spatialized syntax: errors in verb agreement.

handed signing and because both women exhibit neglect of left hemispace, one might expect that each would produce signs only in the right half of signing space. This was not the case, however. Brenda I.'s signs extended beyond the right-hand side of the signing space, as she often set up indexes on the left and, furthermore, maintained them consistently where required throughout a stretch of signing. In one sample she indexed half of the twenty-four pronouns and thirty-four verbs on her left. Not only did she index on her left-hand side as well as on her right, she also had a noun/pronoun ratio in the normal range (1.58). Thus, despite her severe visuospatial disorganization, Brenda I. made correct use of the system of verb agreement in ASL, a system central to the spatially organized syntax of ASL. We found no instances of verbs that should have been indexed but were not. Brenda I. did index a large number of verbs correctly. The lone error in verb agreement was the form $\text{SEE}_{\text{a(to left)}}$ (this sign was indexed on her left even though no indexing was appropriate for the context). In addition to making correct use of verb agreement, Brenda I. maintained the same locus point for coreference across a stretch of discourse.

The signing of right-lesioned Sarah M. was virtually impeccable. Her sentences were grammatical, and her signs were without error (except for occasional errors in fingerspelling and in hand orientation while signing numbers). Her noun/pronoun ratio was in the normal range (2.54). In the 10-minute sample of free conversation, she used many verbs that could be indexed, with no errors of omission or commission. In light of her severe visuospatial deficit for nonlanguage tasks, Sarah M.'s correct use of spatial mechanisms for sign syntax highlights the abstract nature of these mechanisms in ASL.

The signing of right-lesioned Gilbert G. was also completely correct, without error in aspects of spatialized syntax. In his signing there were fifty-two verbs that could be indexed, all of which were correctly handled. Thus his signing is entirely error free, and his use of spatialized syntax is perfect.

The patients with left-hemisphere damage use spatialized syntax differently from the patients with right-hemisphere damage. Beginning with the left-hemisphere-damaged patient Gail D., we noted that she produced few verbs and no indexes of verb agreement. Her utterances were mostly single signs, too sparse to allow scoring of this grammatical feature of ASL. The left-hemisphere-damaged patient Karen L. had a perfect score on both aspects of verb agreement, and her frequent use of verb indexing was uniformly grammatical. With left-lesioned Paul D., however, we see failure to index nearly 40 percent of the verbs that require indexing; in addition, when he did index a verb, he tended to do so incorrectly for the context (see figure 8.6). This omission of syntactically based verb agreement is quite unlike his overelaboration and augmentation of other aspects of his ASL morphology (such as inflections for temporal aspect and derivationally related forms). His omissions and simplifications were primarily restricted to inflections specifying the arguments of the verb (subject and object relations), that is, to syntactically based morphology.

Thus the left-hemisphere-damaged patients were all deviant on our measures of spatially organized syntax, although the deviations differed from one patient to another. In these spatial underpinnings of sentences and discourse in ASL, however, the right-hemisphere-lesioned patients, despite their severe visuospatial deficits, showed no impairment.[1]

8.4 *Dissociation of Language and Nonlanguage Visuospatial Functions*

We have found two double dissociations of function among left-lesioned and right-lesioned signers. These are particularly telling with regard to how sign language and nonlanguage visuospatial functions are represented and interact in the brains of deaf signers. Thus these findings have important implications for an understanding of cerebral specialization in humans. In double dissociations one component function is intact and another impaired in one individual, and in another person the pattern is reversed. The first double dissociation we found is at the level of brain mechanisms for language and nonlanguage functions. Left-lesioned Gail D. and right-lesioned Sarah M. present a remarkable set of dissociations of function.

All six of our patients before their strokes were skilled signers who had used ASL as their primary mode of communication throughout their lives. Although the left-lesioned patients are able to process visuospatial relations well and although the right-lesioned patients are extremely impaired, the language behavior of these patients, as we have shown, is quite the opposite. All three left-hemisphere-damaged patients are clearly aphasic for sign language. The most severely aphasic patient is Gail D., who suffered massive damage to

1. We have recently obtained some remarkable converging evidence from the study of a hearing signer who underwent chemical anesthesia of her left hemisphere and subsequently had portions of her right hemisphere surgically removed. This patient was globally aphasic for both sign and speech following anesthetization of her left hemisphere and was aphasic for neither following removal of portions of her right temporal lobe (Damasio et al. 1986).

the left frontal lobe. It is important to note that her capacity for nonlanguage visuospatial processing is the most intact of any of the six patients. She had excellent performance on the WAIS-R Block Design test, in drawing, and in copying the Rey-Osterreith complex figure, and she scored in the normal range on tests of facial recognition and line orientation. Gail D.'s case is striking because it shows the separation that can occur in brain organization for linguistic and for visuospatial capacity, even for a visuospatial language.

The case of Sarah M., one of the right-hemisphere-lesioned patients, is in marked contrast. Sarah M. suffered massive damage to the right hemisphere, involving most of the territory of the right middle cerebral artery. Her case is a dramatic one, because she had been an accomplished artist before her stroke, with superior nonlanguage visuospatial capacities. After her stroke Sarah M.'s visuospatial nonlanguage functioning showed profound impairment. Her drawings were spatially disorganized, and they showed massive left hemispatial neglect. Her performance on the block design test was extremely impoverished. Her few eforts to resume her artwork after her stroke reflect this profound effect of right-hemisphere damage. Her spatial disorder also affects other aspects of her communication in sign language; Sarah M. no longer looks directly at her addressee but receives signing with an averted gaze. These profound deficits might lead one to expect an equally profound effect on Sarah M.'s signing and on her comprehension of a visuospatial language. Thus it was astonishing to us to find that Sarah M.'s signing is flawless, without a trace of impairment, and furthermore that her comprehension of sign and her performance on tests for processing the structural levels of ASL is good.

These two cases—one with massive damage to the left hemisphere and the other with massive damage to the right hemisphere—bring into focus the central questions addressed in this book, namely, the nature of the principles underlying the specialization of the cerebral hemispheres. The left-hemisphere-lesioned patient Gail D. is the most severely aphasic, with extremely impoverished sign language functions; yet she is normal in other visuospatial capacities. Her pattern of abilities shows that left-hemisphere specialization is also operative for language in a visuospatial mode. The right-hemisphere-lesioned patient Sarah M. shows extreme impairment of nonlanguage visuospatial functions, and yet her signing (including spatially expressed syntax) is completely unimpaired. This pattern shows how little of an effect right-hemisphere damage can have on language function, even though the language is expressed in a visuospatial mode. It seems clear that the differing functions of the two cerebral hemispheres emerge for spatial cognition and for language, even for deaf signers whose language is visuospatial. We now turn to the second dissociation of function between left- and right-lesioned signers, one that occurred between two aspects of sign language that depend on the use of space.

8.5 Spatialized Syntax versus Spatial Mapping

In the last part of our battery of tests for language, we asked patients to give a sign language description of their living quarters. Such verbal descriptions in spoken language have been studied from a number of viewpoints (for example, Jarvella and Klein (1982)). In ASL such descriptions are of particular interest. They involve the use of a variety of special signs (called classifiers, or size-and-shape specifiers, and verbs of motion or location). In signed descriptions of spatial arrangements space is used to represent space, and, unlike the use of space in syntax, actual spatial relations among points are significant. Figure 8.7 shows such a simple spatial description of the arrangement of three pieces of furniture in a room. The signer indicates the furniture (chair, TV, table) using lexical nouns and shows their spatial location with respect to one another using classifier signs to indicate the size, shape, and relative locations of the referents. Such spatial descriptions involve spatial mapping. In these descriptions the spatial relations among the locations established by the classifier signs (for example, for chair, TV, and table) represent topologically the spatial relationships among the actual items.

We first saw this mapping aspect of signing in its full form when a visiting deaf friend was telling us about his recent move to new quarters. For five minutes or so, he described the garden cottage in which he now lived—rooms, layout, furniture, windows, landscaping, and so forth. He described it in exquisite detail, with such explicit signing that we felt he had sculpted the entire cottage, garden, hills, trees, and all in front of us. Since then we have systematically studied layout descriptions in ASL (Corina 1984). In ASL such descriptions of spatial array and layout use the same horizontal plane of signing space as do ASL nominal and pronominal reference and ASL verb agreement devices. But in spatial description the relations among spatial loci become significant because they represent actual spatial relations topologically. This significance of relations among loci for mapping stands in contrast to the arbitrary, abstract nature of loci established for the syntax and discourse of ASL. This duality of func-

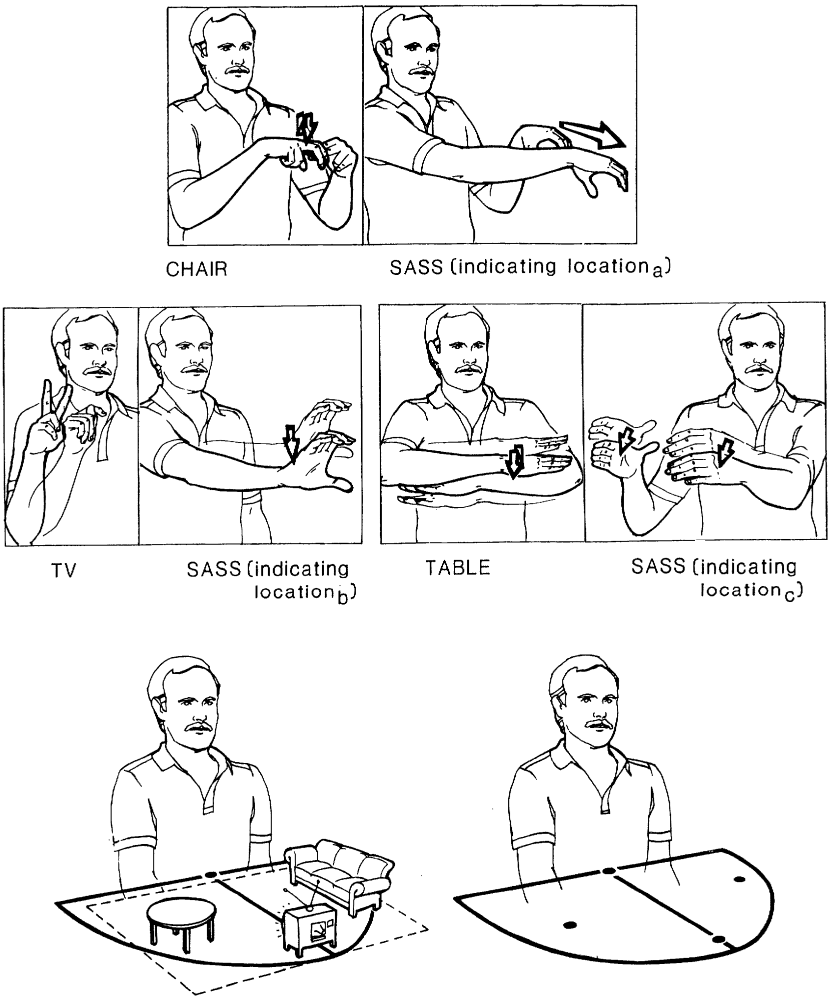


Figure 8.7
Spatial description in ASL showing topological relations established for signed description. Instead of illustrating the signs used, we have substituted objects in appropriate locations for the description. We use the abbreviation SASS for classifiers called size and shape specifiers.

tion of spatial loci in a plane of signing space permits a unique investigation of brain organization for differing linguistic uses of space.

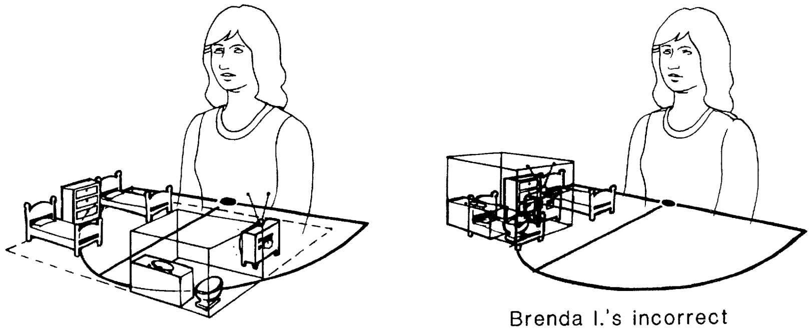
We asked four deaf patients—two with left-hemisphere lesions (Paul D. and Karen L.) and two with right-hemisphere lesions (Sarah M. and Brenda I.)—to describe their living quarters from memory. We asked them to specify both the items in the room and their arrangement within the spatial layout. In this task signing space is used to describe space, and actual spatial relationships are thus significant. The patients' spatial impairments varied according to whether the points in space were used for syntactic function or for giving relative position in space. As we will show, we found a striking double dissociation among the patients, even within the signing itself.

Right-lesioned Sarah M. was asked to draw her bedroom from memory and also to describe it in sign. In both her description and her drawing she indicated all the major items of furniture in the room correctly, and she specified correctly the locations of all but one item. Her description and her drawing matched. Both contained the major pieces of furniture arranged correctly throughout, except for the leftmost wall, which was left blank. A large white dresser, which is actually located on the left wall (from the point of view of the entrance, which Sarah M. was using for reference), was displaced to the far wall, more toward the right. Furthermore, there is a hallway to the left of the bedroom, which Sarah M. displaced in her signed description from the left to the lower right. Thus it appears that Sarah M.'s drawing and description show the effects of her left hemispatial neglect. The items are appropriately named but displaced in topographic relationship.

Right-lesioned Brenda I. also described her room in sign but with far greater spatial distortion. Again, the major pieces of furniture were correctly enumerated, but their spatial locations were greatly distorted: The entire left-hand side of the room was left bare, and the furniture was piled in helter-skelter fashion on the right. Even a bathroom that is actually to the left of the entrance was displaced to the right (figure 8.8).

In contrast, when left-lesioned Paul D. described his apartment, he showed omission of spatial detail (walls were not always indicated, for example), and his signing was linguistically bizarre—replete with grammatical paraphasias; however, there was no evident spatial distortion. Thus Paul D. tends to omit detail and to simplify in his description.

Karen L.'s description of her bedroom is indicative of the way left-lesioned signers can correctly use spatial mapping mechanisms in ASL despite their linguistic impairments. We first asked Karen L. to



Correct Spatial Layout

Brenda I.'s incorrect Signed Spatial Layout

Figure 8.8
Brenda I.'s incorrect signed spatial mapping of her room. Instead of illustrating the signs used, we have substituted objects in the appropriate locations for the description. Notice the severe distortion in Brenda I.'s use of signing space, including neglect of the left side and incorrect arrangement.

describe her bedroom and the arrangement of furniture in it, without having seen the room ourselves. From her description we could not reconstruct the arrangement of the items in her room, and the examiner stopped her many times to ask for clarification ("You mean the closet is here?"). Then we asked her to draw the layout of furniture in the room, giving her a frame on a piece of paper and having her first indicate the location of the door. Her drawing was clear and, in fact, matched in every detail the correct spatial arrangement of furniture, windows, closets, etc. in her room, as we later ascertained. An analysis of the videotape of the signed interview afterward revealed the problem in her signed description. Karen L. used classifiers and size-and-shape specifiers in a generally appropriate way (but with a sub-lexical error or two), and she correctly indicated their spatial locus with respect to one another in the signing space she had designated. What made her communication unclear was her failure to specify the nominals, that is, her failure to enumerate the referents of the classifiers. In fact, in ASL the classifiers and their use with verbs of motion and location require the prior specification of the nominal referents; this is what Karen L.'s spatially correct description failed to communicate clearly. Karen L. correctly indicated the spatial placement and orientation of the classifier but often failed to specify its nominal referent. Thus her description in ASL was spatially correct and was appropriate in terms of spatial mapping but showed the same kind of linguistic deficit that characterized her signing, failure to specify nominals and some sublexical errors.

It appears that the spatial descriptions of the left- and right-

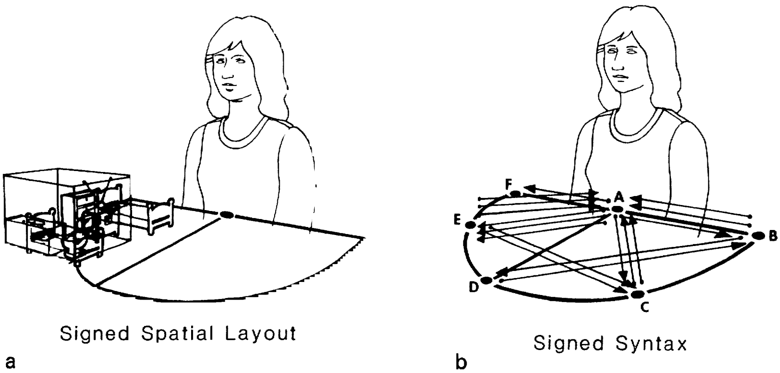


Figure 8.9
Brenda I.'s spatial mapping versus spatialized syntax. (a) Schematized representation of Brenda I.'s signed room description. (b) Schematized representation of Brenda. I.'s spatialized syntax, showing correct nominal establishment and verb agreement. Notice the dramatic difference between spatial mapping (highly distorted) and spatialized syntax (virtually error free).

hemisphere-damaged signers are not unlike their nonlanguage visuospatial functions: Generally, left-lesioned Paul D. omits and simplifies, whereas the signers with right-hemisphere damage include many features but make errors of spatial organization.

When space is used in the language to represent syntactic relations, however, the pattern is reversed. Paul D. showed impaired spatialized syntax; he had a disproportionately high ratio of nouns to pronouns and tended to omit verb agreement. (Both pronouns and verb agreement involve spatial indexing.) Furthermore, when Paul D. did use spatial syntactic mechanisms, he sometimes failed to maintain the correct agreement. For all three right-hemisphere-lesioned signers, spatially organized syntax is correct and appropriate; indeed, all three even used the left-hand side of signing space in syntax. Figure 8.9 presents the contrast between spatial mapping and spatialized syntax in Brenda I.'s signing. For example, in her mapping everything is piled on the right in a disorganized fashion, whereas the left part of the spatial framework is unused. In her use of the spatial framework for syntax in ASL, she establishes spatial loci freely throughout the signing space (including on the left); furthermore, she even maintains consistent coreference to spatial loci.

There is evidence that left hemispatial neglect can affect both the internal representation of space and the exploration of space. In an intriguing report Bisiach and Luzzatti (1978) found neglect in descriptions from memory of familiar surroundings by hearing patients. Two patients with left hemispatial neglect were asked to name the buildings on the two long sides of the main square of Milan. The patients were asked to make the descriptions in two ways: as if they were facing the square and as if their backs were turned to it. In both descriptions the patients failed to recall buildings on the left-hand side, given the particular perspective taken. Thus the *same* buildings were omitted when they were on the left-hand side of the imagined square but were recalled when they were imagined on the right. Patients with hemispatial neglect, then, can show specific deficits in dealing with the mental representation of the left half of space, either in terms of mental scanning or in terms of the representation of space itself (see also Bisiach, Luzzatti, and Perani (1979) and DeRenzi (1982)).

The dissociation between mapping and syntax in sign language is all the more remarkable because both involve arm movements that cross the body's midline to the left-hand side of space. Nonetheless, we found left hemispatial neglect for mapping but not for syntax in signing. This dissociation strongly suggests that the internal representations for the two uses of space in signing—spatial mapping and spatialized syntax—are basically different. Clearly, the internal representation for mapping relies heavily on the inherent spatial relationships among objects described in the real world, whereas the internal representation for syntax is based on abstract linguistic syntactic properties, despite their realization in a spatial medium.

Thus within signing the use of space to represent *syntactic* relations and the use of space to represent *spatial* relations may be differentially affected by brain damage, with the syntactic relations disrupted by left-hemisphere damage and spatial relations disrupted by right-hemisphere damage.

Analysis of the patterns of breakdown of a visuospatial language in deaf signers allows new perspectives on the nature and determinants of cerebral specialization for language. First, these data show that hearing and speech are not necessary for the development of hemispheric specialization: Sound is *not* crucial. Second, the data show that in these deaf signers, it is the left hemisphere that is dominant for sign language. The patients with damage to the left hemisphere show marked sign language deficits but relatively intact capacity for processing nonlanguage visuospatial relations. The patients with damage to the right hemisphere show much the reverse pattern. Thus not only is there left-hemisphere specialization for language functioning but there is also a complementary right-hemisphere specialization for visuospatial functioning. The fact that much of the grammatical information is conveyed by means of spatial manipulation appears not to alter this complementary specialization. Furthermore, the fact that components of sign language (for example, lexicon and grammar) can be selectively impaired suggests that the functional organization of the brain for sign language may turn out to be *modular*. Finally, patients with left- and right-hemisphere damage show dissociations between two uses of space in ASL: the representation of spatial relations and the representation of syntactic relations. Right-hemisphere damage disrupts spatial relations but spares syntactic ones; left-hemisphere damage disrupts the use of space for syntactic relations but spares its use for spatial relations.

Taken together these data suggest that the left cerebral hemisphere in humans may have an innate predisposition for the central components of language, independent of language modality. Studies of the effects of brain damage on signing make it clear that accounts of hemispheric specialization are oversimplified if stated simply in terms of a dichotomy between language and visuospatial functioning. Such studies may also permit us to come closer to the real principles underlying the specializations of the two cerebral hemispheres, because in sign language there is interplay between visuospatial and linguistic relations within one and the same system.