Right Brain and Gesture

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Our work is concerned with the gestures that occur when people speak, and the possible role of cerebral laterality in coordinating gestures with speech. Gesture is not language, but is part of a system of speech and language. Unlike sign language, gesture has little syntax and no standards of well-formedness, and is not socially regulated; these are properties of the accompanying speech. Indeed, as noted elsewhere in this volume by Singleton, Goldin-Meadow, and McNeill, when gestures must bear the full burden of communication, qualitative changes take place that move the gestures in the direction of language (see also Bloom, 1979; Dufour, 1992). Gestures with speech are nonredundant co-expressive displays of meaning, and comprise symbols of a different type to speech altogether. Thus, to consider gestures together with speech, is to consider two types of symbol that occupy the same moment of expression. This kind of binocular vision leads to new insights into the nature of the language system itself—insights that may bear equally on spoken and signed languages.

Taking into account gestures, we discover that language (spoken or signed) is not just a linear progression of segments, words, and phrases, but is also imagistic, instantaneous, nonlinear, and holistic. The imagistic component co-exists with the linear-segmented linguistic component and the coordination of the two gives us fresh insights into the processes of language and thought.

We have been interested to delineate the cerebral substrate of language by studying language and gesture in patients with unilateral right or left...
brain damage. We argue that in the production of narrative discourse, there are contributions from both cerebral hemispheres, and therefore that an important aspect of the cerebral control of language is the combining of the inputs from the two sides of the brain. Gestures provide a unique source of information about cerebral functioning and the effects of brain damage: they let us escape the hall of mirrors in which language studies language, because gestures let us observe mental operations in a fresh way, without language providing all the information itself.

Classically, the left hemisphere has been regarded as dominant for language. It is held to be the analytic, rational, and linguistic side of the brain. The right hemisphere is thought to be specialized for holistic, emotional, and imagistic thinking—the “minor” hemisphere in relation to speech (Springer & Deutsch, 1981). We argue that the right hemisphere plays an important role in narrative discourse, and this role is more apparent when gesture is taken into consideration.

We have collected samples of gesticulations and speech in a quasi-experimental paradigm that constrains the content of discourse adequately to allow us to compare language and gestures across speakers. Speakers are shown a narrative stimulus—an animated Warner Brothers 1949 “Tweety and Sylvester” cartoon—and then immediately tell the story of the stimulus from memory to a listener as we videotape the performance. They are not aware that their gestures are of interest. The narration is transcribed and its linguistic and narrative structure analyzed, and independently we code and analyze the gesticulations.

We divide the gestures into four categories, as shown in Table 4.1: iconic, metaphoric, beat, and abstract pointing or deictic gestures. The four can be differentiated on a purely formal basis with excellent reliability (McNeill, 1992; McNeill & Levy, 1982; Pedelty, 1987). Moreover, we have found that the four types distribute differentially over narrative structure (Cassell & McNeill, 1991). The telling of a story entails two processes: One, clearly, is conveying the events of the story itself, usually in a linear sequence; the other is overtly or implicitly conveying the structure of the story, including references to the very act of communicating it. For normal speakers of spoken English (and other languages), these tasks are accomplished gesturally as well as verbally. Iconic gestures appear with references to the story events themselves. For example, Tweety and Sylvester looking at each other through binoculars is typical of the narrative content of an iconic. Metaphoric, beat and abstract deictic gestures appear with references to the story structure itself. For example, the introduction of characters or props, references to the next scene, and so forth, are the typical metaphorical content of utterances that appear with metaphorics, beats and abstract deictics. The different discourse associations of the gestures are important in the discussion that follows.

### Table 4.1

<table>
<thead>
<tr>
<th>Four Types of Gesture</th>
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<tr>
<td><strong>Iconics</strong> display, in their form and manner of execution, concrete aspects of the same scene that speech is also presenting. Iconics appear with narrative level references to the concrete events of the story.</td>
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<tr>
<td><strong>Metaphorics</strong> display, in their form and manner of execution, abstract concepts and relationships. Metaphorics appear with metanarrative level references to the structure of the story itself.</td>
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<tr>
<td><strong>Beats</strong> are timed to occur with thematic discontinuities in discourse and do not depict any imagery. Beats often appear with shifts between narrative levels.</td>
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<tr>
<td><strong>Deictics</strong> (abstract) point to a location in gesture space that stands for an abstract concept or relationship. Deictics also appear at the metanarrative level.</td>
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## THE IMPORTANCE OF SPACE

Just as in sign languages (Klima & Bellugi, 1979), speakers continuously set up spatial distinctions and relations by way of their gestures and use these spaces to structure the discourse. Although there is but one physical space, there are multiple semiotic spaces, and it is possible to look for specific effects of brain lesions on the patient’s use of the gesture space and the different semiotic values that space takes on. This statement holds equally for sign languages. In both systems, there is heavy reliance on space and there might be important parallels in how these two systems make use of space—a question for future research; here, we pursue the implications of brain injury for the spatial semiotics of hearing speakers.

To have some analysis of semiotic value, we can distinguish three spatial regimes that differ in their levels of abstractness, as shown in Table 4.2. In the concrete regime, space is topographically equivalent to the space of events in the cartoon world and is the space in which the observed actions are played out gesturally. In the referential regime, space is not the space of some concrete event, but a space with which referents are identified. A part of the gesture space can come to represent a particular character, idea, or event, to be returned to when that character or event is referred to after a lapse. In the structural regime, space is not a concrete event or a re-emergent character, but a space that represents the structure of the story itself, as a spatial object. For example, one of our normal speakers conceived of the plot of a full-length film narration as a dilemma, a contrast between the actual morals of characters and their apparent morals, and this opposition was diagrammed as a contrast between two regions of the gesture space (Tuite, 1993). All of these regimes are structures of space as a symbolic medium, but they differ in the abstractness of the meanings being represented—concrete events, characters and other referents from the narrative, the structure of the story itself.
Moreover, the three spatial regimes imply a hierarchy in which more abstract spaces are founded on earlier uses of more concrete spaces. In many cases, abstract spaces seem to emerge during the stream of discourse out of earlier concrete spaces. For example, the concrete action of a character is depicted in a certain space and this space becomes established as the locus of the character him/herself. From then on, gestures return to this space to represent the character even though the action is no longer represented. In this case, the referential regime is based on the concrete regime. The structural regime also can be founded on lower regimes, either concrete or referential. In one film narration, the speaker leapt from the concrete to the structural in a single bound. The first gesture was concrete and pointed at the locus of a character who was being depicted as leaving the scene; the gesture occurred while saying *you know Frank obviously mad walks off*. The next gesture pointed at the same location but the space was now structural and provided a locus in (abstract) space where the next scene began while saying *and then the next time we see anyone involved*. The gestures looked morphologically identical, but their semantic value was different with each occurrence (Cassell & McNeill, 1991).

Finally, we observe that the three spatial regimes can be integrated when multiple discourse levels are represented simultaneously. In a single utterance there can be a reference both to events in the story and to the contribution of the utterance to the overarching discourse structure—two regimes in one utterance. Gestures and gesture spaces differentiate these regimes. For example, a story event can be depicted in an iconic gesture with an appropriate linguistic description. Simultaneously, this event can mark the boundary of a new scene and this discourse content can be realized in the form of a spatial contrast motivated, not by the event itself, but by the differentiation of the new scene from the preceding scene. One utterance and gesture thus mark two regimes at once.

**TABLE 4.2**

| Concrete space | Topographical space (Emmonroe, Corina, & Bellugi, this volume), where the gesture space maps onto physical space, either in the real world or the story world. An example is showing the path taken by a character by tracing a path in gesture space. Referential space, where the gesture space is separated into distinct spaces for different characters or other arguments and successive verbal references to the same entities are accompanied by gestures returning to the same spaces. Such spatially coded coreferential chains, although not mandatory, can ribbon their way through long passages of narrated text. Structural space, where a new gesture space or hand shape is used to mark thematic discontinuities. Conversely, continued use of old space is used to signal thematic cohesion (Levy & McNeill, 1992; McNeill & Levy, 1993). |

4. RIGHT BRAIN AND GESTURE

Cerebral damage can disrupt these processes of differentiation and integration across all levels of abstractness.

**GESTURES AND NARRATIVE IN RIGHT HEMISPHERE DAMAGED PATIENTS**

We turn now to the effects of right hemisphere damage on gesture and narrative. The right and left sides of the brain have long been known to subserve different cognitive functions. The right brain is important for affect and visuospatial cognition; the left, for production and comprehension of language. Injury to the left side of the brain thus produces aphasic syndromes with dramatic effects on speech and gesture. Gestures in the aphasias tend to break down in parallel with the breakdown of speech (McNeill, 1992; McNeill, Levy, & Pedelty, 1990; Pedelty, 1987). Broca's aphasics, with their halting, effortful and content-laden speech, have a high proportion of iconic or concrete gestures but few gestures that are sensitive to linkages across stretches of speech. Conversely, Wernicke's aphasics, with their fluent, effortless but notoriously empty speech, marred by paraphasic errors and frank jargon, have the opposite types of gestures—few concrete depictions but relatively many gestures that pick up cross-text connections (see Pedelty, 1987, for the gestures of Broca's and Wernicke's aphasics). What is not so apparent is that injury to the minor or right hemisphere also has important consequences for language, although they are more subtle. The effects of right hemisphere damage are seen on levels where the representations are more abstract, less immediately tied to the concrete present, and less purely linguistic. The patients, although they have no obvious deficits in understanding or producing linguistic forms, are impaired in their ability to organize linguistic narrations, to appreciate jokes, to understand metaphors, etc. (Gardner, Brownell, Wapner, & Michelow, 1983; Moscovitch, 1983; Rehak et al., 1992). Right hemisphere damaged patients also have the well-known nonlinguistic deficits in visuospatial cognition and affect, in particular an inability to appreciate complex spatial configurations, loss of topographic memory, and, more frequently than in left hemisphere damage, perceptual and motoric neglect of regions of space contralateral to the side of the injury (thus, neglect of the left side of perceptual and motor space in the right hemisphere damaged). Given the role played by spatial cognition in the storytelling of normal speakers, we expect that right hemisphere damaged patients will systematically fail to use space in some or all of the regimes described earlier, with resulting severe deficiencies in the quality of their narratives.

We have recently begun videotaping narrations of the cartoon stimulus by children and adults with right hemisphere damage (the children were
damaged at birth and are being studied longitudinally by S. Levine of the University of Chicago; the adults are recent stroke victims.

To have a basis for comparison, we first describe a normal speaker (Fig. 4.1) and then a right hemisphere damaged speaker (Fig. 4.2) describing the same scene. The scene is concrete in the extreme; it involves a character catapulting himself into the air by throwing a weight onto one end of a see-saw while standing on the opposite end. Depicting it therefore taps the most immediate and primitive abilities to apprehend spatial relations.

Where the normal narrator performs numerous gestures that use space cohesively to tie together the events of the episode (the hand rises up, grabs Tweety at the apex, plunges down, runs at the same level off to the right), the right hemisphere damaged narrator, a child of 12 years, with fewer gestures fails to build up any cohesive chain of gestures at all. The patient's gestures, taken individually, are semantically interpretable; collectively, however, they are not linked in space. The speaker instead reset her gestures after each segment: her hand returned to rest after depicting Sylvester's ascent (1) and again after grasping Tweety (2). The hand remained at rest while the descent is described (3), and because there was no gesture at this point, there is no opportunity to link the gesture at (2) describing Sylvester getting the bird, to the one at (4) describing the denouement, the weight landing on him. Where the normal narrator spatially tied together the different events of this episode, the right hemisphere damaged child failed to build up any cohesive chain of gestures at all. Thus the right hemisphere damaged speaker did not avail herself of a concrete spatial map of the kind with which the intact brain organizes stories.

Right hemisphere damaged patients also seem to lack access to the referential spatial regime, wherein different regions of the gesture space are used to depict different characters and objects. This may be because spatial distinctions were never set up in concrete space in the first place, and thus there is no foundation on which to build a more abstract referential space. Although one must be cautious in drawing conclusions from the absence of evidence, it is striking that we have seen no instances of consistent deictic coreferences in our right hemisphere damaged speakers. When they point,
they tend to make their points to the same locus for all references. This lack of meaningful variation differs strikingly from the space usage of normal speakers, where, for example, verbal coreferences are accompanied by gestures that remain in the same gesture space and shifts of reference by gestures that move into a different space (see McNeill & Levy, 1993, for examples from normal adult speakers).

The right hemisphere damaged patients thus fail to use space consistently in at least two of the spatial regimes that we described earlier—the concrete and the referential. The structural spatial regime also appears to be inaccessible to them. Again, this could be because right hemisphere damaged patients do not initially set up a consistent concrete space. Patients create narratives in which the visuospatial marking of scene boundaries is lacking or used inconsistently. Perhaps the absence of gestural markers reflects an impaired ability to represent the narrative as a visuo-spatial object, as a normal narrator seems to do. It is interesting to note that these patients fail to perform the task of structuring the narrative linguistically as well as gesturally: linguistic markers are used inconsistently, along with the inconsistent use of space. This implies a deeper and more extensive deficit in the right hemisphere damage syndrome than just an interruption of concrete spatial cognition. Consider the following examples from the same 12-year-old described in Fig. 4.2. Here, she is describing a transition from one scene to the next. She refers explicitly to the scene boundary, but then continues to use inexplicit pronouns to refer to the character. Normally, the character would be reintroduced by an explicit referring form at such a juncture (Levy & McNeill, 1992).

1. and then after that
2. he fell and then he's trying to get the cat again by um
3. going with wire but uh there was a train there and
4. he was getting shocked every few minutes and then the cat
5. says uh I thau- um the [bird says] thau- faw- a purs- p- cat

Shakes bead

Her style is contradictory: she identifies the scene boundary at (1), but her reference to the character at (2) implies not a boundary, but a continuation of the previous scene. The child made only one gesture (a head movement) with the repair of the referential error of calling the bird the cat, in (4–5); thus she provided no gestural marker of the scene transition itself. This lack of visuo-spatial support suggests that the child had not fully separated the old episode from the new episode, despite the formal reference to the new scene.

The lack of access to both the referential and structural regimes (because of overall spatial incoherence) means that right hemisphere damaged speakers, even when they create semantically appropriate gestures, cannot link them into an overall discourse structure. They seem to lack the visuo-spatial foundations for creating a coherent pattern of discourse content.

**LEFT-SIDE-NEGLIGENCE AND DISSOCIATIONS OF SPACE**

On the concrete level, we also find the phenomenon of left-side neglect, that is, the speaker ignoring events occurring on the side of perceptual and motor space contralateral to the damage (see Bischi & Luzatti, 1978; Morrow & Ratcliff, 1988). When we examined our two adult right hemisphere damaged patients, it was several months after their strokes and by then little evidence for left-side neglect remained in most concrete activities in their daily lives. However, they continued to neglect the left side of space in producing iconic gestures. The example in Fig. 4.3, illustrates an exclusive use of the right-side, of space for iconic gestures produced by an elderly right hemisphere damaged patient, as she described a scene in the cartoon where Tweety and Granny in a trolley chase Sylvester along overhead wires in what was in the cartoon a

![Image](image-url)

(1) wasn' he ran across
Right hand in B-shape moves up at right side, hand in front of face at eye level, palm toward center, holds this.
(2) [and he 'lectrocuted]
Right hand, in same shape and space, chops straight down to the front, holds this space.
(Experiment: uh-huh how did that happen?)
(3) well by [pullin' the]- the sound-the signal
Right hand, still in right space, changes to loose A-shape for gripping the bell cord, and pulls down. Goes to lep.
(Experiment: uh-huh and then? If you pull the signal, then what would happen?)
(4) n' the fell off

**FIG. 4.3.** A right hemisphere damaged adult performs concrete gestures almost exclusively on the right side of space. This seems to be left-side neglect in gestural form. The drawings illustrate (1), (2), and (3).
right-to-left path. Normal speakers consistently reflect this path by the full right-to-left use of the gesture space (McCullough, 1992).

A neglect of the left half of gestural space is strikingly consistent in the iconic gestures of our two right hemisphere damaged patients. It is seen mainly in concrete contexts, however, and disappears at more abstract levels. Patients on occasion made isolated abstract deictic gestures with the left hand in the left side of space, and made coordinated use of both hands in the full right-to-left array of gesture space when making other abstract gestures. Figure 4.4 shows the same elderly right hemisphere damaged patient performing a beat and a metaphoric gesture. These abstract gestures accompanied nonconcrete self-references—I don't like cartoons, I don't watch it—and were produced with the two hands in center space: a deployment in the left and right spaces not seen in the patient's iconic gestures.

A similar pattern of dissociation was found with right hemisphere damaged signers by Poizner, Klima, and Bellugi (1987; see also, Corina, Kritchevsky, & Bellugi, 1992). Signers with right hemisphere damage are able to identify linguistically codified signs presented in the left visual field, but neglect nonlinguistic objects in the same spatial field (Corina, Kritchevsky, & Bellugi, 1992). In descriptions of room layouts, signers with right hemisphere damage greatly distort the placement of objects, piling up furniture and even other rooms on the right side of space, and leaving the left side completely vacant. Yet the same signers can employ the full left-to-right space for the non-topographic mappings utilized for the spatial framework of ASL syntax (Poizner, Klima, & Bellugi, 1987). Unlike the dissociation discovered by Poizner et al. and Corina et al., our patient's dissociation is not according to whether the use of space is linguistic, symbolic, or motoric. It is, rather, a dissociation within symbolic space according to whether the use of space is abstract or concrete. These dimensions—abstract-concrete or linguistic-topographic—are of course related, and the same principles of dissociation might underlie both the dissociation seen with sign language and that with gesticulation. Apparently, when there is mapping onto concrete physical space, right hemisphere damaged patients lose the left side of it. However, when gestures are abstract and the gesture space does have a physical meaning, the left and right sides of space are both accessible.

To sum up, the narrations of right hemisphere damaged speakers are characterized by the following: well-constructed speech that is accompanied by minimal gestures (few iconics, mostly beats and deictics), and an inconsistent use of the gesture space for depicting events in the concrete world. Lack of coherent spatial uses in concrete contexts seems to prevent right hemisphere damaged speakers from forming more abstract spatial regimes. Their iconic gestures exhibit left-side neglect but other gestures—metaphorics, beats and deictics carrying pragmatic discourse content—provide conditions for joining the two sides of gesture space or actually performing left-sided gestures. However, a lack of spatial consistency cascades throughout the discourse, and right hemisphere damaged speakers cannot form integrated wholes in which different narrative levels are combined into an overall discourse structure.

EXPLAINING THE RIGHT HEMISPHERE SYNDROME

Generally speaking, the two hemispheres make complementary contributions to the forming of narrative discourse. Interfering with a hemisphere's normal contribution has a characteristic signature, an effect identifiable in the discourse itself. One hypothesis to explain this signature in the case of the right hemisphere is that, in addition to controlling visuo-spatial cognition and affect, the so-called nonlinguistic hemisphere may be a crucial partner in the construction of narrative discourse and the integration of verbal processes. Our focus in this chapter is on the right hemisphere and our list of left hemisphere contributions accordingly is brief. The left hemisphere's role is inferable from the aphasias, and the chief effects, as is well-known, are seen in the dramatic impairment of the internal structure of utterances: processes of speaking that include phonetic and phonological organization, word selection, and syntactic and semantic organization. From such deficits we
infer that the specific contribution of the left hemisphere is to construct the hierarchical structures that comprise the internal organization of sentences. Injury to the right hemisphere, in contrast, can be characterized as impairing external relationships. These are the numerous, often not explicit pragmatic references that link the ongoing utterance to the discourse structure and help to create this structure. Following right hemisphere damage, there is impairment in the processes of identifying and controlling new information, controlling cohesion and discontinuity, identifying and utilizing the major boundaries between scenes, and relating concrete events to the overarching narrative structure. In general, there is weakness in the holistic structures of discourse. Our hypothesis, then, is: the left hemisphere, despite its ability to manipulate linguistic structures, lacks the ability to create an overarching discourse structure in which relations of thematic cohesion and discontinuity are defined; the right hemisphere is the source of these relations and thus is a crucial partner to the purely linear constructions of the left hemisphere.

Normal narrative production thus appears to involve the cooperative interaction of the two hemispheres, each making its own specific contributions. The locus of the convergence may be the left hemisphere for purposes of output control, as we argue later. This convergence is interrupted when there are disruptions of visuo-spatial cognition. A right hemisphere damaged speaker can formulate utterances with abstract content (such as metapragmatic self-references) and perform matching gestures (such as beats and metaphorics), but not have the ability to redefine space on abstract levels, and thus loses the structuring foundation provided by the normal brain in the spatialization of discourse.

DISCONNECTION SYNDROMES

Yet another source of disruption of the cooperative interaction of the two hemispheres is through disconnections of the left and right cerebral hemispheres; this is the situation we examine next. The disconnection syndromes confirm our proposal that the right hemisphere is crucial to the construction of an overarching discourse structure. We describe here two syndromes that involve partial or total sectioning of the corpus callosum and observe a progression of disturbances: after partial sectioning, the patient manifests two redundant but otherwise normal gesture spaces; after full sectioning, there is a unitary gesture space with accompanying deficiencies of various kinds, both linguistic and gestural.

The Alien Hand

We have had the opportunity to observe the gestures of a patient who, following a ruptured aneurysm, sustained damage to the anterior corpus callosum. Both cerebral hemispheres are relatively intact and are able to intercommunicate in a normal way, except for the motor regions, which are cut off from each other. This produces a disorder known as the alien hand syndrome (Bogen, 1985; Feinberg, Schindler, Flanagan, & Haber, 1992), a curious loss of voluntary control of movement, especially in the minor hand: The right hand literally does not know what the left is doing. Because all parts of the brain except the anterior regions are in contact with one another, processes originating in the right hemisphere are accessible to the left hemisphere and vice versa. There can be gestures displaying the same meanings by both hands, therefore, but the hands perform them separately. The patient was taped in the context of a medical interview consisting of a neurological examination and a discussion of the conditions and consequences of her stroke.

Normally, the brain constructs a unitary gesture space for two-handed gestures in which the right and left hands are combined to present a single meaning and two-handed gestures are either (a) symmetrical mirror images or (b) asymmetrical coordinated images of relationships in which one hand is active and the other passive (not unlike ASL). Speakers particularly seem to adopt the asymmetrical two-handed form of gesture when they want to depict something inherently relational such as the positions of objects, phases of actions (actions referred to as accomplishments by Vendler, 1967), or the points of view of other persons. In these gestures, one hand depicts the referent and the other the "relatum" (also see McNeill & Levy, 1982, on two-handed gestures and End States). The crucial fact is that the two hands work in concert.

The alien hand patient, in contrast, seems not to use the hands in concert. Often the patient employed both hands simultaneously but never combined the hands to construct a single space. Neither hand ever moved across the midline or associated with the other to present a single, integrated image. Instead, we find gestures with the same meanings that are separately organized on the two sides of space. The patient's speech was quite fluent and coherent, her statements followed in logical order, and her gestures presented a consistent and appropriate imagery. However, she was never seen to combine gestures performed by the two hands into one space. She thus seems to have access to all structures, both linguistic and gestural, but doesn't integrate them into one spatial representation. The example in Fig. 4.5 illustrates this phenomenon as the patient describes her state of consciousness: she feels, she says, as though some part of her identity is missing. Although the patient's description is striking in itself, we are interested in her gestures. Each hand made its own gesture for the idea of a missing chunk; the gestures differed in their size, handshape, orientation and locus, and the two images were not coordinated. Each hand presents its own version of a chunk gone. We have the same idea twice. This is quite different from a normal speaker. We would expect a normal speaker to use one hand to depict the mind and the other
**Commissurotomy**

What sort of narration might be produced by a patent who has undergone commissurotomy, the complete surgical separation of the tracts connecting the left and right hemispheres of the brain? It is conceivable that each hemisphere might control its own domain of functions, but these functions would not be integrated—thus the speaker might produce spatial gestures with the left hand only, or frame the narrative with left-handed gestures, while the right hand performs beats to accompany the spoken narration.

We have obtained three narrations of the cartoon story by two split-brain patients, two collected about a year apart from a 35-year-old male known as LB, who underwent commissurotomy for intractable epilepsy as an adolescent, and one from NG, a woman of 57 years, who was commissurotomized at age 30. (These patients are described in detail in Levy, Trevarthen, & Sperry, 1972.) Our analysis suggests that, far from each hemisphere controlling its own functions, the left hemisphere may have controlled both speech and gesture, to the detriment of each channel of expression.

We find a limited ability to combine the abstract and the concrete. We also find a spatial dissociation, not unlike that displayed by right hemisphere damaged patients. The split-brain's nonrepresentational gestures are made with one or both hands (in mirror images), in the central part of gesture space, and are accompanied by fluent meta-level references to the discourse itself. Representational gestures, in contrast, are made only with the right hand, in the right space, and often present abnormalities of timing, direction, or stereotypy and may also be accompanied by abnormalities of speech (such as dysfluencies).

To illustrate the nonrepresentational/abstract/fluent pole, LB produced a story that reads at places like a metanarrative description of looking at the visual text of the cartoon, rather than the cartoon story itself; his narrative slighted the story text and highlighted the metanarrative text of himself receiving and recounting the story. Consider two contrasting versions of the scene from the cartoon where Sylvester swallows a bowling ball, one from a normal speaker, and the other from LB:

**A NORMAL SPEAKER** (the most laconic available)

**Tweety drops a bowling ball. The bowling ball falls into Sylvester's mouth. Sylvester falls back down the drainpipe.**

(no gestures)

**THE COMMISSUROTOMY PATIENT**

he had a bowling ball dropped on him along with other things

(Raises eyebrows, nods.)
We have picked as the normal speaker the most laconic narrator we have observed—even so, his description of this scene was more detailed than that of LB, incorporating explicit information about the interaction of characters and objects in the scene. Crucially, the order of description by the normal speaker was the same as the order of events in the cartoon. The split-brain narrator’s version reversed this order. This type of time-reversal implies a nonnarrative context. The gestures confirm the nonnarrative perspective: nonimagistic beats highlighting the discourse content (which was metanarrative, among other things, and background information, while he was coming up). The “narrative” was in fact a metanarrative.

In keeping with the principle of speech-gesture coexpression, his gestures function on the same metanarrative level as the spoken narration. Both gestures and speech slighted the story text and overemphasized the metanarrative text. Although a normal speaker’s narrative also makes extensive use of metanarrative perspectives, the metanarrative is always at the service of organizing and presenting the narrative content. It is conceivable that a metanarrative perspective without strong visuo-spatial content is the form in which the left hemisphere apprehends, stores, and reproduces visually presented narrations, such as cartoons. In this case, we should conclude that a metanarrative perspective in the left hemisphere can be adopted in the absence of visuo-spatial sources of cohesion from the right hemisphere; in other words, that a dissociation may exist between cohesion of discourse (dependent on right hemisphere input) and a thematically distant or metanarrative perspective toward it (possible with the left hemisphere alone). There is certainly no use by LB of the gesture channel to compensate for the lack of narrative content in the speech channel, confirming the connection of narrative content and visuo-spatial processes. LB made beats and other small movements of such generic form as to be impossible to relate to the narrative content. In terms of space, LB tended to cluster all his metanarrative gestures in the center, much like the beats of normal speakers. He could use either hand and use the two hands together in mirror image movements. However, he never used the two hands in a coordinated display in which each hand performed different movements or occupied different spatial positions while presenting organized components.

When LB performed iconic gestures with concrete descriptions, there would be breakdowns of synchrony that suggest that gesture was being cued by speech. The following example illustrates this type of breakdown:

_While he was coming up the drainpipe_
(Light hand fingers rise up then fall on left side.)

That is, LB said _puts a_, paused, then started a gesture for putting in the bowling ball. With normal speakers, a gesture that depicts putting in the bowling ball would coincide with or slightly anticipate the speech segment that it goes with, here the verb _puts_. However, with LB, the gesture _trailed_ the verb. This pattern suggests cuing of the gesture by the spoken word _puts_. Moreover, the pause between starting the gesture and starting the word _bowling_, suggests that speech also was tracking the gesture. Speech interrupted itself to give time for the gesture to take place. Thus, LB may have been making use of his left hemisphere to generate both speech and an iconic gesture. This suggests that the left hemisphere can produce iconic gestures so long as it uses language as the mediator. 

If indeed LB used language in the left hemisphere to mediate the production of right handed iconic gestures, we should expect that these gestures trailing speech would be generic. They would be representational but not tailored to the specific concrete events in the cartoon story. This prediction follows from the proposed mechanism. If the gestures are driven by words, not by memory images of the cartoon, which are presumably apprehended by the right hemisphere and inaccessible to the left, iconic gestures should reflect general linguistic category values, not specific details of the cartoon’s visual text. In the example cited previously, the hands formed an upward facing cup, perhaps a generically depicted act of putting, not the _downward_ facing hands shown in the cartoon itself. Thus, the gesture may reflect, as expected, the implications of stored lexical data but not the right hemisphere’s detailed visuo-spatial input.

In the case of NG, we again see right handed iconic gestures exclusively in the right space, two-handed metaphoric gestures in the central space, and high stereotypy of iconics. It is also possible that her gestures were triggered by speech, but the situation is ambiguous. In all the relevant examples, NG’s gestures were points, not iconics, and thus cannot be unambiguously linked to a particular lexical affiliate. In one example, NG said the _streetcar_, then showed the trajectory of the streetcar: the gesture trailing the speech, as in LB. But during the execution of this gesture, she also referred to the path itself (along the) and this shows speech trailing gesture, the normal asymmetry. NG’s timing is ambiguous, therefore, but it does not rule out verbal cuing of gesture.

We also see an intriguing new phenomenon that, in its own way, suggests left hemisphere involvement in the production of representational gestures. These are occasional spatial reversals in which gestures copy movements

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1In an earlier discussion (McNeill & Pedelty, 1992), we proposed that the left hemisphere was cross-cuing the right. Now, however, taking into account the right-side bias with iconics, we believe this interpretation to be incorrect, and that the cuing was done within the left hemisphere.
from the cartoon in the correct horizontal plane, but with the motion going in the wrong direction. Normal speakers recreate very accurately the left-to-right locations of events and objects from the cartoon, and do so even when they do not include any spoken references to placement on the horizontal plane at all (McCullough, 1992). As noted, NG tends to put everything on the right side of her gesture space. When the cartoon showed something moving from right to left (and a normal speaker would have performed a right-to-left gesture), NG performed gestures that went from left to right. Absent or inconsistent use of space is typical of the gestures of right hemisphere damaged patients, and this reversal of trajectory may represent yet another instance of spatial disorientation related to impaired right hemisphere input (in this case, absent input, if the right handed gesture is produced by the NG’s left hemisphere).

The complete reversal about the vertical axis, however, suggests a more systematic process. This may represent a dynamic form of left-side neglect. On a right-to-left trajectory, an object approaches, crosses, and then moves away from the midline. But because NG avoids the left side of space, the only way she could depict a movement away from the midline is to move her hand to the right, opposite to the cartoon. (Theoretically, this mechanism would cause left handed gestures made on the left side of space to show the opposite reflection, a left-to-right path bounced into a right-to-left one. Because NG had no left handed iconic gestures, however, we cannot test this intriguing idea with her data. However, the fact that all bimanual gestures take the form of mirror-image trajectories suggests that there may be, in split-brain patients, a bias to organize movement about the axial dimension, symmetrically toward or away from the midline—a proposition that we hope to test in future work.)

Considering both split-brain patients, we find a picture not unlike the right hemisphere damaged patients in terms of space use. Concrete gestures showed a right-sided bias and there are noniconic gestures without a right-side bias. Thus, a dissociation appears, as in right hemisphere damage, between the abstract and concrete.

However, the mechanism for the production of gestures is presumably not the same. In the right hemisphere damaged patients, iconic gestures presumably were organized in the right hemisphere, whereas the split-brain’s iconic gestures were the product of the left hemisphere.

Comparing the split-brain to the alien hand patient, we find yet another argument that the two hemispheres normally combine their separate contributions both in terms of left and right spaces and in terms of the level of abstractness of representation. The two kinds of disconnection present complementary gesture disorders arising from the ways in which the left and right hemispheres can combine their contributions. The alien hand patient exhibited the same tendencies twice, once in each spatial map. The implication is that the left and right hemispheres could combine forces to generate single meaning representations, but could not create a unified spatial realization of the meaning. The split-brain patients, in contrast, presented their meanings just once, but their meanings were dissociated from concrete context. Presumably these meanings arose from the left hemisphere working alone. Thus, a normal narrative, in which the categorical and the contextually specific are seamlessly blended and a single spatial map is constructed, may demand the cooperative processing of both cerebral hemispheres.

DISCUSSION

Implications for Sign Language

Although sign languages and spontaneous gesturalization by the hearing are fundamentally different forms of semiotic system (only the first is an independent language, and only the second is an unspoken component of a spoken language) gesticulation may still shed light on the cerebral organization of language and on the nature of sign language itself. Patterns observed with non-deaf gesticulation may have implications for how sign languages choose to grammatically encode particular distinctions. That is, the study of gesture might provide clues to the constraints and tendencies for grammatical encoding. In particular, the dissociations we have observed after right hemisphere damage between concrete and abstract level references, might also play a part in the cerebral organization of ASL. We find that abstract use of gesture space and syntactic use of ASL sign space both survive right hemisphere damage, although concrete uses of space in both cases suffer neglect. This pattern suggests that the treatment of space with nontopographic valuations may be one of the crucial conditions for the cerebral organization of ASL in which syntax is a left hemisphere specialty. This factor, the abstractness of space, is added to the more familiar left hemisphere specialties of segmentation and the hierarchical combination of linear sequences of segments (Kimura & Archibald, 1974). In a left hemisphere damaged signer, Corina et al. (1992) observed severe disruption of
ASL performance, but preservation of nonlinguistic pantomime. They interpret this dissociation to reflect the different degrees of compositionality involved in ASL and pantomime. Hearing aphasics of the nonfluent type also make extensive use of pantomime, but display a marked disruption of the abstract types of gestures, metaphoric, beat, and abstract deictic gestures (Pedelty, 1987). We argue that the underlying dissociation with both the signing and the hearing aphasic patients is the concrete-abstract dimension. That is, compositionality is a function that rests on abstractness and is undercut by left hemisphere damage. We thus predict that the aphasic signer would lose just those aspects of ASL structure that rest on the left hemisphere's powers of abstract valuation but would preserve those aspects that utilize concrete space.

Implications for Cerebral Organization of Narrative Discourse

We propose the following schematic differences between the contributions of the left and right cerebral hemispheres: The left hemisphere is involved in the linear, hierarchical, and temporal aspects of discourse, including the verbal components of speech but also thematic linearizations such as cause-effect and purpose-action, and those metanarrative perspectives that imply distance from the narrative content. In general, these are abstractions from the immediate context of speaking. The functions of the left hemisphere are definable in all contexts and are not dependent on any specific context. As we have seen, the left hemisphere functions moreover are not tied to a specific channel. In hearing speakers, they are expressed in the speech channel, but the example of sign language shows conclusively that the visual-kinesic channel is capable of expressing the same left hemisphere functions.

The right hemisphere is involved in the holistic, global, precisely nonlinear and atemporal aspects of discourse. These include cohesion, discontinuity, identification of significant boundaries, and the management of narrative levels. In general, these depend on registering the concrete properties of the immediate context. Thus, the complementary contributions of the two hemispheres appear most obviously in narratives, where the essence is to combine the schematic with the concrete. In this light, a particularly interesting finding is that children with left hemisphere damage at birth, when eventually tested at 5th grade, are impaired in their projection of purposes and actions from story stems, but children with congenital right hemisphere damage do not differ from their age-matched normal controls. The left hemisphere thus appears to be necessary for comprehending relationships between purposes and actions. One might have expected that purpose-action would be the province of the right hemisphere, because the relation is semantic; but it turns out that the left hemisphere is crucial. Perhaps the projection of goals-purposes is a left hemisphere function because goals-purposes is inherently temporal; it also can be abstracted from the concrete context of speaking and be projected according to schemas. To this result can be added the just as surprising observation of Rehak et al. (1992), that adult right hemisphere damaged patients display no deficits in their comprehension of canonical story forms such as "suspense" or "surprise." Again, canonical story forms can be abstracted from the context of speaking. Conversely, as we have reported, nonlinear, atemporal, holistic instantiations of events in space favor the right hemisphere, because they reflect properties of the concrete immediate context. The same right hemisphere damaged children, therefore, are able simultaneously to project purposes and goals (as in the Levine study) but unable to keep track of cohesive linkages (as we observe). A narrative depends on both the abstract-schematic and the concrete-idiosyncratic, and organizing these levels in relation to one another is the essence of presenting the story. A proper understanding of the left hemisphere and right hemisphere and their roles in narrative discourse must take all levels into account.

A Hypothesis

Finally, we can sum up our observations of gesture and the brain in a hypothesis for the cerebral control of speech and gesture: What appears to speakers to be a single unified space is constructed of different spaces that are controlled separately and must be actively combined—the right and left sides, the space of motor control and space of language, and the distinct spatial regimes for different levels of abstraction. Creation of a unified space is not an automatic result of invoking space and attaching meanings to it. The whole brain is playing a part in this construction. Each hemisphere makes its own characteristic contribution, but the two together are necessary to obtain a discourse. The left hemisphere, working alone, as in a split-brain, or working with insufficient right hemisphere input, as in right hemisphere damage syndrome, produces a type of narrative in which there is linear form, but form deficient in imagistic content. This can produce a dissociation—a narrative distant from the concrete narrative level. Such a discourse may contain metanarrative content, as in the narration of LB, but this content is dissociated from a foundation of imagery on which cohesion rests. Narrative structure (a complex of meanings) draws widely on the brain's powers of spatialization. When visuo-spatial input from the right hemisphere is lacking, narrative is incomplete: lack of coherence, inability to match physical
and abstract content, and inconsistent treatment of structural boundaries—these are just some of the defects that appear in the alien hand syndrome, right hemisphere damage, or commissurotomy and show the right brain to be an equal partner with the left in the construction of space and narrative discourse.

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REFERENCES


4. RIGHT BRAIN AND GESTURE