Cognition, 8 (1980) 93–108

Book Review

Language by Hand and by Eye*
A Review of Edward S. Klima and Ursula Bellugi's The Signs of Language**

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Language is form, not substance. Yet every semiotic system is surely constrained by its mode of expression. Communication by odor, for example, is limited by the relatively slow rates at which volatile chemicals disperse and smell receptors adapt. By the same token, we might suppose that the nature of sound, temporally distributed and rapidly fading, has shaped the structure of language. But it is not obvious how. What properties of language reflect its expressive mode? What properties reflect general cognitive constraints necessary to any imaginable expression of human language? How far are those constraints themselves a function of the mode in which language has evolved?

Until recently, such questions would hardly have been addressed, because we had no unequivocal example of language in another mode, and because there are grounds for believing that language and speech form a tight anatomical and physiological nexus. Specialized structures and functions have evolved to meet the needs of spoken communication: vocal tract morphology, lip, jaw and tongue innervation, mechanisms of breath control, and perhaps even matching perceptual mechanisms (Lenneberg, 1967; Lieberman, 1972; Du Brul, 1977). Moreover, language processes are controlled by the left cerebral hemisphere in over 95% of the population, and this lateralization is correlated with left-side enlargement of the posterior planum temporale (Geschwind and Levitsky, 1968), a portion of Wernicke's area, adjacent to the primary auditory area of the cortex and known to be involved in language representation. Wernicke's area is itself linked to Broca's area, a portion of the frontal lobes, adjacent to the area of the motor cortex that controls muscles important for speech, including those of the pharynx, tongue, jaw, lips and face; damage to Broca's area may cause loss of the ability to speak grammatically, or even to

*Preparation of this review was supported in part by NICHD Grant HD 01994 to Haskins Laboratories, New Haven, Connecticut.

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speak at all. Taken together, such facts suggest that humans have evolved anatomical structures and physiological mechanisms adapted for communication by speech and hearing.

Furthermore, the structure of spoken language, based on the sequencing of segments, follows naturally from its use of sound, that is, of rapid variations in pressure distributed over time. At the level of syntax, the segments are words and other morphemes. At the level of the lexicon, the segments are phonemes (consonants and vowels) arranged in sequences to form syllables and words. This dual pattern of sound and syntax, commonly cited as a distinctive property of language, perhaps evolved to circumvent limits on our capacity to produce and perceive sounds. Certainly, the number of holistically distinct sounds that the human vocal apparatus can make and the human ear perceive, is relatively small. Perhaps in consequence all spoken languages construct their often vast lexicons from a few (usually between about 20 and 60) arbitrary and meaningless sounds, and set restrictions on the sequences in which the sounds may be combined.

The sounds selected and the rules for their combination differ from language to language, but all languages make a major class division between consonants, formed with a more-or-less constricted vocal tract, and vowels, formed with a relatively open tract. The division reflects a natural opposition between opening and closing the mouth, and is therefore peculiar to speech. The combination of consonant and vowel gestures into a single ballistic movement gives rise to the consonant-vowel syllable, a fundamental articulatory and acoustic unit of all spoken languages. The acoustic structure of the syllable departs from the rule of sequence, since parallel or co-articulation of consonant and vowel yields an integral event in which acoustic cues to the two components are interleaved. However, this departure may itself be an adaptation to limits on hearing, short-term memory and the cognitive processes necessary to understand a spoken utterance. If we hypothesize an ideal speaking rate – neither too slow nor too fast for comfortable comprehension – and take, as a measure of this ideal, a standard English rate of about 150 words a minute, the phoneme rate (allowing, say, 4 phonemes per word) will be 10 per second, close to the threshold at which discrete acoustic events merge into a buzz. By packaging consonants and vowels into the basic rhythmic unit of the syllable, speech reduces the segment rate to a level within the temporal resolving power of the ear (Liberman, Cooper, Shankweiler and Studdert-Kennedy, 1967).

In short, the dual pattern of lexical form and syntax, the detailed acoustic structure by which lexical form is expressed, and what little we know of the neurophysiology of speech and language, all suggest that speech is the natural, and perhaps even necessary, mode of language. But the advent of systematic

research into sign languages, employing a manual-visual spatial mode rather than an oral-auditory temporal mode, has made it possible to test this assumption and to ask fundamental questions about language and its organization. Can language be instantiated in another mode? If so, how is it organized? Does it display a dual structure of lexical form and syntax? How are its formational and grammatical functions realized within the constraints of hand and eye rather than of mouth and ear?

Sign languages are of two types (Stokoe, 1974). The first type is artificial and is based, like writing and reading, on a specific spoken language: its signs refer to letters ("fingerspelling") or higher-order linguistic units (words, morphemes), and its syntax follows that of the base language. Examples are the sign languages of Trappist monasteries, of industrial settings, such as sawmills, and the various sign languages of the deaf (e.g., Signed English), developed and largely used in schools to facilitate reading and writing. The second type is not an artefact: it is not based on any spoken language. Rather, both lexicon and syntax are independent of the language of the surrounding community or of any other spoken language. Examples are the sign languages of the Australian aborigines, of the American Plains Indians (West, 1960; Umiker-Sebeok and Sebeok, 1977) and of deaf communities all over the world. An important distinction is drawn by Stokoe (1974) between aboriginal and deaf sign languages. The former are usually learned as a second language by individuals who already know a spoken language. The latter are usually learned as a first language by congenitally deaf infants, and are ontogenetically free from contamination by spoken language. The most extensively studied deaf language has been American Sign Language (ASL), said by Mayberry (1978) to be the fourth most common language in the United States.

Modern ASL derives from a French-based sign language, codified by the Abbé de L'Epée in the 18th century and introduced to the United States by Thomas Gallaudet in 1817. (Users of ASL today find French SL more intelligible than British SL (Stokoe, 1974) – evidence for the independence of ASL from the surrounding language). Early French sign language, and its American counterpart, were combinations of lexical signs originating among the deaf themselves and of grammatical signs corresponding to French (or English) formatives introduced by de L'Epée and his followers to help deaf pupils to learn to read and write. However, these speech-based signs rapidly fell into disuse – presumably because they ran up against the natural tendency of sign languages to conflate rather than concatenate their morphemes – and for the past 160 years ASL has developed among the deaf as an independent language (although see Fischer (1978) for a discussion of ASL as an English-based creole).

Until recently, established wisdom regarded sign languages of the deaf, like that of the Plains Indians, as more-or-less impoverished hybrids of conventional iconic gesture and impromptu pantomime. Analysis of their internal structure was limited to description of the images suggested by the forms of signs.[1] The first steps toward a structural description of ASL were taken by Stokoe (1960). With the publication of *A Dictionary of American Sign Language on Linguistic Principles* (Stokoe, Casterline and Croneberg, 1965), containing an account of nearly 2500 signs, the study of ASL entered a new period. Stokoe and his colleagues showed that signs were differentiated along three dimensions, or parameters: handshape, place of articulation, and movement. On the basis of a minimal pair analysis, they posited a limited set of distinctive values, or primes, on these dimensions: 19 for handshape, 12 for place of articulation and 24 for movement, making a total of 55 "cheremes", analogous to the phonemes of a spoken language. By demonstrating the existence of sublexical structure, Stokoe opened the way for systematic research into ASL and its relation to spoken language.

The task was undertaken by Edward Klima and Ursula Bellugi, and has been the focus of an ambitious program of research for the past seven years at the Salk Institute for Biological Studies in La Jolla, California. The present book is a brilliant recension of that research, extending Stokoe's original analysis, supplementing it with an imaginative range of linguistic and psycholinguistic studies and, for the first time, revealing some of the complex grammatical processes by which ASL combines and elaborates its lexical units.

The authors strictly observe the distinction between linguistic and psycholinguistic analysis. The book is divided into four parts. Part I undertakes to separate iconic invention from arbitrary structure; Part II reports a series of psycholinguistic studies of short-term memory, slips of the hand, and the featural properties of signs; Part III returns to linguistic analysis with an extended investigation of grammatical processes; Part IV concludes the book with an account of wit, play and poetry. The subject matter may seem difficult, even forbidding, to the glottocentric reader, like myself, who knows no sign language and is taxed by the effort of imagining the complex, three-dimensional shapes and movements by which ASL conveys its messages. But

[1] LaMont West, Jr.'s (1960) unpublished dissertation was an exception. At about the same time that Stokoe (1960) was beginning his analysis of ASL, West undertook to demonstrate, by morphemic and kinemic analysis, duality of patterning in Plains Sign Language (PSL). He isolated some eighty "kinemes," dividing them into five classes reminiscent of the Stokoe-Klima-Bellugi parameters of ASL: hand-shape, direction, motion-pattern, dynamics and referent. West proposed parallels between kineme and phoneme classes, but was not fully satisfied by the parallels because of the large element of iconicity in PSL, and its tendency to form new signs with *ad hoc* handshapes which were not part of a closed kinemic system. West's work on PSL has not been followed up, but many of his doubts might be resolved by Klima and Bellugi's work on ASL.

the exposition is simple, precise, and so richly illustrated with photographs and detailed drawings (roughly one every three pages) that one soon forgets one's ignorance and is absorbed in the argument of the text. The work, marked throughout by analytic rigor, depth and weight, is unquestionably the most thorough and detailed study to date of any sign language.

The focus of the book is on the effects of modality. Its aim is to broaden and deepen understanding of language by sifting finer properties peculiar to language mode from more general properties common to all forms of linguistic expression. The most pervasive property of ASL (and, doubtless, of every manual sign language) is its iconicity. Signs are often global images of some aspect of their referents, their grammar is often marked by congruence between form and meaning, and casual discourse grades easily into gesture and mime. Such mimetic processes are themselves worthy of study (e.g., Friedman, 1977), for they certainly reflect human cognitive and semiotic capacity – what other animal is capable of the "excellent, dumb discourse" of pantomime? But ASL is also abstract, and the first task for the analyst is to separate what the authors call "the two faces of sign: iconic and abstract".

The iconic itself has two faces: first, the extrasystemic pantomime that may accompany signing; second, the iconic properties of the lexical signs themselves. Of course, a modest pantomime often accompanies speech – imagine an excited account of a car crash – but we have no difficulty in separating vocal from bodily gesture because the two types follow different channels of communication. To separate the channels in a sign language is a more delicate task, and one that has defeated many earlier analysts. The authors, with typical directness and ingenuity, solved the problem by asking a deaf mime artist to render a variety of messages in both ASL and pantomime, and to maintain as much similarity between the two renditions as possible. From slow motion playback of his performance they established criteria for separating pantomime from sign. In general, the signed rendition was shorter than the mime (by a factor of 10 to 1), the signs themselves discrete rather than continuous (cf., West, 1960, p. 5), relatively reduced, compressed, and conventionalized. Moreover, in pantomime, the eyes were free to participate in the action, anticipating or following movements of the hands, while, in signing, they made direct contact with the addressee throughout the sign. Thus, by requiring sustained eye contact during signing, ASL limits the visual field within which signs may be made. The perceptual structure of this field for the addressee (fine at its foveal center, coarse at its periphery) then constrains the form and location of signs (Siple, 1978).

Before commenting on the iconic properties of the signs themselves, we should note their range of reference. Some signs translate into a single English word, some into several; others, such as distinct pronominal signs for

persons, vehicles and inanimate objects, have no English counterparts at all. In short, there are thousands of lexical signs in ASL, covering a full range of categories and levels of abstraction. Yet many signs do have obvious iconic components: the sign for "house" traces the outline of roof and walls; the sign for "tree" is an upright forearm, with spread, waving fingers; the sign for "baby" is one arm crossed in front of the other, while the arms rock. Nonetheless, just as we are often unaware of metaphor until it is pointed out ("He's a *sharp* operator"), non-signers usually cannot judge the meaning of a sign, but, once informed, may readily offer an account of its iconic origin. The "paradox of iconicity", in the author's phrase, is, first, that icons are conventional, so that quite different aspects of a referent may be represented by different sign languages (Chinese, Danish, British, American, and so on); second, that icons, despite their "translucent" origin, become so modified by the structural demands of the language that their iconicity is effectively lost. Indeed, as Frishberg shows in her chapter on historical change, comparisons of modern ASL signs with those depicted in manuals and films of seventy years ago show a strong tendency for signs to be condensed, simplified, stylized, moving toward increasingly abstract forms, by a process perhaps analogous to the development of figural representation in, for example, Byzantine painting. Similar observations have been made of Plains Indian Sign Language (e.g., Kroeber, 1958, cited by Umiker-Sebeok and Sebeok, 1977, p. 75). Thus, a main goal of the book's argument is to demonstrate, in compelling detail, how arbitrary form and system subdue mimetic representation.

Here, we need some account of the structure of ASL signs. As already noted, Stokoe (1960) and his colleagues (Stokoe, Casterline and Croneberg, 1965), first described the sublexical structure of ASL citation forms. Various later analysts have proposed slightly different classifications or numbers of primes and sub-primes ("phonetic" variants), but all have followed the principle of Stokoe's analysis. Klima and Bellugi, terming the three parameters of variation Hand Configuration, Place of Articulation, and Movement, propose a number of modifications, most of them needed for the analysis of morphological processes not attempted by Stokoe.

Hand Configuration refers to distinct shapes assumed by the hands, and includes a minor parameter of hand arrangement, specifying the number of hands used to make a sign and their functional relation (about 60% of ASL lexical signs use two hands). Place of Articulation refers to the location within signing space (a rough circle, centered at the hollow of the neck, with a diameter from the top of the head to the waist) at which a sign is made or with reference to which it moves (chin, cheek, brow, torso, and so on). Klima and Bellugi further posit a division of the space in front of the signer's torso into three orthogonal planes (horizontal, frontal, sagittal); these abstract sur-

faces prove important in the description of inflected forms. Movement, the most complex dimension, includes primes that range from delicate hand-internal movements through small wrist actions to the tracing of lines, arcs or circles through space. But a full description of the movement parameter, sufficient to distinguish between certain lexical signs, between lexical categories (such as noun and verb (Supalla and Newport, 1978)) and, especially, among the multitude of richly varied, inflected forms, requires a description of the dynamic qualities of movements: rate, manner of onset or offset, frequency of repetition, and so on.

Structural analysis of ASL is at its beginning, but the lower level of a dual pattern, analogous to that of spoken language, has already begun to emerge. The number of possible hand configurations, places of articulation, types and qualities of movement must be very large. Yet ASL uses a limited set of formational components, analogous to the limited set of phonemes in a spoken language. Moreover, just as spoken language restricts the sequential combination of phoneme types within a syllable, so ASL restricts the simultaneous combination of spatial values within a sign. Some combinations are doubtless difficult, or impossible, for physical reasons. For example, the Symmetry Constraint, posited by Battison (1974), requires that, if both hands move in forming a sign, their shapes, locations, and movements must be identical. Given the well-known difficulty of coordinating conflicting motor acts of the two hands, this rule may prove common to all sign languages. However, other combinatorial constraints seem to be ruled out for arbitrary, language-specific reasons. As preliminary evidence for this, in the absence of a full linguistic analysis of another sign language, the authors adduce psycholinguistic evidence from a comparison of selected signs in Chinese Sign Language (CSL) and ASL. The study showed that certain combinations of handshape, place of articulation and movement primes used in CSL are unacceptable to native signers of ASL, while other CSL combinations are acceptable, but do not occur in ASL.

Thus, linguistic analysis leads to a view of the ASL sign as a complex, multidimensional structure, conveying its distinctive linguistic information by simultaneous contrasts among components arrayed in space rather than by sequential contrasts arrayed in time. As the authors observe, if this arbitrary sublexical structure exists in a language of which the representational scope is so much richer than that of speech, we may reasonably infer that the formational structure of both languages offers more than mere escape from the limits of articulation. We may suspect, rather, a general cognitive function, perhaps that of facilitating acquisition, recognition, recall, and rapid deployment of a sizeable lexicon (cf., Liberman and Studdert-Kennedy, 1978; Studdert-Kennedy, in press).

In Part II of the book the authors report a variety of psychological studies, designed to "...explore the behavioral validity of the internal organization of ASL signs posited on the basis of linguistic analysis" (p. 87). Several studies – of short-term memory for random lists, of slips of the hand in everyday signing, of sign perception through visual noise – are modeled on similar studies of speech, often cited as evidence for the psychological reality of the coarticulated components of the syllable, and they reach strikingly similar conclusions.

The central question of these studies is: In what form do native signers encode and process the signs of ASL? Do sublexical components enter into the coding process? Unequivocally, they do. For example, when native signers, fluent in reading and writing English, were asked to recall random lists of ASL signs and to write their responses in English words, their errors did not reflect either the phonological structure or the visual form of the written words, nor did they reflect the global iconic properties or the meaning of the signs. Instead, errors reflected the signs' sublexical structure, and the most frequent errors differed from the presented sign on a single parameter. By contrast the intrusion errors of hearing subjects, asked to recall equivalent lists of English words, reflected the phonological structure of the words – the usual result in such studies (see, for example, Conrad, 1972). These results hint, incidentally, at an answer to the old question of whether intrusion errors in short-term memory for spoken (or written) words are based on similarities in sound or in articulation. The parallel between signs and words suggests that the effects may be based on a coding process common to both speech and sign. Rather than acoustic for speech, visual for sign, short-term memory codes for both modalities may be either motor (cf., Aldridge, 1978) or abstract and phonological (cf., Campbell and Dodd, in press).

That the motor system codes signs along the posited linguistic dimensions is evidenced by errors in everyday signing. The authors analyzed a corpus of 131 slips of the hand, much as comparable speech errors have been analyzed (e.g., Fromkin, 1971), and with analogous results. As in the speech data, most errors were anticipations and perseverations (rather than complete metatheses) of sublexical units – here, values of the structural parameters – and, typically, the errors gave rise to permissible combinations of parametric values which happened not to be items in the lexicon (ruling out lexical substitution as the source of error). The rarity of inadmissible parametric combinations demonstrates the force of formational constraint. The important conclusion is that everyday signing is not a matter of concatenating globally iconic forms, but is sensitive to the internal structure of the signs.

Moreover, native signers are aware of sign structure, just as speakers are aware of word structure. Wit and play (Part IV) are quite different in the two

However, since the perceptual study did not include a control group of hearing subjects, we have no way of knowing whether the derived features reflect an abstract "phonology" or mere psychophysical similarities among Hand Configurations.[2] The latter interpretation is encouraged by the outcome of a subsequent study of Place of Articulation in which hearing controls were used (Poizner and Lane, 1978). Here, although the linguistic knowledge of native signers was reflected both by a response bias in favor of places of articulation that occur more frequently in ASL and by greater overall accuracy than hearing controls, scaling and clustering solutions to the confusion matrices of the two groups were essentially the same. Such an outcome for the Hand Configuration study of the present book would have robbed the derived features of even psycholinguistic validity. But, as the authors explicitly state, their "...preliminary model of suggested features...ultimately must depend for its confirmation on its usefulness for linguistic analysis" (p. 178), and this usefulness has yet to be demonstrated.

In any event, we have seen that ASL signs do display a clear sublexical structure to which native signers are sensitive. Evidently, duality of patterning did not evolve, as we first surmised, merely to circumvent limits on speaking and hearing, but, as suggested above, has a more general linguistic function that must be fulfilled in both spoken and signed languages. Can the same be said of the syllable into which the sublexical units of speech are compressed? Certainly, with few exceptions, hand configuration and place of articulation are maintained throughout the movement of a sign, so that ASL exploits its visuo-spatial mode to achieve the ultimate compression of its sublexical units: simultaneity. However, the degree of compression is so much greater for the sign than for the syllable that we may suspect quite different functions. What we need is a broader comparison between the fundamentally temporal structure of speech and the fundamentally spatial structure of sign.

The authors lead into this comparison with several studies on the rates of speaking and signing. Their first discovery, confirmed by Grosjean (1977), was that the average sign takes roughly twice as long to form as the average word takes to say. Their second discovery was that, if the spontaneously signed version and the spontaneously spoken version of a story are divided into propositions – "defining a proposition as something that can be considered equivalent to an underlying simple sentence" (p. 186) – the mean proposition rates for the two versions are roughly equal. These results suggest,

[2]For fuller discussion than is appropriate here of errors commonly made in interpreting perceptual studies of speech sounds heard through noise, and of the distinction between linguistic features and their physical manifestations, see Parker (1977) and Ganong (in press).

modalities because, while spoken gesture is confined to the hidden space of a vocal tract and can be revealed only by its acoustic effect, signs are executed in the same physical space as the signers themselves occupy. Accordingly, like figures on a Baroque ceiling whose limbs break from their frame into the real space below, signs readily escape into informal gesture or pantomimic elaboration. Nonetheless, structural play does occur. Punning, it seems, is rare, perhaps because ASL has few homomorphs (virtually every distinction of meaning is signaled by a distinction of form). The characteristic mode of sign play is apparently the "...compression of unexpected meanings into minimal sign forms" (p. 320), often by substituting the hand configuration, place of articulation, or movement of one sign for the corresponding parameter of another, to produce a cross between the two, analogous to Lewis Carroll's portmanteau words (e.g. chuckle + snort = chortle). In "art sign", as the authors term the developing poetic (or perhaps better, bardic) tradition of the National Theater for the Deaf, artists fulfill the cohesive functions of spoken alliteration, assonance, and rhyme by choosing signs that share hand configuration or place of articulation; effects analogous to melody and rhythm they achieve by enlarging, blending, syncopating sign movements into a spatiotemporal kinetic superstructure. In other words, signers display, in both casual humor and formal art, a knowledge of the internal structure of signs.

Up to this point we have treated the values, or primes, of the major parameters as integral units, analogous to the phonemes of spoken language. Indeed, in their early linguistic analyses, the authors found no evidence for formational (i.e., "phonological") rules defining featural classes among the primes, analogous to those posited for phonemes by current linguistic theory. They therefore undertook to reverse the usual direction of research by looking for psycholinguistic evidence of sub-prime features that might later guide (and be validated by) linguistic analysis. They modeled their study on the well-known work of Miller and Nicely (1955). Miller and Nicely, it will be recalled, attempted to test the perceptual reality of certain traditional articulatory features by measuring the systematic feature-based confusions among English, nonsense-syllable consonants offered for identification in random masking noise. Similarly, the present authors videotaped a set of nonsense-signs, incorporating the 20 primes of Hand Configuration, and offered them to native signers for identification in random visual noise. They gathered their results into confusion matrices and derived, by cluster analysis and multidimensional scaling procedures, a set of 11 features that differentiated the 20 hand configurations. The psychological validity of the proposed feature set was suggested by the outcome of other studies: for example, intrusion errors on the recall of Hand Configuration, in the short-term memory studies described above, tended to be on a single feature.

first, that ASL has time-saving devices for expressing grammatical relations among signs spatially rather than temporally; second, more generally, that a single, temporally constrained cognitive process may control the proposition rates of both languages.

The authors identify three main spatial devices by which ASL conflates lexical and grammatical information. First is a device often emphasized in accounts of Plains Indian Sign Language (West, 1960): deixis or indexing. ASL achieves pronominal and anaphoric reference by establishing a locus for each of the actors or objects under discussion. Later reference is then made simply by directing action signs toward the established locus.

A second device, of the utmost importance in demonstrating recursive, syntactic mechanisms in ASL, is the use of facial expression and bodily gesture to indicate clausal subordination. The authors do not elaborate, since they confine their attention in this book to the formational properties of manual signs. But they cite Liddell (1978), who has shown that a relative clause may be marked in ASL by tilting back the head, raising the eyebrows and tensing the upper lip for the duration of the clause. Other non-manual configurations (including blinks, frowns and nods) may mark the juncture of conditional clauses (Baker and Padden, 1978).

The third incorporative device is the modulation of a sign's meaning by changes in the spatial and temporal properties of its movement. Among the many functions of such changes are those intended to differentiate nouns from verbs, modify adjectival and verbal aspect, and inflect verbs for distinctions within a variety of grammatical categories. These modulations are the topics of chapters in Part III, devoted to morphological processes in ASL.

Part III begins with an account of productive grammatical processes by which new signs enter the language. One fertile process is the stringing together of existing lexical items to form compounds, analogous to English *breakfast, kidnap, bluebird*. For example, ASL has combined the signs BLUE[3] and SPOT to form a new sign BLUESPOT, meaning "bruise". In English, such compounds are distinguished from phrases by overall reduced duration and by a shift in stress from the second word to the first: *hard hát* (a hat that is hard) becomes *hárdhat* (a construction worker). Similarly, in ASL overall duration is reduced, so that the compound lasts about half as long as the original two signs together, but (the opposite of the English process) reduction of the first sign is roughly twice as great as that of the second. Typically, the first sign reduces its movement, suggesting an incipient blend into a single sign (cf., English: *anise seed* becomes *aniseed*). Even before the blend is complete, the contributing signs will have lost their original meaning. BLUESPOT

[3] By convention, words in capital letters represent English glosses of ASL signs.

can refer to a bruise that is yellow, just as *hárdhat* designates a person, not a hat. Similar compounding processes are used in ASL to derive from signs for objects (chair), signs for superordinate (furniture) and subordinate (kitchen chair) lexical categories. The discovery of such grammatical mechanisms for creating new signs (fully analogous to those of many spoken languages) challenges the common notion that sign language lexicons are intrinsically limited and can be expanded only by iconic invention.

But the real breakthrough in morphological analysis was the discovery of changes in the temporal-spatial contours of signs to modify their meaning. The key insight was that, in its grammar no less than in its lexicon, ASL uses simultaneous rather than sequential variation.[4] Modulations of the meaning of a lexical item are achieved not by adding morphemes, as is typical of many spoken languages, but by modifying properties of one of the sign's parameters, its movement. In English, changes in aspectual meaning (that is, distinctions marking the internal temporal consistency of a state or event, such as its onset, duration, frequency, recurrence, permanence, intensity) are made by concatenating morphemes. A single adjectival predicate is used in a range of syntactic constructions to yield different meanings: *he is sick, he became sick, he gets sick easily, he used to be sick,* and so on. In ASL precisely the same modulations of meaning are achieved by changes in the movement of the predicate SICK itself: hand configuration and place of articulation remain unchanged, movement is modulated.

Modulations for aspect tend to be changes in dynamic properties, such as rate, tension, and acceleration, inviting description by such terms as thrust, tremolo, accelerando. Each modulation correlates with a grammatical category: predispositional, continuative, iterative, intensive, and so on. Often modulatory forms suggest their meaning, but their possible iconic origin does not interfere with their grammatical application. Thus, in the sign QUIET the hands move gently downward, but when its aspect is modulated by repetitive movement to mean "characteristically quiet", the hands move down in rapid, unquiet circles.

Once these inflectional processes had been discovered, whole sets of others came into view. ASL verbs are not inflected for tense: Time of occurrence is indexed for stretches of discourse, when necessary, by placing a sign along an arc from a point in front of the signer's face (future) to a point behind the ear (past). But ASL verbs are inflected for person, dual, number, reciprocal

[4] Interestingly, West (1960) asserts of Plains Indian Sign Language that "... the obligatory grammatical relationships are established not by temporal order or syntax, but by spatial relationships ..." and, further, that "... grammatical structure is almost entirely a matter of internal sign morphology ..." (p. 90).

action and, using the same modulatory forms as adjectival predicates, for aspect.

As a step toward description of the system underlying inflectional structure, the authors posit eleven spatial and temporal dimensions of variation. The spatial dimensions include locus with respect to the three intersecting planes in front of the signer's torso, mentioned above, geometric pattern, and direction of movement; these dimensions are used to inflect for number and for the distribution of events over time, place, and participants in an action. The temporal dimensions include manner, rate, tension, evenness, and size of movement; these dimensions are used to inflect for manner, degree, and temporal aspect. Each dimension has only two or three values and many of the dimensions are independent, so that a single opposition often suffices to cue a distinction of meaning. A full featural account of ASL inflection may ultimately be possible, and the authors do, in fact, present a preliminary six-feature system that captures aspectual modulation of predicate adjectives.

The central puzzle, with which the authors leave us, is the relation between inflectional and lexical structure. The dimensions of movement that describe inflections are quite different from those that describe lexical forms. Often, the movements of uninflected signs seem to be embedded in the movement imposed by inflection, and indexical movements are superimposed on both. In other words, ASL appears to have three parallel formational systems: lexical, morphological, and indexical. If this is really so, ASL differs radically from spoken languages where the same phonological segments are used for both lexical and morphological processes.

However, there is also evidence that this separation into layers may be more apparent than real. Supalla and Newport (1978) have shown that a lexical sign with repeated cycles of movement has only one cycle, when it is inflected for continuative aspect; similarly, a lexical sign with repeated downward movements loses all but one of them under modulation. Other signs with iterated, oscillating or wiggling movements in their surface lexical form are also reduced under modulation to a single base movement. And for yet other signs, lexical movement is not embedded in the modulation, but is transformed into a qualitatively different pattern. For such signs, at least, inflectional processes seem to operate not on the surface lexical form, but on an underlying stem. The authors conclude that a deeper analysis of ASL structure could reveal "... a unified internal organization which, in its systematicity, may bear a striking resemblance to equivalent levels of structure posited for spoken languages" (p. 315).

Whatever the outcome of this endeavor, the final chapters of Part III firmly establish ASL as an inflecting language, like Greek or Latin or Russian. They complete the demonstration that the dual structure of spoken language

is not a mere consequence of mode, but a reflection of underlying cognitive structure. How far that cognitive structure was itself shaped by the (presumably) oral-auditory mode in which language evolved, we do not know. But language, as it now exists, can indeed be instantiated in another sensorimotor modality, and, when it is, its surface is shaped by properties of that modality.

What does this conclusion imply for the study of language and speech? Certainly not – and the authors firmly deny this inference – that speech is excluded from the biological foundations of language. Rather, we are impelled to study more closely the behavioral and neurological relations between vocal and manual articulation. The association between lateralizations for manual control and speech is well established. Recent studies have demonstrated that both skilled manual movements (Kimura and Archibald, 1974) and non-verbal oral movements (Mateer and Kimura, 1977) tend to be impaired in cases of non-fluent aphasia, and that disturbances of manual sign language in the deaf are associated with left hemisphere damage (Kimura, Battison and Lubert, 1976). Evidence is also accumulating that sequential patterns of manual and vocal articulation are controlled by related neural centers (Kinsbourne and Hicks, 1979). Finally, preliminary studies at the Salk Institute (not reported in the present volume) have found behavioral evidence for left hemisphere superiority in the perception of ASL signs by native signers (Neville and Bellugi, 1978), suggesting the existence of a specialized sensorimotor mechanism, analogous to that for speech. The burden of all this work is that manual sign language belongs in the anatomical and physiological nexus of speech and language to which we alluded at the beginning of this review. The capacity for spoken and manual communication may rest on the evolution not only of the yet unformulated mechanisms that support abstract cognitive functions, but also of the fine, motor sequencing system in the left hemisphere by which those functions are expressed.

The discovery that language can be instantiated in another mode has implications for many other aspects of its study. Ultimately, language universals will have to be specified in a form general enough to capture the cognitive processes of both spoken and signed language. At present, the most fruitful study may be of language ontogeny. Logically, we still cannot exclude developmental mechanisms specialized for the discovery of language through speech. But the fact that deaf infants learn to sign, no less readily than their hearing peers learn to speak, argues for a broad adaptive mechanism, perhaps controlling the infant's search for patterned input in any communicatively viable modality (cf. Menn, 1979; Studdert-Kennedy, in press). The nature of this mechanism will surely be illuminated by comparisons between the ways deaf and hearing children learn their languages. Cross-linguistic studies are already under way at the Salk Institute and elsewhere. Indeed, the authors state

in their introduction that the study of ASL acquisition was the initial impetus for the present work, and they promise a second volume reporting their developmental research.

Finally, as I look back on this splendid book, with its remorseless, subtle argument and its endless images of pert hands, winking and weaving, I am filled with admiration: for the deaf who invented the system of their extraordinary language, for the authors and their colleagues who are discovering it.

References

Aldridge, J. W. (1978) Levels of processing in speech perception. *J. exper. Psychol.: Hum. Percept. Perform., 4,* 164–177.

Baker, C. and Padden, C. A. (1978) Focusing on the nonmanual components of American Sign Language. In Siple, P. (ed.), *Understanding Language Through Sign Language Research.* New York, Academic Press, 27–58.

Battison, R. (1974) Phonological deletion in American Sign Language. *Sign Language Studies, 5,* 1–19.

Campbell, R. and Dodd, B. (In press). Hearing by eye. *Quart. J. of Exp. Psychol.*

Conrad, R. (1972) Speech and Reading. In Kavanagh, J. and Mattingly, I. (eds.) Language by Ear and by Eye. Cambridge, Mass., MIT Press.

Du Brul, E. L. (1977) Origin of the speech apparatus and its reconstruction in fossils. *Brain Lang., 4,* 365–381.

Fischer, S. D. (1978) Sign Language and Creoles. In Siple, P. (ed.), *Understanding Language Through Sign Language Research.* New York, Academic Press, 309–332.

Friedman, L. A. (ed.), (1977) *On the Other Hand.* New York, Academic Press.

Fromkin, V. A. (1971) The non-anomalous nature of anomalous utterances. *Lang., 47,* 27–52.

Ganong, W. F. (In press). The internal structure of consonants in speech perception: Acoustic cues, not distinctive features.

Geschwind, N. and W. Levitsky (1968) Human brain: Left-right asymmetries in temporal speech region. *Science, 161,* 186–187.

Grosjean, F. (1977) The perception of rate in spoken language and sign language. *J. psycholing. Res., 22,* 408–413.

Kimura, D. (1976) The neural basis of language *qua* gesture. In H. Whitaker and H. A. Whitaker (eds.), *Studies in Neurolinguistics, Vol. 3.* New York, Academic Press.

Kimura, D. and Archibald, Y. (1974) Motor functions of the left hemisphere. *Brain, 97,* 337–350.

Kimura, D., Battison, R. and Lubert, B. (1976) Impairment of nonlinguistic hand movements in a deaf aphasic. *Brain Lang., 4,* 566–571.

Klima, Edward S. and Bellugi, Ursula (1979) *The signs of language,* Cambridge, Mass., Harvard University Press.

Kroeber, A. L. (1958) Sign Language Inquiry. *Internat. J. Am. Ling., 24,* 1–19.

Kinsbourne, M. and Hicks, R. E. (1979) Mapping cerebral functional space: competition and collaboration in human performance. In M. Kinsbourne, (ed.), *Asymmetrical function of the brain.* New York, Cambridge University Press, 267–273.

Lenneberg, E. H. (1967) *Biological Foundations of Language.* New York, Wiley.

Liberman, A. M., Cooper, F. S., Shankweiler, D. P., and Studdert-Kennedy, M. (1967) Perception of the speech code. *Psychol. Rev., 74,* 431–461.

Liberman, A. M. and Studdert-Kennedy, M. (1978) Phonetic perception. In Held, R., Leibowitz, H. W. and Teuber, H.-L. *Handbook of Sensory Physiology, Vol. VIII: Perception.* New York, Springer-Verlag, 143–178.

Lieberman, P. (1972) *The speech of primates.* The Hague, Mouton.
Liddell, S. K. (1978) Nonmanual signals and relative clauses in American Sign Language. In Siple, P. (ed.), *Understanding Language Through Sign Language Research.* New York, Academic Press, 59–90.
Mateer, C. and Kimura, D. (1977) Impairment of non-verbal oral movements in aphasia. *Brain Lang., 4,* 262–276.
Menn, L. (1979) *Pattern, control and contrast in beginning speech.* Bloomington, Indiana University Linguistics Club.
Mayberry, R. I. (1978) Manual communication. In H. Davis and S. R. Silverman (eds.), *Hearing and Deafness (4th ed.)* New York, Holt, Rinehart & Winston.
Miller, G. A. and Nicely, P. E. (1955) An analysis of perceptual confusions among some English consonants. *J. Acoust. Soc. Amer., 27,* 339–352.
Neville, H. J. and Bellugi, U. (1978) Patterns of Cerebral Specialization in Congenitally Deaf Adults: A Preliminary Report. In Siple, P. (ed.), *Understanding Language Through Sign Language Research.* New York, Academic Press, 239–260.
Parker, F. (1977) Distinctive features and acoustic cues. *J. Acoust. Soc. Amer., 62,* 1051–1054.
Poizner, H. and Lane, H. (1978) Discrimination of location in American Sign Language. In Siple, P. (ed.), *Understanding Language Through Sign Language Research.* New York, Academic Press, 271–288.
Siple, P. (1978) Visual constraints for sign language communication. *Sign Language Studies, 19.*
Stokoe, W. C., Jr. (1960) Sign language structure. *Studies in Linguistics: Occasional Papers 8.* Buffalo, Buffalo University Press.
Stokoe, W. C., Jr. (1974) Classification and description of sign languages. In T. A. Sebeok (ed.), *Current Trends in Linguistics, Vol. XII,* The Hague, Mouton, 345–371.
Stokoe, W. C., Jr., Casterline, D. and Croneberg, C. (1965) *A Dictionary of American Sign Language on Linguistic Principles.* Washington, D.C., Gallaudet College Press. (Second edition, 1976).
Studdert-Kennedy, M. (In press). The Beginnings of Speech. In Barlow, G. B., Immelmann, K., Main, M. and Petrinovich, P. (eds.), *Behavioral Development: The Bielefeld Interdisciplinary Project.* New York, Cambridge University Press.
Supalla, T. and Newport, E. L. (1978) How many seats in a chair? The derivation of nouns and verbs in American Sign Language. In Siple, P. (ed.), *Understanding Language Through Sign Language Research.* New York, Academic Press, 91–132.
Umiker-Sebeok, D. J. and Sebeok, T. A. (1977) Aboriginal Sign 'Languages' from a semiotic point of view. *Ars Semiotica, 1,* 69–97.
West, LaMont, Jr. (1960) *The Sign Language: An analysis.* Unpublished doctoral dissertation. Indiana University, Bloomington.