

Chapter 4

PLANNING AND PRODUCTION OF SPEECH: AN OVERVIEW

PETER F. MACNEILAGE
University of Texas, Austin, TX

MICHAEL G. STUDDERT-KENNEDY
City University of New York, NY
and
Haskins Laboratories
New Haven, CT

BJORN LINDBLOM
University of Stockholm

This paper is a progress report on part of a biologically-based approach to the understanding of spoken language presently in preparation (Lindblom, MacNeilage, & Studdert-Kennedy, 1984a). Our aim is to view language in the perspective of the evolution of adaptive functions. Our strategy is to begin by focusing on aspects of language which are closest to the transmission process, namely, the production and perception of the sound pattern of language; in linguistic terms, the more peripheral aspects are closer to direct observation than more central aspects associated with meaning and thought. But it is also partly theoretical—we believe the constraints of the transmission process have played a crucial role in molding the form of language functions as a whole.

The topic of this paper is the serial organization of language output—the process whereby some intention, which is itself not serially organized, is converted into a rule governed sequence of linguistic symbols. If we look directly at the result of this serial organization process—if we look at the movements of the speech apparatus and their acoustical resultants—we immediately encounter the central paradox of speech research. We find that the parts of this output that are supposed to signal the string of consonants and vowels given us by the linguist are neither context-free, nor marked off discretely from segment to segment. The context-sensitive representation of a given consonant or vowel in the transmission process is termed the *Invariance problem*. The absence of obvious temporal boundaries to the representation of segments is termed the *Segmentation problem* (see Lindblom, 1982). Collectively these two problems constitute what we can call the *Nonisomorphism Paradox*.

Context-sensitivity seems to result primarily from the overlap of gestures required for adjacent phonemes. This overlap is termed *coarticulation* (Kent & Minifie, 1977). An early attempt to account for these coarticulatory effects was the *Motor Command Hypothesis* (Cooper, Liberman, Harris, &

Grubb, 1958) according to which the control system did send out an invariant command for a given segment in all of its contexts, but context effects were produced simply by temporal overlap in the effects of adjacent commands on the mechanically sluggish articulatory system. This hypothesis was laid to rest by electromyographic studies that showed that the instructions sent to the muscles for instances of a given vowel or consonant varied with the identity of both the preceding and following segments (MacNeilage, 1970). Thus, context sensitivity was shown to be, at least in part, built into the control process. With respect to the segmentation problem, a number of attempts were made to show that while coarticulation patterns in continuous speech did not delimit intersegment boundaries they might indicate the presence of higher order boundaries such as syllable boundaries, word boundaries or morpheme boundaries. This search for evidence for units other than the segment in the transmission process has been for the most part unsuccessful, just as the search for evidence for segments has been (Kent & Minifie, 1977). Thus we cannot resolve the nonisomorphism paradox by denying that the signal lacks invariance or discreteness, either for the segment or other units. Can we resolve the paradox by denying the existence of discrete units underlying the production process? Confining our attention to the segment for the moment (i.e., the consonant or vowel) the answer is emphatically no. Errors involving single segments in an otherwise correct output sequence happen often enough in normal subjects to suggest that the segment is an independent unit in the control process. The most well-known example is the reversal or spoonerism, for example:

fish and tackle † fash and tickle

But segments are also omitted, added, shifted in location, and substituted for other segments. When these things happen, the resultant output of the erroneous form seems to be correct at the transmission level, suggesting that the error oc-

curs at an underlying level, and that processes directly concerned with transmission, particularly with coarticulation, can operate independently of more underlying levels (MacNeilage, 1972).

Another source of evidence for the independence of surface and underlying levels of organization comes from a number of studies done recently in which subjects attempt to produce speech after bite blocks of various sizes are placed between the teeth (e.g., Lindblom, Lubker, & Gay, 1979). It has been shown that normal subjects have a remarkable ability to adapt to these blocks virtually immediately, even though such adaptation involves generating unique control signals for each segment.

Thus the peripheral stage of speech transmission can perhaps best be described as "an elegantly controlled variability of response to the demand for a relatively constant end" (MacNeilage, 1970, p. 184). However, it is important to note that this phenomenon itself, often termed *motor equivalence*, is not specific to speech or even to human action. Instead it is characteristic of goal-oriented action in general and can be seen in operation well down the phylogenetic scale. For example, Fentress (1983) has noted that if restrictions are placed on limb movements of mice while grooming, movements are reorganized so that grooming successfully occurs. But two aspects of the speech action are probably specific to humans—first, the rate at which independent acts are carried out. We speak at a rate of about 14 segments per second. The fastest rate we are aware of in other primates doing roughly comparable tasks is a rate of about 7½ acts per second in baboons opening a puzzle box (Trevarthen, 1978), but that was after practice on a single sequence and not for sequences in general. Second, the principles of segment organization at the underlying level are probably unique to human vocal output in ways that we will now discuss. Again phonological errors of normal subjects are the best source of information about the organization of underlying levels. These errors show definite patterns, both in terms of the relative involvement of various units and in terms of the places to which units can migrate when they are misplaced. The single segment is by far the most popular unit of error. Collections of errors show it to participate liberally in all five classes of error mentioned earlier (reversals, shifts, additions, omissions, and substitutions). On the other hand whole syllables rarely move around as units and syllable reversals are virtually unknown. Also, as Shattuck-Hufnagel and Klatt (1979) have argued, there is very little evidence that the distinctive feature is a separable unit in errors of serial organization.

Migration patterns for segments in errors are very narrowly defined. For example, in reversal errors it is extremely rare for segments to move to a different position in the syllable than the one they came from. Vowels and consonants never reverse. Consonants which were supposed to precede or follow a vowel in the correct syllable seldom reverse positions. The best conception of what is actually happening at this stage of production has been developed by Shattuck-Hufnagel (1979). She visualizes the process as one of first scanning for information about segments in representations of words from a mental dictionary, and then copying the information into a second representation more directly related to output. She interprets the positional restrictions on segment migration to

mean that segmental representations must be copied into slots marked for syllable structure. Additional evidence for a separation between a content specification and a specification for serial organization comes from observations of Shattuck-Hufnagel on omission errors. She notes that a number of omission errors such as "Dr. —inclair has emphasized" (Sinclair) give the impression that a null consonantal segment is initially represented for the beginning of the word "emphasized," and it is this null segment that is copied into the beginning of the word "Sinclair" instead of the initial "s." If even a representation of the absence of a content element can be moved around to a corresponding structural location, then it would seem that content and serial structure must be independently specified. We would like to describe the form of operation suggested for the phonological level by Shattuck-Hufnagel as a Frame/Content mode of organization. Segmental content elements are copied into syllabic frames.

Language is widely described as having a dualistic structure. At the phonological level, segments are concatenated into patterns. So, for example, one gets the words "tack," "cat" and "act" from the same three segments. But, in addition, there is a morphological or meaning level at which meaning units are concatenated into various forms. So, for example, one gets "John hit Mary" or "Mary hit John," or, according to a slightly different principle, "blind venetian" and "venetian blind" (Miller, 1965). Evidence from language errors suggests that the morphological level of language output may also have a frame/content mode of organization, analogous to the one found in phonology. Garrett (1975) has noted a large class of reversal errors in which what could be called a grammatical frame remains in its correct order while the stem forms of content words (nouns, verbs, adjectives, and some adverbs) are apparently inserted in the wrong positions. An example is: McGovern favors busting pushers † McGovern favors pushing busters. Note here that the grammatical bound morphemes "ing" and "ers" remain in correct position while the content word stems "push" and "bust" exchange. Garrett also notes a class of apparent reversals of adjacent forms (e.g., "little beads of blood" † "beads of little blood") which he believes are also best interpreted as a misplacement of content elements in their syntactic frames.

It is not possible to do justice to the arguments of Shattuck-Hufnagel and Garrett in this context. But their work persuades us of the importance of the frame/content mode of organization at both the phonological and morphological levels. Part of the importance of this mode of organization for spoken language derives from the likelihood that many other complex output processes do not possess it. In typing, for example, reversal errors usually involve adjacent letters. A consideration of the letters involved in reversal errors (MacNeilage, 1984a) reveals no sign of the prohibition of reversals between consonants and vowels seen in speech errors. We do not know of error data for musical performance but the intuition of musicians we have talked to is that they do not tend to exchange elements with common positions in a musical structure (e.g., first beats in the bar). The equivalent of the phonological level of spoken language in the sign language of the deaf seems to be sets of four sign attributes that form something like a monosyllabic word. The attributes are (a) handshape, (b) location, (c) orientation, and (d) movement. Although we

know of no collection of sign reversal errors, there appears to be no serial structure restriction equivalent to that in the spoken syllable that would constrain the positions of elements in reversal errors. On the other hand, errors might reveal a frame/content mode of organization at the morphological level. At this level syntactic morphemes are typically signalled by superimposing movements on concurrent signs for lexical stems. It would be at least possible for syntactic information to stay at its correct location in the utterance while signs for lexical stems migrated around.

From our biological standpoint it is now necessary to consider how a frame/content mode of organization might have evolved. Perhaps the first question to ask is: Evolved from what? The best estimate of the status of vocal communication systems at the time when hominids first diverged from an ancestral line common to great apes comes from considering present great ape vocal communication in the natural state. (Incidentally, evidence from molecular biology suggests that the divergence may have occurred as recently as 7 million years ago (Pilbeam, 1984). Evidence suggests that rather than having a dualistic system with concatenation rules at two levels, great apes have a limited number of cries, perhaps not exceeding 30 (Dingwall, 1979), with no combination rules either within cries or between them. One way to pose the question of the evolution of serial organization of language is to ask how did we get from a communication system like that of the great apes to the human one? A plausible scenario for the phonological level has been provided by Hockett and Ascher (1964). They suggested that the principle of sound concatenation may have been forced by the inability of the transmission system (production and perception) to keep distinct the increasing number of holistic signals needed to keep pace with an increasing message capacity. In another paper we have considered issues related to the formation of sound systems under constraints of this type (Lindblom, MacNeilage, & Studdert-Kennedy, 1984b). Although that may have been the selectional pressure, the question remains as to how our predecessors were able to respond with a concatenation strategy of the frame/content type. Our answer is that the form of the response was possible because we had already evolved a mode of organization that could be adapted for the purpose. That mode of organization may have been the one required for bimanual coordination. In particular, we have in mind the mode of organization whereby an object is held in the nonpreferred hand, serving as the frame, and manipulated by the preferred hand (providing content elements). Note, however, that this hypothesis does not commit us to the view that speech evolved from a manual gestural language. We are claiming that only a mode of organization of bimanual function was adapted for language use.

In addition to the obvious analogy, there are other reasons for suggesting bimanual coordination as a precursor to phonological organization. First, from our standpoint, attempting as we are to derive linguistic phenomena partly from motor constraints, bimanual coordination is an obvious candidate for a precursor, because, with the possible exception of speech, it is the complex serial voluntary action that man does best. In addition it is, without exception, the complex serial voluntary action that our nearest primate relatives do best. Second, the coincidence of the control of the preferred hand and of lan-

guage in the same hemisphere in most humans, particularly language production, is consistent with the hypothesis. Note in this context, that it is probably more appropriate to regard right hand preference as part of a specialization for *bimanua* coordination than as simply a unilateral specialization. There is evidence that left hemisphere damage affects the function of both hands whereas the same cannot be said for the right hemisphere (Kimura, 1979). Thirdly, the hypothesis that bimanual coordination is a precursor to phonological organization has the merit that it is consistent with the evolutionary principle of conservation of adaptive functions (Jerison, 1973). The principle states that functional adaptations tend to be conserved once they have evolved. Thus it is not necessary to fly in the face of this well-accepted tenet of evolutionary biology, as Chomsky (1968) and others do when they claim that language evolved *de novo*. The same consistency with the principle of conservation of adaptive functions can be claimed for the additional hypothesis that frame/content organization in morphology, evolved from frame/content organization in phonology. (We think most people would accept the speculation that we had phonological organization before we acquired syntax.)

Pulling together the threads of this discussion, the frame/content hypothesis states that there is a three-stage sequence in the evolution of serial organization of language: (a) bimanual coordination, (b) phonological organization, and (c) morphological organization. In this development, evolution proceeds as it usually does, as a tinker, adapting available material to new needs (Jacob, 1977) rather than an engineer making a new structure from parts specially designed from scratch, just for that purpose.

If we now consider current knowledge of brain-behavior relations, there seem to be two particular problems for the frame/content hypothesis. The first, is the possibility that some individuals control language and the preferred hand from different hemispheres. The second, is the claim that nonhuman primates do not have hand preferences like those of man.

The possibility that language and preferred hand control are in different hemispheres seems to pose a problem for an hypothesis that says that language had an evolutionary precursor in manual specialization. This would appear to be true in any case in which language control is in the hemisphere ipsilateral to the preferred hand, because direct control of the hand is contralateral. It is estimated that this is true of 1% of right handers and 60-70% of left handers (Corballis & Beale, 1983). As left handers constitute about 10% of the population we are talking about 7-8% of the population. This population needs careful scrutiny. One possibility, that does seem to occur in some instances, is that the control information for skilled voluntary actions originates in a center ipsilateral to the hand, but is then sent across the corpus callosum to the hand to be transmitted contralaterally in the usual way (e.g. Heilman, Coyle, Gonyea, & Geschwind, 1973). In addition, left handers as a population are thought to be slightly more likely to have some early medical problems that could affect localization of cerebral functions and dissociation of language and preferred hand control could occur for this reason. Another problem is that unless clinical studies give equally detailed information on language function, manual function, a:

lesion site it is difficult to establish instances of dissociation of language and hand control. We intend to look very carefully at this body of literature to see whether it poses problems for the frame/content hypothesis or not.

The second apparent problem—the problem of handedness in nonhuman primates—we have looked into (MacNeilage, Studdert-Kennedy, & Lindblom, 1954). The following paragraphs summarize the conclusions of our review. Efficient bimanual coordination may have first evolved in old world monkeys together with the truly opposable thumb (Napier, 1962). This development probably occurred several million years ago. Great apes are also quite capable of efficient bimanual coordination. If right-hand preference is associated with the evolution of bimanual coordination, as we believe it is, these primates should show at least some trend toward right-hand preference, but it is the virtually unanimous conclusion of a number of recent reviewers and participants in several recent published symposia that other primates are quite unlike humans in hand preference. The consensus seems to be that if preferences are shown, they are about equally frequent for left and right hands, but very task specific and often unstable. Secondly, there is considered to be virtually no evidence to sustain a conclusion that either old world monkeys or great apes have hemispheric specialization of function. To put it bluntly, the likelihood that various nonhuman primates have been capable of bimanual coordination for several million years without the evolution of either patterns of hand preference, or hemispheric specialization, does not appear favorable for the frame/content hypothesis. However, our review of this literature suggests that these negative conclusions are mistaken, or, at the very least premature (MacNeilage et al., 1984).

Almost all the work on primate handedness has been done on old world monkeys, so we will restrict the present discussion to this group. Most of the negative conclusions either come directly from the work of J. M. Warren (e.g., Warren & Nonneman, 1976) or are based on his work. Unfortunately there are three major problems with this work. First, he has typically used relatively young monkeys (under 2 years of age) and other studies suggest that hand preferences may not be fully developed in monkeys at this age. Consequently, it is not too surprising that he finds these monkeys to be inconsistent in hand preference from task to task and on repetitions of the same task. Second, he has used a relatively narrow range of tasks in terms of the necessity for the use of both hands and in terms of the level of complexity of the required manipulative movements. Third, and perhaps most important, his criterion for human-like handedness is that monkeys perform each individual act in multiact tasks with the same hand. In other words his criterion ignores the tendency toward bimanual coordination in humans performing multi-act tasks, in which different hands are favored for different acts. Then when he finds that monkeys also use different hands for different acts in multi-act tasks he declares them to be unlike humans.

Warren's use of the criterion that one hand must be used for all acts may have prevented him and perhaps others from noting that there is a definite pattern in what hand monkeys use for what act, that is like the pattern shown by humans in some respects, but not in others. This pattern is most clearly

shown in a paper by Beck and Barton (1972) who have studied a far wider range of tasks than anyone else—17 different tasks. Like humans, the 10 monkeys in this study show a definite preference for the right hand for aspects of tasks that involve complex manipulation. The extreme example of this is shown in a task that required two embedded hasps to be opened by insertion of a single finger under each hasp [2IHC]. The median preference level for right hand actions for these two acts was 96.5%. But in general, all of the 9 manipulative movements studied showed an overall right hand preference.

The other part of the pattern is a tendency to favor the left hand to pick up the reward—in our terms a left hand preference for incentive grasping. The extreme example was a median left hand preference of 100% for incentive grasping in one of the embedded hasp tasks. In general, 14 of the incentive capture movements in the 17 tasks showed an overall left hand preference.

Two other types of task also reveal this trend towards a left hand preference for incentive capture movements. Ettlinger and his colleagues have found it in each of four studies of discrimination tasks in which the monkey obtains food by uncovering a foodwell under the correct one of two simultaneously presented stimuli (Ettlinger, 1961; Ettlinger & Moffett, 1964; Gautrin & Ettlinger, 1970; Milner, 1969). Secondly, three independent field studies have shown about a 2:1 preference of left over right hands in Japanese macaques in tasks that involve picking up food thrown on the ground (Itani, 1957; Itani, Tokuda, Furuya, Kano, & Shin, 1963; Tokuda, 1969). In a fourth field study a 2:1 preference ratio has been shown for the hand used to catch food in a group of smart monkeys who developed one-handed food-catching skills (Kawai, 1967).

The number of monkeys showing a left hand preference for incentive capture increases with age in free ranging monkeys. But in a number of experiments involving manipulation, an increasing preference for right hand even for the incentive capture act is observed with practice. These results lead us to the hypothesis that the predominant natural pattern of handedness in old world monkeys is a dichotomous one—a left hand preference for incentive capture movements and a right hand preference for fine manipulation. In nature, the variety of circumstances associated with manual grasping of food suggests that the left hand preference is for movements that require visual guidance in space because each movement is a relatively novel one for the animal. The left hand preference for incentive capture may also be observed in experiments because the expectation of food or the visual stimulation associated with food may put the animal into a left hand response mode even after the spatial contingencies of the situation have ceased to be novel to it.

On the other hand, under natural circumstances the right hand may more typically be used to manipulate an object already placed by the animal in a particular relatively stereotyped non-novel position with respect to the hand, often with the left hand. The serial effects of increasing right hand preferences observed in experimental tasks may result from some animals increasingly assimilating the stereotypy of the situation and moving to a mode of response which is more suited to stereotyped situations—a right hand response.

The right hand preference we propose for monkeys is obviously analogous to the one found in humans, and we suspect it is accompanied by a similar left hemisphere specialization. At first glance there seems to be no human analog to the left hand preference. But some studies have shown a left hand advantage for right handers in tasks that appear to involve a spatial component (e.g., Kimura & Vanderwolf, 1970). A French group (Guiard, Diaz, & Beaubaton, 1983) has shown that right handers are more accurate with their left hand in tasks that involve a single rapid movement to a visual target. In addition, Hampson and Kimura (1984) have shown a left hand preference in assembling blocks according to nonverbal principles, coexisting with a right hand preference for block assembly following verbal principles. Although it is difficult to see exactly what these tasks have in common, further consideration may suggest some relation between the role of the left hand in monkeys and humans. Perhaps humans and old world monkeys are separated by an evolutionary progression in which the importance of bimanual coordination, with its usually associated right hand preference, has so increased that it has preempted any propensity for left hand use in unimanual tasks under most normal circumstances.

We must now confront the consensus in the literature that old world monkeys do not have hemispheric specialization related to handedness (e.g., Warren, 1980). We believe this conclusion to be premature. Perhaps most importantly, our reanalysis of the monkey handedness literature leads us to suspect that the criteria for determining handedness in the relevant studies were usually inappropriate. Two additional problems with this work have been noted by Charles Hamilton (Hamilton, 1977; Hamilton & Vermeire, 1982). First there have been relatively few studies of tasks of a type that would reveal hemispheric specialization in man. Therefore, there is no reason to expect these tasks to be associated with hemispheric specialization in monkeys. Second, workers in this field find themselves in the uncomfortable position of trying to prove the null hypothesis. This is made especially difficult by a practical constraint that leads investigators to study only a small number of monkeys per experimental condition. Nevertheless in spite of all these problems there have been a few positive findings (e.g., Hamilton & Vermeire, 1982). We contend that with a better theory of handedness, an appropriate choice of task, and a large enough number of subjects, significant hand-hemisphere relations could be found.

Our conclusion that nonhuman primates may indeed possess significant hand preferences is presently specific to old world monkeys. In our opinion there is at present insufficient evidence to conclude one way or another about other taxa. However, as great apes are more closely related to man than are old world monkeys, more careful study may reveal that they too have hand preferences that are worthy of interest. This conclusion is encouraged by the fact that these animals are capable of efficient bimanual coordination, and by their possession of human-like patterns of hemispheric structural asymmetries which cannot be attributed to possession of human-like language (e.g., LeMay, Billig, & Geschwind, 1982).

We believe the frame/content hypothesis has a number of important implications. The emphasis on the importance of bimanual coordination may help to focus more attention on

the evolution of bimanual coordination in other primates and the possibility that evolution of brain specialization may parallel evolution of this capacity across the entire primate order. The hypothesis leads to the prediction of universal patterns of speech errors at both phonological and morphological levels, although precise expectations for languages that differ markedly from English (e.g., agglutinative languages or languages with relatively free word order) remain to be developed. Some implications of the frame/content hypothesis for the acquisition of language are presented elsewhere (MacNeilage, 1984b). One important implication is that although there may be a natural propensity for a frame/content mode of organization, infants have to develop it from an initial mode in which frame and content are not separately available at either the phonological or the morphological levels. Thus certain well-known and apparently regressive discontinuities in phonological and morphological development, such as loss of progressive phonological idioms, and use of incorrect regular plural forms for previously correct irregular plurals (e.g., went + goed or wented) might be taken as evidence for shifts towards a frame/content mode.

The claims that both left and right hemispheric specializations for manual functions may have already evolved in old world monkeys has the implication that human specializations may be superimposed on them. A different but well-known approach to human hemispheric specialization is to argue that the human hemispheres have species-specific specialization for *meta functions*, (i.e., generalized capacities that facilitate certain functions). Well known meta functions proposed for the left hemisphere are analytic and serial capacities and for the right, synthetic (holistic) and parallel processing capacities. We would assert that natural selection acts on functions not meta functions and consequently it is better to think in terms of a relatively specific functional adaptation resulting in a capacity for a variety of behaviors than to think of meta functions arising *de novo* in humans.

Some well-known effects of brain injury on language function are placed in an interesting perspective by the frame/content hypothesis. One finding is that patients who have lost the left hemisphere early in life typically have more problems with syntax and certain aspects of phonology such as rhyming than with semantic or lexical aspects of language (e.g., Dennis & Whitaker, 1977). This is consistent with the implication that the right hemisphere has a disadvantage in representing structural aspects of language independently of content elements (i.e., it lacks a propensity for frame/content organization). In addition, the two major syndromes resulting from damage to the left hemisphere, Broca's and Wernicke's aphasia, can readily be given a general characterization in frame/content terms. The agrammatism of Broca's aphasia can be characterized as a frame disorder at the morphological level, while the lexical choice problems, segmental paraphasias, and neologisms of Wernicke's aphasia suggest a content disorder at both morphological and phonological levels.

To sum up: The first problem we encounter in looking at speaking is the nonisomorphism paradox—the lack of a straightforward relation between underlying context-free linguistic units and context sensitive surface representations of these units. The elaborate patterns of surface adjustments that we observe are made at an extremely versatile motor

control stage, beyond the stage of organization of message units. This output stage probably does not involve actions that are in principle different from those seen in goal-seeking behavior well down the phylogenetic scale. What we believe is new about language production is the high rate of output of different elements and the mode of organization of these elements. We suggest that a frame/content mode of organization exists at both levels of the dualistic system: the sound level, where vowel and consonant content elements are inserted into syllable frames; and the meaning level, where content word stems are inserted into syntactic frames. We suggest that the morphological mode may have evolved from the phonological mode, and the phonological mode may have evolved from an analogous mode of organization for bimanual coordination. In total then, we propose a three-stage evolution of language functions which is consistent with the principle of capitalization of adaptive functions—serial organization of language arose by capitalizing on an existing adaptation rather than arising de novo in humans.

One issue that this hypothesis brings into sharp focus is the status of the evidence that language and the preferred hand can be controlled by different hemispheres in subjects with neurologically normal histories. Another issue is handedness in nonhuman primates. A reexamination of handedness studies of old world monkeys shows the tendency towards right hand preference for manipulation that would be expected from the hypothesis, and also a left hand preference, which may be a precursor to the right hemisphere specialization for spatial functions in man. The frame/content hypothesis has implications for a number of areas of inquiry, including non-human primate evolution, hemispheric specialization, internal organization of the left hemisphere in man, language acquisition, and cross language studies of errors. Finally, we hope that one beneficial function of the frame/content hypothesis, whether it is right or not, is to draw more attention to a biological approach to language, which might lead to a more unified view of language evolution, language development, language pathology, and normal language function than exists at present.

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