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Continuing Commentary

Commentary on **Peter F. MacNeilage (1998). The frame/content theory of evolution of speech production. BBS 21:499–546.**

Abstract of the original article: The species-specific organizational property of speech is a continual mouth open-close alternation, the two phases of which are subject to continual articulatory modulation. The cycle constitutes the syllable, and the open and closed phases are segments – vowels and consonants, respectively. The fact that segmental serial ordering errors in normal adults obey syllable structure constraints suggests that syllabic "frames" and segmental "content" elements are separately controlled in the speech production process. The frames may derive from cycles of mandibular oscillation present in humans from babbling onset, which are responsible for the open-close alternation. These communication-related frames perhaps first evolved when the ingestion-related cyclicities of mandibular oscillation (associated with mastication [chewing] sucking and licking) took on communicative significance as lipsmacks, tonguesmacks, and teeth chatters – displays that are prominent in many nonhuman primates. The new role of Broca's area and its surround in human vocal communication may have derived from its evolutionary history as the main cortical center for the control of ingestive processes. The frame and content components of speech may have subsequently evolved separate realizations within two general purpose primate motor control systems: (1) a motivation-related medial "intrinsic" system, including anterior cingulate cortex and the supplementary motor area, for self-generated behavior, formerly responsible for ancestral vocalization control and now also responsible for frames, and (2) a lateral "extrinsic" system, including Broca's area and surround, and Wernicke's area, specialized for response to external input (and therefore the emergent vocal learning capacity) and more responsible for content.

The limbic language/language axis theory of speech

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Abstract: In a recent *BBS* target article, MacNeilage (1998) presents what he claims to be the only theory that can account for the evolution of language. However, major portions of his target article basically repeat and in many respects are identical to the theories of language evolution and development first proposed and detailed by the present commentator.

In a series of books, articles, research, and case studies, Joseph (e.g., 1982; 1986; Joseph et al. 1984) has presented a comprehensive theory of the origin and organization of language, portions of which have been repeated by MacNeilage (1998; also see Damasio & Damasio 1992) and presented in a recent *BBS* article. For example, as summarized in the second edition of the 1990 text, Joseph (1996) details the underlying commonalities between human and nonhuman vocalization, and the hierarchical (limbic, neocortical) organization and representation of speech and oral-laryngeal motor control, beginning with brainstem mediation of respiration and vocalization. MacNeilage makes similar statements but also emphasizes what he believes to be the role of mandibular movements in speech development. According to Joseph (1993; 1996) over the course of evolution the limbic system hierarchically gained control over these brainstem vocalization respiratory centers, beginning with the amygdala and culminating with the evolution of the anterior cingulate (beginning around 200 million years ago), which imparts considerable flexibility to vocal production; and this same pattern is repeated over the course of early development. MacNeilage makes similar statements.

According to Joseph (1993; 1996), the cingulate gave rise to the medial frontal cortex (which also subserves speech) and contributed to the evolution of Broca's area, with which it maintains extensive interconnections. In conjunction with the evolution of the angular gyrus, Broca's area gained hierarchical control over these subcortical and brainstem vocalization centers and can program the adjoining oral-facial motor area to produce segmented units of speech. MacNeilage makes similar statements. To support his position, Joseph (1996) discusses the call systems in primates and points out that ablation of "Broca's area" in primates does not disrupt vocalization, whereas cingulate destruction does. MacNeilage makes similar statements.

In both the first and second edition of the (1990) text, Joseph (1996) also details the role of the medial versus the lateral frontal lobe in speech production and motor control, including detailed discussions of the alien hand and "willful" self-generated behavior. Joseph argues that whereas the medial area is driven by internal input, the lateral (Broca's) speech area is driven by the medial area and the posterior language areas and is highly responsive to external input as transmitted by the sensory receiving (and association, assimilation) areas. MacNeilage makes similar statements.

In addition, Joseph details the role of babbling, as well as that of the neocortical somatomotor and speech areas, in the segmentation, punctuation, and the imposition of syllabification and content on the emotional-melodic contours produced by the limbic system, which allow us to vocalize and shape words. MacNeilage repeats these ideas and makes similar statements.

Finally, although I agree that no other theory can account for the evolution (and development) of speech, it should be evident that except for the comments regarding mandibular movements (an idea that also predates MacNeilage), major portions of this theory were first proposed, detailed, and researched by Joseph, and that the theory is best referred to as the "limbic language" and

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"language axis" theory of language and speech (summarized in Joseph 1996; 2000).

Author's Response

The explanation of "mama"

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Abstract: Joseph apparently does not understand the main purpose of my target article and how different it is from any purpose underlying his work. In addition, most of the neurological ideas of the target article for which he claims unacknowledged priority are not original to him, but instead predate the work of both of us.

My reading of **Joseph**'s work certainly generated respect for its wide-ranging nature. However, he does not appear to have understood what I was trying to do in the target article (MacNeilage 1998t), namely, to give a specific basis in phylogeny and ontogeny for why the *detailed structure* of speech production is the way it is. The differences in our approaches can be seen by looking at how they apply to babbling, which is a central concern in the target article because it is considered to reveal important aspects of the form of the earliest speech.

The operative sentence in Joseph's commentary is: "Joseph details the role of babbling . . . in the segmentation, punctuation, and the imposition of syllabification and content on the emotional-melodic contours produced by the limbic system, which allow us to vocalize and shape words." Joseph's treatment of babbling in his 1982 paper was as follows: "Initially, however, cries, babbles, or, for example the word "mama" do not signify the infant's feeling states, desires, etc. Rather, these are limbically induced motoric responses to the evocation of a diffuse feeling that merely signifies itself" (p. 18). In the (1990) monograph, "babbling speech in infants" was listed in the index as being discussed on pages 64–66, but there was nothing about babbling on those pages. At this point I gave up my search.

Joseph's concern in the (1982) paper was with the communicative significance of the production of "mama." In contrast, in the first paragraph of the target article I stated: "There will be little concern with the evolution of the conceptual structure that underlies speech actions. Instead, the focus will be on . . . How do we explain our remarkable capacity for making the serially organized complexes of *movements* that constitute speech?" (p. 499). Accordingly, for me "mama" is an example of the early appearance of the "Frame," the mandibular cycle that dominates babbling and early speech, and is a key component of the form of adult speech. I am concerned with whether the "exaptation" (Gould & Vrba 1982) of the frame from visuofacial communicative cyclicities might have been the first step toward true speech. For me, the co-occurrence of the nasal consonant [m] with the central vowel [a] makes this an instance of two successive cycles of the most basic frame type – the "Pure Frame," thought to be generated by mandibular oscillation alone, with the tongue in its rest position. The nasal quality of the consonant, which we have also shown to be characteristic of the adjacent vowel (Matyear et al. 1997), is quite fundamental and characteristic of primate vocalization in general. We have also found that an additional factor potentiating the central perceptual quality of the vowel in this context is that nasalization tends to lower the second vowel resonance, which is the main basis for perceptual judgments of vowels in the front-back dimension (Matyear et al. 1997). What is also characteristic of this utterance, and probably of the earliest speech, is that it begins with a consonant and ends with a vowel.

Joseph's complaint is that I have "repeated" without appropriate attribution, portions of his "comprehensive theory of the origin and organization of language." I do not find a *theory* in his writings. As in the case of "mama" there is little emphasis on what the structure of language actually is, without which a theory of how it got that way cannot be constructed. Moreover, most of the claims for priority that he presents involve work that is not original to him, but was first done by others. For example, Joseph claims he has detailed "the underlying commonalities between human and nonhuman vocalization, and the hierarchical . . . organization and representation of speech and oral-laryngeal motor control, beginning with brainstem mediation of respiration and vocalization." A multiple-authored monograph on this topic was published in 1979 by Steklis and Raleigh, predating any of Joseph's references, and most of what I said on this topic was accompanied by citations of more recent work by Jürgens, who in my opinion made the most important contribution to this early book.

Joseph also says that he "details" the intrinsic-medial versus extrinsic-lateral distinction, which was central to the target article. To my knowledge the first systematic statement of this distinction, which I cite, was by Goldberg in this journal in 1985, predating any of Joseph's citations of his own work.

Joseph's (1996) discussion of the role of Broca's area versus cingulate cortex in primate vocalization was most firmly documented, prior to 1996 by Jürgens et al. in their (1982) paper. To my knowledge, the only original claim Joseph makes is that the cingulate gyrus gave rise to Broca's area. I do not find this claim to be adequately justified.

I could give further examples of Joseph's citations of his own views that were antedated by others, but it would be unprofitable. If Joseph's original contributions were neglected by me, so were they neglected in the 27 peer commentaries on the target article. Part of the problem may be that most of the publications he cites are in clinical journals or have clinically oriented titles. If Joseph does indeed have the "only theory that can account for the evolution of language," something I do not claim to have (the target article was about speech production), my advice to him is to get it published in a prominent peer-reviewed journal focusing on pure science in the relevant area.

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[Note: Letters "a" and "r" appearing before authors' initials refer to target article and response, respectively.]

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