gan producing "Mama" at a modal age of 2 months, usually as part of a cry (Goldman 2001). The results showed that some infants uttering "Mama" appeared satisfied if a favorite caretaker approached and paid attention to them, whereas others also needed to be picked up. Another study revealed that, by the time infants are 6 months of age, they understand that the word "Mama" specifically refers to "my Mom" (rather than to any woman), which suggests that they have begun to form a lexicon with sounds that are linked directly to socially significant people (Tincoff & Jusczyk 1999). Thus, it does not seem unreasonable to suggest that the equivalent of the English word "Mama" may well have been one of the first conventional words developed by early hominins. After all, wouldn't maturing prelinguistic infants, then as now, be inclined to put a name to the face that provided their initial experiences of warmth, love, and reassuring melody?

## 4. Concluding thoughts

Motherese has provided a rich source of information for this discussion, which is appropriate since it is the *only* available model for elucidating how humans universally acquire spoken languages today, and therefore may have acquired them in the past. The behaviors of primate (including human) mothers, of course, are pivotal for perpetuating their genes (and their offsprings') into future generations. The central thesis regarding motherese is that bipedal mothers had to put their babies down next to them periodically in order to go about their business, and that prosodic vocalizations would have replaced cradling arms as a means for keeping the little ones content. It is not a stretch to suggest that such vocalizing (and the elaboration of distal gestures) would have had strong selective value. It is reasonable to speculate that by the time individuals across social groups began to originate and conventionally share simple instructive utterances, protolanguage was in the process of emerging from the prelinguistic melody. Whatever its precise nature, however, protolanguage and the other languages that eventually evolved would, forever after, retain some of that melody. Thus, rather than being totally separate from language (Burling 1993), tone of voice represents a signature from its very origin that, as transpired for the cosmic microwave background signature left over from the Big Bang, should be recognized and investigated.

It is hoped that readers will consider the ideas developed in this article as possible alternatives to suggestions that language could not have emerged from an earlier primate communication system (Burling 1993; Hurford 2002); that it was evolved primarily for internal thought and only applied secondarily to communication with conspecifics (Burling 1993); and that the Upper Paleolithic record of artwork indicates it evolved only recently (Davidson & Noble 1989). That said, the precise role of gesture during prelinguistic evolution and the exact nature of the first language are likely to remain academic bones of contention until we get the time machine. In the final analysis, however, at least the suggestion that true syntactic language probably did not evolve until after the emergence of the genus *Homo* around 2 million years ago (Corballis 2002; Rizzolatti & Arbib 1998) rings true to many, if not most, workers.

ACKNOWLEDGMENTS

I thank Robin Dunbar, Michael Corballis, Bill Parkinson, and numerous referees for helpful comments. Ann Powell is gratefully acknowledged for library research.

NOTES

**1.** Although human fathers engage in motherese (or parentese), chimpanzee fathers are unrecognized in the wild and adult males interact relatively little with infants. The parental focus of the present analysis is therefore on females.

**2.** At least one familiar western lullaby reifies the concept of lullabies as substitutes for physical rocking. Interestingly, it also refers to infants falling from trees (or off traveling mothers?). One might therefore suggest (somewhat fancifully) that this lullaby soothes a primordial fear retained from the time when hominin mothers still slept with infants in tree nests (cradles of boughs), as chimpanzee mothers do. Primary stresses are capitalized and underlined; secondary stresses are underlined (modified slightly from Trainor et al. 1997, p. 388):

*ROCK*-a- // bye / *ba*- // by / *ON* the // tree / *top* ///
*WHEN* the // wind / *blows* // the / *CRA*- / dle / will / *rock* ///
*WHEN* the // bough / *breaks* // the *CRA*- / dle /will / *fall* ///
And /// *DOWN* / will / come / *Ba*- // by / *CRA*- / dle / and / all ///

**3.** Another invention of female Japanese macaques that applies to a natural (rather than provisioned) food was not propagated in this way. Nakamichi et al. (1998) report that 11 free-ranging adult females pulled grass roots from the ground, carried them to a river, and washed them (sometimes on flat stones), but that this behavior did not propagate to most of the group. Six of the animals were from one matriline, and two others were a mother and her adult daughter. The authors speculate that root-washing did not spread widely for several reasons: Roots are eaten only during a brief period of the year; carrying is not common among macaques in natural environments; and pulling long roots from the ground would have been difficult for juveniles. One might therefore conclude that, to become conventionalized, an invented behavior must be possible during much of the year, feasible for juveniles as well as adults, and utilize anatomical substrates that are widely available.

# Open Peer Commentary

## Prelinguistic evolution and motherese: A hypothesis on the neural substrates

Francisco Aboitiz[a] and Carolina G. Schröter[b]

[a]*Departamento de Psiquiatría y Centro de Investigaciones Médicas, Escuela de Medicina, Pontificia Universidad Católica de Chile, Santiago, Chile;* [b]*Facultad de Medicina, Universidad de Chile, Santiago, Chile.*

**faboitiz@puc.cl**

**Abstract:** In early hominins, there possibly was high selective pressure for the development of reciprocal mother and child vocalizations such as proposed by Falk. In this context, temporoparietal-prefrontal networks that participate in tasks such as working memory and imitation may have been strongly selected for. These networks may have become the precursors of the future language areas of the human brain.

Falk proposes a hypothesis on prelinguistic evolution in early humans that is based on the development of prosodic vocal communication between mothers and their babies. Vocal communication was used as a mechanism to compensate for the lack of physical



https://doi.org/10.1017/S0140525X04220118 Published online by Cambridge University Press

contact between mother and child during foraging, a consequence of the acquisition of a bipedal posture. We welcome this attempt to incorporate evolutionary theory into the question of language origin, especially in the context of a still-widespread notion that some aspects of language may not have evolved gradually by a mechanism of natural selection.

We would like to contribute to Falk's hypothesis with a more neurobiological perspective. More specifically, our commentary is related to the neural substrates for the development of reciprocal, vocal interaction between mother and child and its relevance to the elaboration of increasingly complex, learned utterances that served for communication and eventually became language. Previously, Aboitiz and García (1997b) proposed a hypothesis for the origin for the neural substrate for language based on the noticeable similarity between the neural networks involved in language and the neural networks required for auditory working memory. The neural networks involved in language may have evolved as a specialization of widespread parietotemporal-prefrontal networks in the cerebral cortex, which were involved in, among other things, generating a working memory device for processing and learning complex vocalizations. A critical aspect of language origins is that language probably developed as part of a communicative system that was learned by imitation. The process of learning increasingly complex phonological utterances requires a specialized neural system based on the ability to internally rehearse a phonological template and to compare the output with the internal representation. For this, a sophisticated working memory system is needed, which is provided by parietotemporal-prefrontal networks connecting higher order auditory and multimodal association areas. The classical Wernicke's and Broca's language areas, which are supposedly connected via the *arcuate fasciculus,* may have evolved as a specialization of these original networks involved in phonological imitation.

Interestingly, recent findings (Chaminade et al. 2002; Iacoboni et al. 1999; Moo et al. 2003) indicate that parieto-frontal networks are involved in imitative learning of hand movements. As Falk mentions, mother and child interactions imply a complex, multimodal set of signals – phonological, prosodical, and gestural – which the child imitates, perhaps by using these complex parietotemporal-prefrontal networks. The physical detachment of mothers and their babies during foraging activities may well have put emphasis on vocal communication and the development of relatively complex phonological signals to help mother and child recognition. Therefore, we postulate that under these conditions, early human mothers engaged in reciprocal vocal interactions with their babies in which the parietotemporal-prefrontal circuits of mother and child became, so to speak, "locked" in such a way that the child incorporated the exaggerated gestures and vocalizations of the mother, generated a template and rehearsed these in the presence of the mother, who then produced new vocalizations or repeated the same ones.

The acquisition of complex phonological utterances probably occurs in ontogenetic stages somewhat older than those in which baby talk normally takes place. However, some of the elements of baby talk, such as the exaggerated gestures, prosody, and smiling, possibly serve to generate appropriate internal representations of social signals in the child and also to establish close contact between mother and child. These representations will permit the mother and child's locking of parietotemporal-prefrontal circuits that enable both of them to establish reciprocal, conversational interactions by which the child eventually masters complex communicational signals. Furthermore, this locking of parietotemporal-prefrontal circuits probably serves as the basis for the development of more complex reciprocal interactions between older individuals, which may be the precursors of true conversations.

The sequence of events we are proposing – an early engagement in baby talk between mother and child, which initiates the coordinated activation of parietotemporal-prefrontal networks in both of them and leads to the generation of increasingly complex communicative networks, which eventually result in conversational behavior between older individuals – is basically ontogenetic. In phylogeny, it may be that initially there was an ontogenetic limit to the development of these neural networks by reciprocal social interactions, but with the increase in brain size during hominin evolution, these networks may have become more complex and more plastic, gradually releasing the barriers which limited the development of reciprocal social, protolinguistic interactions. This opened the possibility of living in a world of conversations which transmitted internal, emotional states but also referred to the surrounding world.

Hemispheric dominance for language may have evolved as a consequence of the development of slightly different temporoparietal-prefrontal networks in both hemispheres, perhaps because these networks might not have been fully compatible within one hemisphere. In this context, the recent finding that the same stimulus can be processed by the left or the right hemisphere depending on the task to be performed (Stephan et al. 2003) suggests that hemispheric asymmetry might rely at least in part on differences in large-scale neurocognitive networks. It is thus conceivable that the neural network involved in some aspects of mother-and-child reciprocal vocal interactions was somehow biased to develop in one side of the brain. (An additional factor promoting brain asymmetry may have been the increasing transmission delay across the *corpus callosum* in large brains, which impaired adequate coordination of both hemispheres for certain tasks; Aboitiz & Montiel 2003.)

In summary: mother-and-child reciprocal vocalizations, which in human evolution possibly increased as a consequence of a "putting the baby down" strategy, were probably based on interlocked temporoparietal-prefrontal networks between mother and child. These networks may have served as templates for the development of more sophisticated neural networks, which permitted acquisition of a syntactically based language.

## Mothering plus vocalization doesn't equal language

Derek Bickerton

*Department of Linguistics, University of Hawaii, Honolulu, HI 97822.*
**bickertond@prodigy.net**

**Abstract:** Falk has much of interest to say on the evolution of mothering, but she fails to address the core issue of language evolution: how symbolism or structure evolved. Control of infants does not require either, and Falk provides neither evidence nor arguments supporting referential symbolism as a component of mother-infant interactions.

Falk has put together a very thorough and detailed account of child-rearing practices among humans and chimpanzees. This account sheds considerable light on the origins of speech. Unfortunately, it tells us nothing about the origins of language.

All too many researchers – Falk, alas, is one of them – still seem to regard the terms "speech" and "language" as synonymous and interchangeable. They are not. Speech, like signing, is a modality. Language is a system of expression, one that may function by means of speech, sign, Morse code, talking drums, smoke signals, naval flags, and, doubtless, modalities not yet conceived; or it may keep its productions within the individual's brain, not employing any modality at all. Until the distinction between speech and language is clearly grasped, little progress will be made in our understanding of language evolution.

It is highly likely that the exigencies of maternal care formed a significant factor in determining that the preferred modality for expressing language should be speech, with sign as a fallback for those with impaired auditory systems. If an infant is running away from you, a sound will work better than a gesture. It is even possible that the distinctive prosodic patterns of "motherese" evolved directly



https://doi.org/10.1017/S0140525X04220118 Published online by Cambridge University Press