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Prelinguistic evolution in early hominins: Whence motherese?

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Abstract: In order to formulate hypotheses about the evolutionary underpinnings that preceded the first glimmerings of language, mother-infant gestural and vocal interactions are compared in chimpanzees and humans and used to model those of early hominins. These data, along with paleoanthropological evidence, suggest that prelinguistic vocal substrates for protolanguage that had prosodic features similar to contemporary *motherese* evolved as the trend for enlarging brains in late australopithecines/early *Homo* progressively increased the difficulty of parturition, thus causing a selective shift toward females that gave birth to relatively undeveloped neonates. It is hypothesized that hominin mothers adopted new foraging strategies that entailed maternal silencing, reassuring, and controlling of the behaviors of physically removed infants (i.e., that shared human babies' inability to cling to their mothers' bodies). As mothers increasingly used prosodic and gestural markings to encourage juveniles to behave and to follow, the meanings of certain utterances (words) became conventionalized. This hypothesis is based on the premises that hominin mothers that attended vigilantly to infants were strongly selected for, and that such mothers had genetically based potentials for consciously modifying vocalizations and gestures to control infants, both of which receive support from the literature.

Keywords: bipedalism; brain size; chimpanzees; foraging; gestures; hominins; infant riding; motherese; prosody; protolanguage

1. Introduction

One of the most fascinating puzzles to confront evolutionary biologists has to do with *Homo sapiens*' ability for speech. Why are we the only animals that talk? How and when did our ancestors begin to formulate and spew forth segmented bits of air into meaningful sequences, and what behaviors led to the earliest language (protolanguage)? In order to formulate hypotheses about the evolutionary underpinnings that *preceded* the first glimmerings of speech in early hominins, this article synthesizes findings from infant and child development, psychology, primatology, and anthropology.

It is widely recognized that acquisition of vocal language is scaffolded onto the special sing-song way in which parents vocalize to their infants, known as "baby talk" or *motherese* (Dooling 1974; Ferguson 1977; Hirsh-Pasek & Golinkoff 1996; Hirsh-Pasek et al. 1987; Karmiloff & Karmiloff-Smith 2001; Monnot 1999; Snow 1972; 1998; 2002). As detailed below, the worldwide practice of directing musical speech toward human babies provides a temporary framework or scaffold that, among other functions, facilitates their eventual comprehension and production of speech. Nevertheless, one school of thought views the main feature that distinguishes motherese from adult-directed (AD) speech, namely tone of voice or prosody, as a component of a primate gesture-call system that is totally separate from language. Burling (1993), for example, notes that "tone of voice amounts to an invasion of language by something that is fundamentally different"(p. 30). However, because motherese is the medium in which infants around the world initially perceive and eventually process their respective languages, an analysis of its features may elucidate the prelinguistic foundations of the protolanguage(s) evolved by early hominins. Instead of separating prosody from language, then, the view developed below is that parental prosody is not only an integral component for propagating language today, it also formed an important substrate for the natural selection of protolanguage in early *Homo.* In addition to focusing on infant-directed (ID) communications of parents, clues for modeling the evolution of prelinguistic behaviors are also gleaned from examining the processes by which infants acquire languages.

Although there is a robust literature on the vocal aspects of motherese, few workers have appreciated the important parallel roles of mother-infant interactions in visual, gestural, and tactile domains. For example, infant-directed communications from mothers of 3- to 4-month-old infants are frequently accompanied by exaggerated facial expressions that have precursors in other primates and that signal

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affiliation and invitation for contact (e.g., raise eyebrows, eyebrow flash, smile, nod, bob head backward) (Dissanayake 2000). With this in mind, mother-infant interactions that encompass visual, vocal, gestural, and tactile communication are compared below in chimpanzees and humans in order to identify the probable nature of the mother-infant interactions that characterized early hominins.[1]

Hominins are believed to have spent much of their prehistory in fission-fusion communities that foraged daily for food, which entailed mothers traveling in the company of dependent offspring and a small number of other individuals (Nishida 1968; Stanford 1998). Around the time of the australopithecine/early *Homo* transition, maternal pelves that had been modified to accommodate bipedalism became subject to an emerging trend for increasingly large brains (Falk 1998; Falk et al. 2000), which eventually caused a selective shift toward females that gave birth to relatively helpless infants (Small 1998). Consequently, the ability of babies to cling actively to their mothers was lost in hominins (Ross 2001). Similar to some anthropoid mothers that live under difficult foraging circumstances (Fuentes & Tenaza 1995; Lyons et al. 1998), these mothers are hypothesized to have adopted postnatal foraging-related changes in maternal care, which included periodically putting their infants down beside them in order to obtain and process food. As a result, the incidence of distal mother-infant gestural communications increased (Tomasello & Camaioni 1997) and prosodic (affective) vocalizations became ubiquitous to compensate for the reduction in sustained mother-infant physical contact.

The *"putting the baby down" hypothesis* focuses on events that *preceded* the emergence of protospeech, and is in keeping with the *continuity hypothesis* that the biological capacity for language evolved incrementally within the hominin line (Armstrong et al. 1994; King 1996): "differences between human language and nonhuman primate communication are only quantitative and . . . these differences may be accounted for by gradual shifts in abilities due to changing selection pressures – perhaps in the ability to create . . . communicative utterances (Gibson 1990) or to donate information to others" (King 1996, p. 193).

According to the *discontinuity hypothesis,* on the other hand, language appeared suddenly, without phylogenetic links to earlier communication systems (Burling 1993). This latter hypothesis views "language backward through the lens of contemporary linguistic theory rather than in the context of how evolution operates" (Callaghan 1994, p. 359). Most evolutionary biologists, however, believe that reproductive fitness (an individual's production of viable offspring) is the driving force behind evolution and that, whether it proceeds gradually or rapidly, most "evolutionary change occurs in the context of what is already in place as a result of prior selective pressures" (Callaghan 1994, p. 359). The present paper is grounded squarely on this premise. Thus, contemporary motherese is viewed as the result of prior selective pressures, the nature of which is explored in the following sections. Since language acquisition today is universally scaffolded onto motherese, it is argued that selection for vocal language occurred after early hominin mothers began engaging in routine affective vocalization toward their infants, a practice that characterizes modern women, but not relatively silent chimpanzee mothers. Below, it is shown that human infants are "primed" to learn their native languages by the particular flavor of motherese to which they are exposed. As well, data are presented that strongly suggest that this universal practice and its associated ontogenetic unfolding of language acquisition in human infants is genetically driven. For all of these reasons, "positing a phylogenetic discontinuity between primate vocal communication and speech seems to [be] an unnecessarily complicating assumption in the absence of more compelling evidence" (Armstrong et al. 1994, p. 358).

2. Mother-infant interactions in chimpanzees and humans

2.1. Mother-infant communication in chimpanzees and bonobos

Because common chimpanzees (*Pan troglodytes*) and the less-studied bonobos (*Pan paniscus*) provide the best referential models for early hominin behavior (Falk 2000; Moore 1996), this section reviews the literature on their mother-infant interactions in order to provide background for examining the evolution of prelinguistic behaviors. As is the case for humans, the period during which infant and juvenile chimpanzees are emotionally and physically dependent upon their mothers is extended compared to monkeys. Indeed, prolongation of the various developmental stages is thought to be one of the trends that characterized the evolution of higher primates. According to this view, increased durations of dependency facilitated extended learning associated with the evolution of bigger-brained, highly intelligent, and longer-living primates (Falk 2000).

Much of what is known about the vocalizations of wild common chimpanzees has been discovered by Jane Goodall and her colleagues (Goodall 1986). Many emotional states of chimpanzees are obviously similar to those of humans, and are expressed in a variety of easily recognizable facial expressions (Preuschoft 2000; Preuschoft & van Hooff 1995; Schmidt & Cohn 2001) that, in turn, are frequently linked with particular vocalizations. Chimpanzees produce vocalizations by alternating the sizes and shapes of their mouths and resonating cavities, and "facial expressions play a key role in close-up communication between chimpanzees" (Goodall 1986, p. 119), which may be related to the fact that, at about the age of 3 months, infants show "a sudden intense interest for the mother's face" (Plooij 1984, p. 142).

Goodall (1986) notes that vocal communication of chimpanzees is far more complex than previously appreciated, and has classified 34 discrete calls along with the emotions with which they are associated. She also observes that chimpanzee listeners learn much from the sequences of vocalizations that pass back and forth between individuals. (For example, the *screaming* of an adult followed by *squeaks* and then *pant-grunts* indicates to a distant chimpanzee that an aggressive interaction has occurred and that the victim has relaxed and approached the aggressor.) Chimpanzee calls are distinguished (with presumably more difficulty for human than chimpanzee listeners) from an acoustically graded continuum. Thus, the *hoo* is an isolated but distinctive part of the *whimpering* sequence:

> The single hoo may be uttered several times in succession, but each vocalization is made separately; as a hoo sequence starts to rise and fall in pitch and volume, and when each sound is produced in temporally rapid succession, it grades into the whimper. The hoo is uttered by both an infant and (much less often)

> his mother when they need to reestablish physical contact – when, for example, the infant wants to ride on his mother's back during travel or when she reaches to retrieve him from a situation she perceives to be dangerous. (Goodall 1986, p. 129)

In addition to *hoos,* several other calls are used by infants as well as older chimpanzees, including *screams* (mothers recognize those of their infants); *whimpering* (most commonly heard in infants, especially during weaning); and *tantrum screams* (which occur in older infants that have been rejected during weaning). Plooij (1984) discusses several additional calls that are emitted by common chimpanzee infants including *effort-grunts, staccatos,* and *uh-grunts.* Because chimpanzees are unable to cling properly for the first two months of life, they are as helpless as human neonates and must be carried and supported on the ventral side of their mothers' bodies (Plooij 1984). Significantly, maternal support for chimpanzee infants varies, is related to their whimpering, and is crucial for infant survival:

> Some mothers supported and carried their babies almost continuously from shortly after birth whereas others restricted themselves to the minimum necessary not to lose their baby. Consequently, during locomotion over greater distances (=travel) babies from the first group were safe; they rarely whimpered or screamed. Babies in the second group, on the other hand, whimpered frequently when loosing their grip on the mother's hair, dangling from only one or two of their four limbs. . . . The maternal support is of vital importance to the baby. *Without it, the baby would surely fall off and may die* (Plooij 1984, p. 45, emphasis mine).

The structure and contextual use of vocalizations of bonobos have been investigated in the wild (Bermejo & Omedes 1999, p. 355). Voices of bonobos are higher pitched than those of common chimpanzees (Kano 1992), and their utterances appear to be more structured and flexible and to always occur in the context of facial expressions, gestures, and tactile communication (Bermejo & Omedes 1999). In bonobos, *peep* sequences are among the most important vocalizations, and *croaks, muffled barks,* and *panting laughs* are used mainly by young individuals. *Peep yelps* and *peeps* that may escalate into *screams* are given by infants that are prevented from nursing, accompanied by intense pouts. Bonobos also produce choruses in which individuals echo each other's calls, and seem to be trading information about emotions and intentions during aggressive confrontations that involve vocalizations, which led de Waal (1997) to suggest that bonobos appear to engage in more language-like exchanges of information about their internal states than do common chimpanzees. Although de Waal did not claim that bonobos talk, they seem, at least, to have a latent ability to learn names, as shown by a study in which two human-enculturated bonobos were able to learn to comprehend English words for novel objects with few exposures to the novel items, an ability that did not require visual contact with items during acquisition of their names (Lyn & Savage-Rumbaugh 2000). In this context it is interesting that, although many believe that apes do not imitate vocally (Fitch 2000), recent spectrographic and statistical analyses reveal that the well-known bonobo Kanzi produces distinct vocalizations for "banana," "grape," "juice," and "yes" (Taglialatela et al. 2003).

2.1.1. Infant-directed vocalizations of common chimpanzees. Mothers of infant chimpanzees are notoriously shy (McGrew 1992) and, except for *hoos,* calls that are specifically directed by mothers to their infants are rarely mentioned in the literature. The few other maternal ID calls noted by Goodall (1986) include *replies to screams* of their infants "even if the child is out of sight" (p. 131), and *soft barks* or *coughs* given in mild rebuke to weaning infants that begin to suckle after throwing temper tantrums (p. 576). Chimpanzee mothers have also been reported to emit soft vocalizations while examining their infants (Nicolson 1977). Maestripieri and Call (1996) note that, when they occur, ID vocalizations of chimpanzee mothers, such as *hoos* and *whimpers,* are similar to the vocalizations produced by their infants. It is significant that one of the few circumstances under which chimpanzee mothers routinely produce ID vocalizations is in conjunction with foraging and travel. For example, *hoos* are uttered to retrieve infants for travel, and "soft grunts may be exchanged when . . . two or more familiar chimpanzees, especially family members, are foraging or traveling together. Typically one individual grunts when he pauses during travel, or when he gets up to move on. . . . Thus these grunts function to regulate movement and cohesion" (Goodall 1986, p. 131).

2.1.2. Infant-directed vocalizations of bonobos. Bermejo and Omedes (1999) note that bonobo mothers in the wild are very sensitive to *screams* of their infants and emit *barks* or *hiccups* during alarm situations, which elicit immediate responses from offspring. Similar to common chimpanzees, bonobo mothers have also been observed vocalizing in order to retrieve infants for travel:

> Nevertheless, the mother often carries her offspring during travel until it is at least three or four years old. The signal initiating this kind of transportation is the mother's vocalization. Then, after walking a short distance, up to 6 m, she will stand with one foot slightly lifted, the sole facing toward the rear, in a stationary walking position. There she will stand, waiting for the juvenile to run after and jump onto her back. (Kano 1992, p. 164)

Bonobos are thought by some to be more intelligent than common chimpanzees, partly because of their relatively greater success at learning nonvocal, humanlike language (Savage-Rumbaugh 1984; Savage-Rumbaugh et al. 1998). Compared to common chimpanzees, the human-enculturated bonobo Kanzi accompanies many gestures with spontaneous vocalizations that "appear to be voluntary and used intentionally to draw attention to Kanzi and to what he wants" (Savage-Rumbaugh 1984, p. 408). Although his adoptive mother (Matata) anticipated and aided Kanzi's developing locomotor activities, there is no indication that she vocalized during these ID gestures. In sum, although both bonobos (Kano 1992) and common chimpanzees have rich vocalization systems, there is little evidence that mothers engage in a significant amount of ID vocalization, in stark contrast to the case for humans.

2.1.3. Infant-directed gestures of common chimpanzees. Although chimpanzees use gestures involuntarily to express moods, as well as intentionally to call attention to themselves or to deliver imperatives, their repertoire of gestures anticipates but fails to achieve the sophistication of that acquired by a typical 1-year-old human child (Tomasello & Camaioni 1997). Tomasello and Camaioni point out three characteristics of natural gesturing in chimpanzees that differ from gesturing in human infants: (1) Chimpanzee gestures are almost exclusively dyadic (used to attract attention to oneself) instead of mostly triadic (used to attract attention to an outside party), (2) their gestures remain largely imperative without developing declarative or referential elements, and (3) most chimpanzee gestures involve physical contact between the signaler and recipient (i.e., they are not distal). Significantly, the two triadic exceptions noted for chimpanzee gestures by Tomasello and Camaioni (1997) appear to be similar to *request* and *offer* gestures of human mother-infant pairs (Messinger & Fogel 1998, see sect. 2.2.1), not only physically, but also motivationally (i.e., used to request food and to seek positive social contact).

For chimpanzees, ID gestural communication appears to be much richer than ID vocal communication. A newborn common chimpanzee is licked and groomed by its mother immediately after birth, and bouts of maternal ID grooming increase in duration during the first year of its life (Goodall 1986). Plooij (1984, Appendix A) documents a rich repertoire of ID gestural and kinesic behaviors toward developing infants in chimpanzee mothers from Gombe related broadly to carrying, cradling, nursing, weaning, play, traveling, and acquisition of motor skills. ID gestures have also been noted for captive mothers (Nicolson 1977), two of which spent considerable amounts of time examining their young infants. One cradled her infant and "kissed" it on the mouth (p. 541). Captive mothers also frequently patted their infants' heads and backs. The captive mothers seemed to test and encourage their infants' developing motor skills by giving them "walking lessons" (pp. 541–42). The first cross-fostered chimpanzee schooled in American Sign Language for the Deaf (ASL), Washoe, has even been reported to mold her adopted son Loulis's hands in the form of a sign (Fouts et al. 1989). (It is important to note, however, that gesturing should not be confused with sign language because it lacks the complex grammar and arbitrariness found in the latter [Karmiloff & Karmiloff-Smith 2001].)

Some of the most interesting ID gestures of chimpanzee mothers have been observed in conjunction with feeding. Mothers begin sharing solid food with infants when they are about 5 months old, and have been observed snatching leaves that were not part of their normal diet from their infants' mouths (Goodall 1986). In addition to teaching infants which foods are palatable, Goodall believes this sort of ID intervention serves to reinforce traditional food preferences in chimpanzee communities. Along these lines, it is fascinating that at least some chimpanzee mothers from the Taï forest, Ivory Coast, have anecdotally been reported to teach their offspring to use implements such as rocks to crack open nuts that have been placed on anvils (Boesch 1991; Boesch & Boesch-Achermann 1991).

Play is the hallmark of a young chimpanzee's life, and its frequency peaks between the ages of 2 and 4 years (Goodall 1986). Females with infants play more than other adults, which entails a good deal of ID physical activity:

> A chimpanzee infant has his first experience of social play from his mother as, very gently, she tickles him with her fingers or with little nibbling, nuzzling movements of her jaws. Initially these bouts are brief, but by the time the infant is six months old and begins to respond to her with play face and laughing, the bouts become longer. Mother-offspring play is common throughout infancy. (Goodall 1986, pp. 369–70)

Significantly, turn-taking in chimpanzees has been documented in the context of mother-infant play: "The early biting triggered the onset of mother-baby play: contingent upon when bitten, the mother started to tickle the baby and this biting-tickling grew into an alternating interaction, in which both mother and baby could take their turns" (Plooij 1984, p. 142).

As the infant matures in the wild, its mother "shapes and cushions his first interactions with other individuals" (Goodall 1986, p. 568), primarily by keeping a wary eye on the infant, which she hurries to remove from potentially harmful social situations. Although chimpanzee mothers are extremely lenient, occasionally a mother seizes her infant and drags it away, for example, if it continues to ignore her obvious signals that it is time for them to move on to a new location (p. 368). Maternal tolerance decreases during an infant's fourth and fifth years as it is weaned and forced to walk by itself. When juveniles throw temper tantrums, their mothers often give in by embracing them and allowing them to suckle. For example, after a 4-year-old son who was being weaned was rejected twice while attempting to climb onto his mother's back, he uttered terrified screams that galvanized her "into instant action, [she] rushed back and with a wide grin of fear gathered up her child and set off – carrying him" (p. 582).

2.1.4. Infant-directed gestures of bonobos. ID gestures of bonobo mothers are similar to those of common chimpanzees. Infant bonobos and common chimpanzees begin eating solid food at about the same age, although the two species differ in how they request solid food from their mothers (Kano 1992). The most observed pattern in common chimpanzees is for infants to put their mouths near their mothers' mouths. In bonobos, the most prevalent form of begging is for the offspring to touch their mothers' mouths. Under these circumstances, bonobo mothers may look away while shaking their heads as if annoyed, but they usually give up the food. As Kano (1992) summarizes, "a kind of food-sharing occurs frequently in which a juvenile approaches and snatches food from its mother or takes food directly from her mouth. The mother certainly does not dole out the food, but she lets her offspring pull and bite at it" (p. 167).

Bonobo mothers frequently play with their infants using slow-moving and gentle motions, often while resting in day nests. During play, mothers tickle with their fingers, play-bite, and grab their infants. "While lying sprawled looking up, she will tickle the infant and hold its hands and feet; hanging high in space, the infant looks very happy and fortunate" (Kano 1992, p. 132). Interestingly, bonobo mothers in this position sometimes appear to be playing "airplane" with their infants (p. 165).

Based on observations of Kanzi and his mother, Matata, Savage-Rumbaugh (1984) and Savage-Rumbaugh et al. (1998) suggest that bonobo mothers foster the emergence of intentional communication skills in their infants by responding to their gestures for aid as they move independently from place to place. Matata monitored Kanzi's acrobatics closely when he was 4 to 11 months old and "would nearly always raise a foot or arm toward Kanzi and shove him toward the object he had been trying to reach . . . Kanzi, like human infants, began to signal his desired intent to go to a particular location and to look back and forth between his locomotor goal and his mother" (Savage-Rumbaugh 1984, p. 405). Such gestures and visual checking appeared rather suddenly when Kanzi was 10 months old, and he then began to "ask" his mother to pick him up, and to help him reach a particular place. At the same age, Kanzi's half-brother, Akili, also signaled his desire for help getting from one place to another to Matata. Shortly after Kanzi began signaling his intentions, he spontaneously began to point by touching objects with an extended index finger. Although common chimpanzees may use an extended hand to refer to things, use of an extended index finger is rare (Butterworth 1997; Savage-Rumbaugh 1984).

It must be kept in mind, however, that Kanzi is a bonobo that was enculturated by humans (Savage-Rumbaugh et al. 1998), rather than mother-reared in a more natural setting, which has important implications for learning to engage in social interactions that focus attention on a third entity and, indeed, the development of triadic gestures (Tomasello & Camaioni 1997; Tomasello et al. 1993). Unlike mother-reared chimpanzees, enculturated chimpanzees imitatively learn actions upon objects in a manner similar to young children, an ability that appears to be scaffolded onto *socialized attention,* which is acquired by interacting with humans (Tomasello et al. 1993). Tomasello et al. argue that such "broadly based skills of social cognition are a prerequisite to the acquisition of language skills" (p. 1702).

By the time the wild bonobo is 6 months old, it starts to move around the periphery of its mother. If the infant attempts to go far away, however, the mother will bar its way with her hand and resume carrying it. Mothers continue to carry their offspring during travel until they are 3 to 4 years old. Similar to common chimpanzees, when it is time to move within or from trees, bonobo mothers assume a posture and wait for their infants to jump on their backs. When the infant gets close, its mother may extend her hand toward it (Kano 1992).

2.1.5. Chimpanzee and bonobo laughter. According to Goodall, laughing that somewhat resembles human laughter is heard during play sessions. Although most laughter results from physical contact such as tickling, it also occurs during chasing play. Because they play more frequently, infants laugh more than adults. "Sound spectrograph analysis shows a change from steady exhaled sound, to chuckle-like pulsed exhaled sound, to 'wheezing' laughter" (Goodall 1986, p. 130). Sonagrams have also been collected of short series of rhythmic *panting laughs* in wild bonobos, which are the only bonobo vocalizations that are clearly associated with only one context, namely play (Bermejo & Omedes 1999).

Provine (1996; 2000) notes that chimpanzee laughter has the sound and cadence of a handsaw cutting wood, and differs from that of humans in the way that sounds are typically related to the airstream. The vowel-like notes of human laughter (e.g., "ha") "are performed by chopping a single expiration, whereas chimpanzee laughter is a breathy panting vocalization that is produced during *each* brief expiration and inspiration" (Provine 1996, p. 40). Chimpanzee laughter also lacks the vowel-like notes that typify human laughter. In other words, unlike the norm for humans, chimpanzees breathe in and out as they produce a breathy, panting laughter. (In a personal communication, however, Phillip Tobias noted that the late Louis Leakey had a marvelous belly laugh that was vocalized on both the exhale and the inhale, an anecdote which shows that the classic human "ha-ha" laugh is a central theme around which variation occurs.) Provine suggests that chimpanzee-like laughter was present in the common ancestor of apes and humans. If so, it would have been an important component of mother-infant communication in early hominins.

2.2. Motherese in humans

Human infants discover how rhythm organizes their native languages between birth and 2 months of age (Karmiloff & Karmiloff-Smith 2001). In most cultures, learning to process the rhythms of speech is facilitated by the special way in which infants are addressed, known variously as motherese, *musical speech* (Trainor et al. 2000), or infant-directed (ID) speech. In ID speech, intonation contours around phrases are exaggerated, as are stress patterns within words and sentences. Many repetitions and questions with rising intonations are used. The following examples provide a feel for the exaggerated stressed syllables (in capitals) that typify motherese (see also Wheeldon 2000):

> Aren't YOU a nice BAby? Good GIRL, drinking all your MILK. Look, look, that's a giRAFFE. Isn't that a NICE giRAFFE? DOGgie, there's the DOGgie. Ooh, did you see the lovely DOGgie? (Karmiloff & Karmiloff-Smith 2001, p. 47)

Infants' preference for ID as opposed to adult-directed (AD) speech increases during the first several months of life (Cooper et al. 1997), and ID speech is used most intensively with 3- to 5-month-old infants, although it persists until around 3 years -of-age (Stern et al. 1983). Six-month-old hearing and deaf infants also show greater attention and responsiveness to ID than to AD Japanese Sign Language (Masataka 1998).

Despite several "flawed" studies to the contrary, Monnot (1999) marshals strong support for the hypothesis that ID speech that is characterized by a simplified vocabulary, more repetition, exaggerated vowels, higher overall tone, wider range of tone, and slower tempo is a universal trait among modern humans. Pitch and rhythmic structure comprise two main dimensions of singing and music, as well (Dissanayake 2000). The singing of lullabies and playsongs to infants is also universal (Trehub et al. 1993), conveys meaning that is emotional rather than linguistic, and has acoustic features that are similar to ID speech: "For both playsongs and lullabies the tempo was slower, there was relatively more energy at lower frequencies, inter-phrase pauses were lengthened, and the pitch and jitter factor were higher" (Trainor et al. 1997, p. 383). From the beginning, then, babies everywhere are predisposed to respond to certain maternal vocalizations that function as unconditioned stimuli that alert, please, soothe, and alarm the infant (Fernald 1994). The *universalist hypothesis* also specifies that ID speech contributes initially to infant emotional regulation, then to socialization, and finally to the acquisition of speech in a sequential, age-appropriate manner (Monnot 1999; Trainor et al. 2000).

Vocal, gestural, and kinesic social interactions between parents and infants serve, in part, to reinforce the latter's attention to, and eventual development of, language. Thus, parents unconsciously establish eye contact with infants and then use motherese to maintain joint attention. As parents realize infants are responding to their voices by kicking, jerking, or with coos and gurgles, they begin taking turns with the infants. Parents speak, pause for the infant response, then speak again. As Karmiloff and Karmiloff-Smith note (2001), "These 'conversations' that are initially one-sided linguistically may actually constitute an important preparation for taking part in later dialogue when the toddler will be capable of using language to replace the primitive kicks and gurgles" (p. 48).

What is particularly important for this discussion is that, rather than meaning or grammar, it is the melodic and exaggerated prosodic patterns of ID speech that initially interest infants (Karmiloff & Karmiloff-Smith 2001). The melodies of mothers' speech are compelling stimuli that are effective in eliciting emotion in preverbal infants (Fernald 1994; Morton & Trehub 2001; Soken & Pick 1999) and, in addition to revealing information about mothers' feelings and motivational states, may be used instrumentally to influence infants' behaviors:

> When the mother praises the infant, she uses her voice not only to express her own positive feelings, but also to reward and encourage the child. And whether or not the mother feels anger when producing a prohibition, she uses a sound well designed to interrupt and inhibit the child's behavior. . . . *In this respect, the use of prosody in human maternal speech is similar to the use of vocal signals by some nonhuman primates."* (Fernald 1994, p. 64, emphasis mine)

As babies mature, motherese has an important role for their development of speech. For example, English, Russian, Swedish, and Japanese mothers hyperarticulate vowels when addressing their infants (but not other adults), thus amplifying the phonetic characteristics of vowels and facilitating the phonological aspects of their infants' development (Andruski et al. 1999; Burnham et al. 2002; Kuhl et al. 1997). The fact that hyperarticulation is didactic rather than merely reflecting high emotional content is illustrated by a comparative study of pitch (fundamental frequency), affect (intonation and rhythm), and vowel hyperarticulation (vowel triangles) of mothers as they spoke to their 6-month-old infants, their pets (cats or dogs), and other adults:

> These results show that infant- and pet-directed speech are similar and distinctly different from adult-directed speech in terms of heightened pitch and affect. Interestingly, only infant-directed speech contains hyperarticulated vowels. Thus, vowel hyperarticulation does not accompany special registers simply because they differ from adult speech in pitch and affect. Rather, it seems to be a didactic device: Mothers exaggerate their vowels for their infants but not for their pets. (Burnham et al. 2002, p. 1435)

By around 10 months of age, children begin to babble in rhythms that are consistent with the prosodic structure of their language (Levitt 1993). At a fundamental level, the vocal turn-taking that develops between mothers and their babbling babies (Karmiloff & Karmiloff-Smith 2001) helps the latter grasp the "rule" that conversationalists take turns. Such "social syntax" (Snowdon 1990) may enhance infants' acquisition of other rules that are preliminary to learning the proper arrangements for elements within sentences (syntax). Infants appear to learn an important aspect of syntax, namely, the boundaries between linguistic categories such as words or phrases, through *phonological bootstrapping*, that is, by attending to the correlations between the prosodic cues of motherese (phonological features, intonation, stress, vowel length) and linguistic categories (Burnham et al. 2002; Gleitman & Warner 1982; Morgan 1986; Morgan & Demuth 1996).

By the time infants reach the single word stage (at around 17 months of age), they are becoming sensitive to the way in which different word orders convey different meanings in English (Hirsh-Pasek & Golinkoff 1996). But once infants acquire some feel for linguistic categories, how do they begin to grasp a sentence's meaning? Pinker (1987; 1994) suggests a likely mechanism is through *semantic bootstrapping* – the mapping of sounds onto mental semantic concepts such as transitive and intransitive verbs. Thus, after an infant has learned the meanings of the relevant nouns, he or she is able to infer the semantic meaning of syntactical categories from the context in which they are heard:

> Upon hearing "The boy is patting the dog," for example, the child needs to know what the words "boy" and "dog" mean before he can even start a grammatical analysis of the sentence. Then, upon seeing the accompanying action (boy touching the dog's back), the child can use this real-world situation to make the formal linguistic analysis, mapping "the boy" to the subject noun phrase, and "patting the dog" to the verb phrase containing a direct object. In other words, to get syntax under way, the child initially extracts an appropriate semantic representation for a verb by mapping the extralinguistic context onto the syntactic string and by inferring what the speaker is trying to convey. In this way, the child is able to learn that "pat" means to move your hand on something in a certain way, as he can infer from the extralinguistic context. He can also derive from the linguistic context that "pat" is a transitive verb that must take a direct object. (Karmiloff & Karmiloff-Smith 2001, p. 115)

Although Pinker's hypothesis is difficult to apply to non-transparent situations, it finds support from research that shows that most of the utterances addressed to infants in the early stages of learning a language are simple, active sentences of the type, "The boy is patting the dog" (Karmiloff & Karmiloff-Smith 2001). What is particularly important for the present discussion is that Pinker stresses the importance of nonsyntactic prosodic cues provided by motherese for semantic bootstrapping.

Recent work illustrates that motherese is also important for infants' acquisition of morphology (Kempe & Brooks 2001). In certain languages in which nouns are classified into different gender classes in ways that seem arbitrary rather than systematically form-based, diminutives are used more frequently when talking to children than adults and serve to increase the transparency of the gender markings. In these languages, learners exposed to diminutives are able to generalize gender from the diminutives' transparent suffixes to the nouns that they modify. Diminutives are important for acquisition of proper gender or case markings in Russian, Spanish, Finnish, Lithuanian, and "there is widespread agreement that the occurrence of diminutives in CDS [child-directed speech] is primarily motivated by pragmatic and semantic factors" (Kempe & Brooks 2001, pp. 251–52).

To summarize, the above studies show that motherese varies between cultures in subtle ways that are tailored to the specific difficulties inherent in learning particular languages. Additional studies on speech development in infants document the effects of prosody on syllable omission (Lewis et al. 1999) and reduction (Snow 1998); the shaping of monosyllabic utterances (Snow 2002) and words (Demuth 1996; Fee 1997); auditory memory of speech (Mandel et al. 1994); and prediction of dialogue structure (Hastie et al. 2002). As a general rule, infants' perception of prosodic cues in association with linguistic categories is important for their acquisition of knowledge about phonology, the boundaries between words or phrases in their native languages, and, eventually, syntax. Prosodic cues also prime infants' eventual acquisition of semantics and morphology. Finally, the fascinating discovery (Burnham et al. 2002) that infant-directed speech contains separate elements that serve to express emotions, on the one hand, and function as didactic devices, on the other, is consistent with the view that motherese evolved incrementally from largely affective ancestral vocal communications to its present highly complex form.

2.2.1. Multimodal motherese in humans. Because communication with infants involves tactile and visual as well as auditory stimuli, interest is growing in multimodal motherese that involves gesture, facial expressions, and touching of infants in addition to vocal utterances (Dissanayake 2000; Fogel 1993). For example, studies of American and Italian mother/infant pairs suggest that ID speech is accompanied by ID bodily gestures that are relatively simple compared to gesticulations directed towards adults (Iverson et al. 1999; Shatz 1982). Compared to AD gestures, ID gestures occur less frequently, are simpler and less abstract, and function to highlight certain utterances or to attract attention to particular objects. As Italian infants' absolute numbers of both gestures and words increased between the ages of 16 and 20 months, their relative use of gestures decreased from 42% to 27%, in proportion to the sharp increase in word production (Iverson et al. 1999, p. 65). Rather than adding information to verbal communications, most ID gestures serve to reinforce the linguistic message.

ID speech is perceived visually as well as aurally by infants. Facial imitation has been reported for human neonates (Meltzoff 1988), and 3- to 4-month-old infants imitate mouth movements only when auditory and visual representations of vowels are temporally coordinated (Legerstee 1990). Four-month-old infants also prefer vowels that are presented with the visual image of the appropriate mouth shape (Kuhl & Meltzoff 1988). Similarly, 5-month-old infants prefer speech sounds that are steadily increased in amplitude when they are presented with gradually opened mouths (Mackain et al. 1983). These studies suggest that infants attend to mouth shapes that correlate with speakers' utterances (Gogate et al. 2000). Maternal speech is also tied to facial expressions at other levels (Schmidt & Cohn 2001): The muscles of facial expression participate in the mother's articulation of speech sounds (Massaro 1998) and contribute information about their meaning (Ekman 1979). Facial expressions on the part of the infant, on the other hand, provide cues about his or her attentiveness to the mother's speech. Interestingly, women appear to be more sensitive and accurate decoders of facial expressions than men (Hall 1984; McClure 2000), and infants appear to vary their facial expressions depending on the sex of the parent (Forbes et al. 2000).

Gogate et al. (2000) studied multimodal motherese involving vocal, gestural, and tactile stimuli in European, American, and Hispanic mother/infant pairs representing three developmental ages: prelexical (5–8 months), early-lexical (9–17 months), and advanced-lexical (21–30 months) infants. Mothers were asked to teach novel names for two brightly colored puppets (dubbed *chi* and *gow*) and two verbs (*pru* meaning leap, and *flo* meaning shake) to their infants by any means they would normally use. Nearly 100% of the mothers' communications were multimodal, with mothers tailoring their productions to the infants' lexical development when specifically teaching words. Mothers spoke the target words synchronously with moving the puppets and touching their infants with them ("auditory-visual-tactile synchrony") in decreasing frequencies from earlier to later developmental stages. This suggests that mothers' trimodal coordination "highlights word-referent relations for infants on the threshold of lexical development" (Gogate et al. 2000, p. 890). Mothers of advanced-lexical infants, on the other hand, were more likely to name objects and actions when the object remained static or was held by the infant. Further, "the decrease in maternal use of temporal synchrony . . . appears to be well-timed with infants' at 14 months increased ability to detect word-referent relations without temporal synchrony on the basis of object motion alone. . . . In addition, mothers' naming of objects or actions with static objects seems well adapted to older infants' ability to glean word-referent relations on their own" (p. 891).

Messinger and Fogel's fascinating 1998 study demonstrates how vocalizations combined with certain gestures become increasingly intentional or instrumental rather than emotionally induced as infants mature, and supports the opinion that intentional gestures were important during language evolution (Corballis 2002; Rizzolatti & Arbib 1998). In Messinger and Fogel's study, smiling, gazing at mothers, and manual gestures (with and without accompanying vocalizations) were analyzed in 11 infants between 9 and 15 months of age as they played with their mothers, several times a month. Gestures were coded as *requests* when either mother or infant extended an arm toward an object, pointed to it, or made a palm-up gesture in a context that indicated a desire for the partner to give the object to the requester; and scored as *offers* when either gave an object he or she was holding to the other. When vocalizations accompanied gestures, approximately 96% of them did not involve recognizable words, that is, they were nonverbal. Interestingly, the proportion of infant requests involving vocalizations rose with age, showing "that as infants approach 15 months of age, they use the behavioral precursors of speech instrumentally to communicate their desire for objects," and these "infant vocalizations increased the instrumental tone of infant gestures, particularly because the vocalizations were not related to either gazing at mother or infant smiling" (Messinger & Fogel 1998, p. 587). Infant offers, on the other hand, did not rise significantly with age, but were more likely to involve smiling and gazing at the mother. Thus, "in offering objects to mother, infants appeared to share and create positive social contact" (p. 586). It appears that infants increasingly use vocalizations with requests to compensate for the fact that they are more ambiguous than manual offers (p. 584), and that "in so doing, they may be combining linguistic topics (the object referred to) with comments (the request gesture) in a manner that presages more complex language use" (Rome-Flanders & Cronk 1995). This important study suggests that development of intentional manual gestures in infants is accompanied by increased use of vocalizations that precede the production of actual words.

The gestures studied by Messinger and Fogel (1998) were triadic rather than dyadic (see sect. 2.1.3). The request and offer gestures were also imperative ("Take this!" or "Give me that!") rather than declarative (informing another about an outside entity), and carried out at a distance from the partner (distal). As such, these gestures were representative of the earliest intentional gestures of developing human infants, which are preparatory to acquisition of referential gesturing:

> Developing human infants' earliest gestures are triadic and distal, and they produce gestures for declarative purposes soon thereafter. Soon after that, they produce a totally novel kind of gesture, the referential gesture, which is clearly learned through imitation and understood bidirectionally and conventionally from the beginning. (Tomasello & Camaioni 1997, p. 19)

Although Tomasello and Camaioni emphasize the primacy of the visual-gestural modality for language evolution, Messinger and Fogel's research suggests that vocalization was the crucial factor that facilitated evolution of the abstract, instrumental aspects of speech. In any event, the discovery that mother-infant multimodal (vocal plus gestural) communication contains separate elements that serve to enhance social contact, on the one hand, and to allow infants to communicate their desires instrumentally, on the other, is concordant with the view that multimodal motherese evolved incrementally from largely affective, multimodal ancestral communications to its present, more complex, form.

2.2.2. Mother-infant laughter in humans. Laughter is predominantly an involuntary behavior that usually occurs in social situations, is associated with high intensity affect, and lasts less than two seconds (Nwokah et al. 1999). Provine (1996, p. 41) underscores the social and emotional aspects of laughter: "Mutual playfulness, in-group feeling and positive emotional tone – not comedy – mark the social settings of most naturally occurring laughter." In adults, most laughter seems to punctuate speech, for example, by occurring after a spoken phrase. For this reason, speech has been interpreted as having priority over laughter for accessing the vocalization channel (Provine 1993).

Bachorowski et al. (2001) propose that laughter influences listeners through acoustic properties that affect attention, arousal, and emotional responses. A listener's attention is tweaked by laughter because of learned positive emotional responses that have been conditioned as a result of repeated pairings of laughter with positive affect. Although Bachorowski et al.'s (2001) research is on young adults, their hypothesis is attractive in light of the fact that infants usually begin to laugh between the ages of 14 to 16 weeks, often during positive interactions with their mothers, and "laughter, smiles and other gestures by the baby reinforce the mother's behavior (tickling, for example) and regulate the duration and intensity of the interaction" (Provine 1996, p. 39). Interestingly, women produce significantly more song-like bouts of laughter than men, who produce significantly more grunt-like laughs (Bachorowski et al. 2001).

But what about laughter that is directed toward infants? Interactions between 13 American mothers and their infants were scored for maternal laughter from videotapes that were taken periodically as infants grew from 4 weeks to 2 years of age (Nwokah et al. 1999). Particular attention was given to co-occurrences of speech with laughter (speech-laughs) in mothers, which were coded for vowel elongation, syllabic pulsation, breathiness, and pitch change. Compared to the near absence of speech-laughs in AD laughter (Provine 1993), speech co-occurred in approximately 19% of the total number of ID laughs that were analyzed, with the figure for individual mothers ranging from 5% to 50%. In most speech-laughs, speech and laugh began simultaneously and incorporated prosodic, affective, repetitive rhythmic features that typify vocal motherese.

Production of speech sounds entails alterations in breathing and manipulation of the respiratory apparatus, which means that important changes in both the vocal tract and respiration were required before hominins could begin speaking (Provine 2000). Because apes and humans both engage in laughter that is constrained by breathing, comparative studies of this behavior provide clues about the nature of those changes. In addition to information about the anatomical and physiological evolution of respiration in hominins, studies of laughter also illustrate give-and-take turntaking ("social syntax"; see Snowdon 1990) between mothers and very young infants. The nearly identical mother-infant tickling/laughter bouts of chimpanzees, bonobos, and humans provide some of the best evidence for the continuity hypothesis with respect to the evolution of mother-infant communication. Despite the similarities in these bouts, however, the breathing and vocalizations that they entail differ fundamentally between apes and humans, and walking upright appears to have been *the* critical event in the respiratory/vocal transition that accompanied not only the evolution of laughter, but also of speech (Provine 2000).

3. Prelinguistic evolution in early hominins

3.1. The role of bipedalism and loss of infant clinging

Two features related to development in chimpanzees and humans differ in profound ways that are important for formulating hypotheses regarding the prelinguistic substrates of language. *Difference 1:* Although infants of both taxa exhibit remarkable similarities in the sequence and timing of various developmental phenomena (e.g., helplessness at birth, distress at separation from mother, disappearance of blind rooting responses, production of social faces, and fear of strangers [Plooij 1984]), landmarks related to control of posture and locomotion (pushing off, sitting and standing without support, creeping on all fours, and walking bipedally (Plooij 1984) appear much later in humans than in chimpanzees. *Difference 2:* Unlike chimpanzee mothers, human mothers continually produce affectively positive vocalizations to their infants. Below, it is reasoned that this first difference between humans and chimpanzees is associated with the evolution of bipedalism and the subsequent trend for brain size increase in late australopithecines/early *Homo* (Falk et al. 2000), and that the second derived from an initial evolution of prosodic and instructional vocalizations in early hominin mothers. Further, it is hypothesized that these differences are related, that is, that the prelinguistic substrates for protolanguage began to evolve from ID vocalizations similar to those of chimpanzees as brain size started to increase in bipedal hominins.

But how? To explore this question, one must address the definitive trait that makes a hominin a hominin, namely, bipedalism. Many candidates (summarized in Falk 2000) have been proposed as the main advantage (or selective pressure) that led to bipedalism including: freeing of the hands to carry things (food, water, babies) or to make tools; increased ability to see predators and game over tall grass or to reach higher to pick food from trees; better stamina in running after game and hunting; and enhancement of sexual signals (genital displays). An important advantage of bipedalism is that upright hominins were more efficient at keeping cool because they had reduced areas of skin exposed to the intense solar radiation (Wheeler 1988) that would have presented a thermal liability for later australopithecines/early *Homo,* which dovetails with the *radiator hypothesis* of brain evolution (Falk 1990; 1992a; 1992b). Although consensus is lacking about the causes of bipedalism (and how long it took to become fully achieved), one thing is certain: Fossil evidence shows that by the time hominins left Africa to begin colonizing the rest of the world (around two million years ago), they did so using fully developed bipedal gaits.

The fossil record also reveals that anatomical changes that broadened and shortened the pelvis and reshaped the birth canal began occurring well before this exodus. These changes, together with the subsequent trend for increasingly large brains that began in late australopithecines/early *Homo* (Falk 1998; Falk et al. 2000), would have made parturition progressively more difficult. The evolutionary solution to this dilemma is that, today, women give birth sooner, that is, before infants' heads are too big to pass through the birth canal, which results in neonates that are relatively undeveloped. This is why human babies reach landmarks related to posture and locomotion later than ape infants (Difference 1), and it is why they are unable to ride clinging to their mothers' bodies. The trend for increasingly difficult parturition was well underway in *Homo* by 1.6 million years ago, as indicated by the comparatively modern body proportions, narrow pelvis, and approximately 900 cm^3 cranial capacity of the famous Nariokotome skeleton from Kenya (WT 15000), which suggests that this youth's female relatives would have been subject to difficult deliveries of relatively undeveloped neonates (Walker & Leakey 1993).

Unlike the infants of many prosimian species that are frequently parked in nests or trees, unweaned infants of monkeys and apes are rarely parked for any length of time but, instead, ride clinging to the fur on their mothers' chests or backs (Ross 2001). In the infrequent reports of infant-parking in lieu of riding in higher primates (e.g., occasional instances in pig-tailed langurs, Mentawai Island langurs, Hanuman langurs, patas monkeys, and talapoins), mothers either place their infants on the ground or leave them alone in tree crowns before moving away (Fuentes & Tenaza 1995). Apparently, these unusual instances of baby parking in anthropoids occur where there are few natural predators and free the mother "from the potential energetic cost of carrying the infant" (Fuentes & Tenaza 1995, p. 173). It is important to emphasize, however, that infant parking is extremely rare in anthropoids; riding in which the infant does the clinging is the norm. For this reason, riding was presumably present in the ancestor of all anthropoids and, although energetically costly to the mother, may have been strongly selected for because it prevented exposure of parked infants to parasites (in nests), predation, and infanticide (Ross 2001). Observations of parking and riding across the primate order suggest that once riding had evolved it was "difficult to lose . . . [and] the only lineage in which riding has been lost . . . is that leading to *Homo sapiens*" (Ross 2001, p. 765).

The occasional reports of anthropoid mothers parking or putting down their young infants are almost always in the context of maternal foraging, which is significant because foraging was a primary means by which early hominins made their living. Since chimpanzee mothers and contemporary women in hunting and gathering societies (who use baby slings) usually forage for food with their infants attached to their bodies, one might assume that early hominin mothers did too. In this context, it is relevant to consider the interaction of maternal foraging and infant-riding in a higher primate species that, like humans (Leutenegger 1972), produces relatively large infants. Mother squirrel monkeys (*Saimiri sciureus*), for example, normally carry infants that are less than 17 weeks old on their shoulders and backs, after which time the infants, having grown to between one-third and one-half the mother's size, move about on their own (Lyons et al. 1998).

Experimental evidence reveals that squirrel monkey mothers stop carrying their infants at earlier ages and spend more time foraging when food is relatively scarce and difficult to find, although they do not decrease the amount of time they nurse (Lyons et al. 1998). For their part, infants living under harsh foraging circumstances make frequent unsuccessful efforts to ride on their mothers compared to infants living under more optimal conditions. Under difficult conditions, mother squirrel monkeys focus their energy on obtaining enough calories to feed themselves and to nurse their infants. Thus, "by rescheduling some transitions in development (carry → self-transport), and not others (nursing → self-feeding), mothers may have partially protected infants from the immediate impact of an otherwise stressful foraging task" (Lyons et al. 1998, p. 290). Similar postnatal foraging-related changes in maternal care have been reported for free-ranging gelada baboons (Barrett et al. 1995), long-tailed macaques (Karssemeijer et al. 1990), and yellow baboons (Altmann 1980).

Although it is the mothers that bear the burden of their infant's weight during infant carrying, it is the infants that usually do the hanging-on in anthropoids, with the exception of humans. Thus, because chimpanzee infants develop motor skills relatively rapidly compared to human babies (again, Difference 1), they are able to cling to the mother's furry belly after 2 months of age (Plooij 1984) and to shift to her back for travel as they grow heavier. During the first weeks of life, however, it is the mothers themselves that support and cling to infants, frequently in response to their distress *whimpers* or *hoos.* Human babies, on the other hand, are born extremely helpless and never develop the ability to cling unaided to their mothers' (unfurry) bellies or backs. This observation is corroborated by literature that documents a strong grasping reflex in human neonates (Halverson 1937a; 1937b; 1937c). For example, the ability of a young infant to support its weight by clinging with one hand decreases from monkeys to chimpanzees, and is apparently extremely limited in human infants despite the fact that they are born with strong vestigial grasping responses (Halverson 1937a). However, even if human babies had the ability to cling to their mothers' bellies, it would be difficult for mature human infants to ride unaided for extended lengths of time on backs that are habitually oriented vertically rather than horizontally. Infant carrying is therefore entirely up to the human mother (or substitute) and, as any mother will attest, growing babies soon become heavy.

Although contemporary hunters and gatherers do not provide exact models for our hominin ancestors, groups such as the Ache, !Kung san, and Efe pygmies offer clues that may help us to formulate hypotheses about the lives of Plio-Pleistocene hominins, including how mothers may have cared for infants (Small 1998). As a general rule, care-taking of infants in most non-Western cultures is physically engaging, with demand feeding, close contact with infants during the day, and sleeping with them at night being the norm. In order to go about their business with freed hands, contemporary women from most of the world's cultures use slings to secure their babies onto their backs or hips, or onto the bodies of older siblings (Small 1998). These habits may seem strange to Westerners that value and nurture independence in very young infants, and thus may permit them to cry for extended periods or to sleep in separate rooms. The cross-cultural ethnographic evidence pertaining to baby slings reinforces the suggestion by Zihlman (1981) and others that baby slings, perhaps made from vegetal matter, may have been among the first nonlithic tools that were invented.

In what contexts would infant riding have suffered its setback in hominins (Ross 2001), and what would have replaced it before the invention and general use of baby slings? Did evolving hominin mothers revert to the prosimian adaptation of parking their babies far away for extended periods of time while they foraged, despite the threats from parasites, predators, and (possibly) infanticidal males? Probably not. For one thing, parking infants would have severely constrained travel distances for lactating mothers, since comparative primatological and ethnographic data suggest that infants would have required frequent nursing bouts throughout the day (Plooij 1984; Small 1998). Instead, as documented above for a number of anthropoids, early hominin mothers may have engaged in foraging-related changes in maternal care. Unlike chimpanzee mothers, by the time early hominins had evolved into habitual bipeds that bore relatively helpless young, it would have been adaptive for them to adopt a "putting the baby down" strategy in which mothers periodically put their infants down to release their hands (and energy) for foraging nearby. That way they could keep their babies within eyesight and, when ready to move on, simply pick them up and go.

3.1.1. Using vocalizations to "keep in touch." Infant parking is a rare event in monkeys, apes, and non-Western human cultures. When it does occur, infants are usually distressed by the unusual situation of being separated from their mothers (Ainsworth et al. 1978; Lamb et al. 1985), which is frequently conveyed by whimpering or crying. Parked infant pig-tailed langurs, for example, "cry" by emitting high-pitched squeals intermingled with low-pitched guttural sounds (Fuentes & Tenaza 1995), while infant rhesus monkeys produce a plaintive series of *coos* when separated from their mothers (Small 1998). Infant chimpanzees whimper and scream loudly if they begin to fall from their mothers' chests while traveling (Plooij 1984). Crying is qualitatively different in human babies, consisting of rhythmic patterns of vocalizations that entail short, breathy expirations alternating with long intakes of air (Frodi 1985). Human crying makes use of the lungs and vocal apparatus much as laughter does; and Provine (2000) notes that "although laughter and cying are considered polar opposites of the emotional spectrum, they are neurologically linked and share the features of tearing and rhythmic vocalization" (p. 187). By around 3 months of age, human infants develop the ability to modulate their cries to express different emotions such as anger, pain, and frustration (Marler et al. 1992; Small 1998); and, like babbling, crying may be a precursor to language (Small 1998).

Although crying is universal in human infants, the degree to which it is manifested varies with culture. In cultures where babies spend most of their hours in close physical contact with adult caregivers, infants engage in relatively little crying; whereas in cultures that encourage infants to gain independence by leaving them alone for much of the time (e.g., much of America) babies cry considerably more (Small 1998). Small believes that crying of infants today is little changed from when it first evolved in hominins as a means for communicating infants' needs. Furthermore, crying and parental sensitivity to it are adaptive traits because they:

> evolved to serve the infant's purposes: to assure protection, adequate feeding, and nurturing for an organism that cannot care for itself. By definition, crying is designed to elicit a response, to activate emotions, to play on the empathy of another. . . . The caretaker has also evolved the sensory mechanism to recognize that infant cries are a signal of unhappiness, and thus be motivated to do something about it. (Small 1998, p. 156)

It is noteworthy that crying increases the strength of the grasping reflex in human infants (Halverson 1937a), which is consistent with experimental research on American infants which suggests that the major reason that infants cry is to reestablish physical contact with separated caregivers (Small 1998; Wolff 1969).

Presumably, early hominin babies were no happier at being separated from their mothers than are anthropoid infants today, and would have been increasingly likely to vocalize distress during the period of evolution when active infant riding was lost and babies were put down periodically so that mothers could forage. It is also reasonable to assume that the crying of their infants would have produced aversive stimuli for early hominin mothers, as it does for contemporary monkey (Small 1998), chimpanzee (Plooij 1984), and human (Small 1998) mothers.

What could hominin mothers have done to discourage separated babies from crying? For one thing, they may have used a strategy commonly employed by contemporary Western women, that is, inducing infants to fall asleep before putting them down. One way to do this would have been to nurse infants because, if they resembled modern babies, "an infant who is fully fed or fatigued is likely to be quiet, if not actually sleepy" (Halverson 1937a, p. 381). Early hominin mothers may also have used other tactile strategies to soothe babies before putting them down, for example, cradling, and rocking – the latter being a coevolved "rhythmic, temporally patterned, jointly maintained" interaction between mothers and infants (Dissanayake 2000, p. 390). (Perhaps the human habit of rocking babies to sleep is effective because it produces a gentle barrage of stimuli that mimics physical contact with the mother.) The very act of placing babies in horizontal positions may also have encouraged them to sleep, as suggested by experiments which show that captive chimpanzee infants that are left horizontally in cradles most of the day sleep more than wild infants that are carried semi-upright by mothers (Plooij 1984). In addition to these tactile strategies, hominin mothers may also have used rhythmic, temporally patterned vocalizations to lull infants to sleep: precursors of the first lullabies (Dissanayake 2000).

What about instances in which hominin infants refused to sleep and, instead, fussed and cried when mothers put them down? Perhaps early hominin mothers then responded "voice to voice." Already accustomed to regulating older infants' travel with vocalizations as chimpanzee mothers do today, early hominin mothers may have elaborated calls from their vocal repertoires into affectively positive, rhythmic melodies as a means, not only to lull them to sleep, but to reassure them that "mommy is near" when they were awake (a kind of vocal rocking[2], or non-tactile way of "keeping in touch"). In a sense, then, prosodic utterances would have become disembodied extensions of mothers' cradling arms. This suggestion is consistent with the fact that singing to human infants to provide comfort and ease unhappiness is a derived practice that appears to be cross-culturally universal (Trainor et al. 1997). It is also consistent with the finding that a "squealing baby, in fact, can be stopped dead in its vocal tracks by a sudden stream of baby-talk" (Small 1998, pp. 145–46).

The argument that mother-infant communication shifted away from being based almost exclusively on direct physical contact between the signaler and recipient (as baby clings to mother) to being distal (when baby is regularly put down) also applies to gestural communication. For example, while most chimpanzee gestures involve physical contact between the signaler and the recipient, the earliest gestures of developing humans do not, that is, like vocal communications, they have become distal (Tomasello & Camaioni 1997). Facial expressions are believed to have been important during the evolution of speech (Schmidt & Cohn 2001), and would have enhanced communication between hominin mothers and their nearby babies. Putting infants down may also have had a significant impact on the development of certain circular and imitative self-teaching devices (Baldwin 1906; Piaget 1952) that are hypothesized to have been uniquely associated with the evolution of symbolic communication in higher primates, especially humans (Gibson 1986; 1990; 2001; Parker 1993; 1996). For example, a secondary circular reaction (Piaget's 3rd stage) occurs in babies that are 3 to 5 months when they persistently focus on the contingent behavior between their hands and inanimate objects (Parker 1993) and "the midline supine posture . . . focuses the infant's eyes on both hands" (Parker 1993, p. 318). The fact that the "putting the baby down" hypothesis entails continuity in the evolution of prelinguistic vocalizations of early hominins from the vocalizations of ape ancestors does not mean that gestural communication is not, or was not, an important complement to speech-based communication (Armstrong et al. 1994; Corballis 1999; 2002; Hewes 1973; King 1996; Rizzolatti & Arbib 1998; Tomasello 1999; Tomasello & Camaioni 1997).

3.2. The broader evolutionary context

3.2.1. The emergence of protolanguage from prelinguistic behaviors. Just as ID speech of women first expresses emotions and engenders them in infants, and later becomes instrumental in socializing and influencing their behaviors (Fernald 1994; Monnot 1999), the prosodic ID vocalizations of hominin mothers would have taken on less emotional and more pragmatic aspects as their infants matured. As is true for human babies toward the end of their first year, prosodic (and gestural) markings by mothers would have helped early hominin infants to identify the meanings of certain utterances within their vocal streams (semantic bootstrapping, Pinker 1987; 1994). Over time, words would have emerged in hominins from the prelinguistic melody (Fernald 1994, p. 65) and become conventionalized. The prosodic elements of prelinguistic vocalizations would have contributed not only to hominins' eventual semantic grasp of utterances, but also to their acquisition and shaping of numerous sensitivities (phonology, boundaries between utterances, monosyllabic utterances, syntax, dialogue structure, and auditory memory for vocal utterances) that, ultimately, became entailed in linguistic evolution.

That said, speculation abounds about the precise nature of protolanguage. For example, it has been suggested that the earliest language might have had nouns and verbs, but lacked affixes, functional categories (Heine & Kuteva 2002), and true syntax (Newmeyer 2002). Whatever the exact configuration of protolanguage, however, certain conjectures about its emergence are relevant for the discussion of prelinguistic evolution. Thus, protolanguage is thought to have been relatively simple grammatically (Heine & Kuteva 2002), essentially pragmatic in nature (Givon 1979), and may have developed in early *Homo* "directly from the requirements of group foraging . . . and instruction of the young" (Bickerton 2002, p. 209). Although foraging is emphasized here as the context in which prelinguistic behaviors were initially selected, it is worth noting that the mother-infant dyad is fundamentally social and that, consistent with Dunbar's (1993) emphasis of selection of language for "vocal grooming":

> As soon as protolanguage had achieved the necessary critical mass (some dozens or perhaps a few hundred meaningful symbols, whether oral or manual is immaterial to the present argument) it was undoubtedly co-opted for a variety of social purposes, which in turn contributed to its further expansion. (Bickerton 2002, p. 209)

Thus, instead of remaining static over time (*uniformitarianism*), once protolanguage appeared, it presumably continued to evolve in a socially meaningful, dynamic, changing, and directional manner (Newmeyer 2002).

The "putting the baby down" hypothesis is based on two fundamental premises. First, hominin mothers that attended vigilantly to their infants would have been strongly selected for; and, second, those mothers would have had a genetically based potential for modifying their vocal and gestural repertoires to shape and consciously control the behaviors of their offspring. The first premise is widely acknowledged to be the case for a variety of primates (and, indeed, other mammals), including monkeys (Small 1998), chimpanzees (Goodall 1986; Plooij 1984), and people (Small 1998). Not all primate mothers are equally attentive to their infants, however, and a "natural experiment" on a mother-infant chimpanzee pair at Gombe supports the suggestion that selection may have intensely favored early hominin mothers who developed a strategy for monitoring infants that lost the ability to cling to their bodies during travel, as well as infants that vocalized their distress upon becoming separated:

> Madam Bee had raised two infants successfully when one of her arms was paralyzed during a presumed polio-epidemic. . . . The two infants that were born afterwards died within a few months. I had the occasion to make observations on the first of these two infants: Bee-hind. Her body was full of wounds and scratches, so she must have fallen repeatedly. Whenever her mother moved about without supporting her, she whimpered and screamed continuously. (Plooij 1984, pp. 45–46)

Just as there is a good deal of variation in the degree to which healthy chimpanzee mothers living in the wild support and carry their infants (Plooij 1984), variation in the attention provided to infants by hominin mothers would have provided the raw material upon which natural selection operated. As detailed above, humanlike crying and mothers' sensitivity to it probably evolved in early hominins to assure protection, adequate feeding, and nurturing for babies that could not care for themselves. If the hypothesis presented here is correct, hominin babies were increasingly put down, in which case maternal visual attention to gesture and facial expression would also have acquired high selective valiance. As noted by Schmidt and Cohn (2001), the fitness effects of maternal attention to facial expression of infants "are potentially great, considering the intense social and nutritional needs of the infant, as well as possible risks associated with lack of maternal attention, including failure to thrive, physical danger, and at the extreme, death from neglect or abandonment" (p. 12).

The second premise that early hominin mothers would have had a genetically based potential for modifying vocalizations and gestures consciously to control infants is consistent with recent studies that suggest that pitch discrimination is highly heritable (Drayna et al. 2001), that the volumes of gray matter in Broca's and Wernicke's language areas of the brain are highly heritable (Thompson et al. 2001), and that the orofacial motor sequencing upon which speech depends is under strong genetic control (Lai et al. 2001). Thus, in humans, a point mutation in one gene (FOXP2 on chromosome 7) severely disrupts the ability to select and sequence fine movements of the mouth and tongue (a praxic problem) that are necessary for articulate speech (Lai et al. 2001). Affected individuals tend to garble pronunciation, put words in the wrong order, and have trouble comprehending grammar and speech sounds, including sentences. Although the exact function of FOXP2 is unknown (it may help to regulate embryonic development), this gene appears to be necessary for the development of normal spoken language (Lai et al. 2001), and may have been a target of selection during recent human evolution (Enard et al. 2002).

Fascinating research on language acquisition in hearing and deaf subjects strongly suggests that, rather than being "hard-wired" to process only vocal language, humans are genetically predisposed to detect aspects of the temporal and distributional regularities which correspond to prosodic and syllabic levels of signed or spoken languages (Petitto 2000). Thus, while certain aspects of abstract grammatical patterning of natural languages may, indeed, be hard-wired in our species (Donald 1993; Pinker & Bloom 1990), Petitto offers a persuasive argument that language acquisition is nevertheless neurologically plastic and biologically flexible because it can be acquired and expressed easily via the hands or tongue. (This is not meant to deny the primacy of vocal over sign languages. All normal people acquire speech; relatively few learn sign languages.) The dominant mode in which natural language is expressed is determined largely by infants' biological circumstances (e.g., hearing, deaf) (Petitto 2000), while the particular flavor of language that they learn (e.g., Chinese, English) is clearly a product of their cultures.

Just as certain referential calls of vervet monkeys (Cheney & Seyfarth 1990) and over 30 discrete calls of chimpanzees from Gombe (Goodall 1986) are produced and interpreted similarly by members of their respective social groups, protolinguistic utterances of early hominins would have become conventionalized across their groups. But how could the cultural propagation of specific utterances that resulted from a genetically driven propensity to produce natural protolanguage have happened? Although a review of the extensive literature on social transmission in nonhuman primates is beyond the scope of this paper, it is interesting to consider how protocultural innovations that arose in foraging contexts were socially transmitted, primarily by mothers and youngsters, in at least one species. As is well documented for the innovations of sweet potato-washing and wheat-washing that "were invented" by a female Japanese macaque named Imo (Kawai 1965), the process of propagation of new behaviors may have gone through two stages: In the initial "Period of Individual Propagation" (Kawai 1965, p. 5), novel behaviors are transmitted between youngsters, and from them to older females and siblings. After the behaviors became fixed (adult males being the last to acquire them), a second "Period of Pre-cultural Propagation" (Kawai 1965, p. 8) ensues in which infants learn the behaviors from their mothers and the practices are thus passed to future generations.[3] If one applies this model to early hominins, once bipedal mothers began using vocalizations to reassure and instruct their infants, processes similar to those documented for Japanese macaques could have facilitated the use, sharing, and understanding of utterances between youngsters and from youngsters to their mothers. As youngsters matured into adults and these utterances became fixed across all members of groups (conventionalized), new generations of infants would begin acquiring the vocalizations from their mothers. This is one example of how individually developed "words" could have come to be shared. It is also worth mentioning that the calls of different groups of chimpanzees are now thought to have different cultural dialects (Gibbons 1992; Mitani & Brandt 1994; Mitani et al. 1992), which is consistent with the possibility that multiple dialects of protolanguage may have eventually arisen.

3.2.2. What's in a name? Although the exact nature of protolanguage is (I believe) unknowable, one may at least speculate about the referents for the first protolinguistic words (or, rather, their English equivalents). Many workers assume that naming was the basic protolinguistic vocal behavior (Harnad 1996a; Horne & Lowe 1996); that a study of the origin of names is a study of the origin of symbolic categories (Harnad 1996b); and that naming was eventually transformed into language by "enhancing the ability of hominids to comment on and think about the relationships between things and events, that is, by enabling them to articulate and communicate complex thoughts" (Armstrong et al. 1994, p. 354). But what concrete categories would the very first names have referred to? Possible answers include "kinfolk, tribesmen, enemies, foods, predators, weather conditions, tools, places, discomforts, [and] dangers" (Harnad 1996b). With respect to the kinfolk category, recent research on the English word "Mama" (Goldman 2001; MacNeilage 2000; Tincoff & Jusczyk 1999) is particularly relevant for the "putting the baby down" hypothesis. According to MacNeilage (1998; 2000), "Mama" is an example of two successive cycles of a *pure frame* (i.e., utterances generated by mandibular oscillation alone, with the tongue held still), each of which begins with a consonant and ends with a vowel, which MacNeilage believes probably typified earliest speech. A study of 75 infants of less than 6 months of age revealed that babies began 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.

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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

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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 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

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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 from the maternal calls of our prelinguistic ancestors. However, these are characteristics of speech, not of language. Had evolution proceeded by slightly different steps, language might have emerged with signing as its preferred modality, with speech as a fallback for those with impaired visual systems. Language has two major (along with many minor) distinguishing features that have nothing to do with modality and that persist regardless of the modality chosen: One, it employs referential symbols, and two, it assembles those symbols to form structured wholes. How symbols emerged and how structures emerged are consequently the two most basic questions in language evolution. Falk's work, although useful and thorough, entirely fails to address either of these questions.

Although referential use of symbols is basic even to a structureless protolanguage, Falk gives us no reason for supposing that mother-infant exchanges would have needed any referential content. Reassurance, disapproval, warning, and all the other types of messages required for such exchanges could have been – indeed, most probably were – conveyed by prelinguistic means: a quick grab and/or a quick slap are often preferred even by modern human mothers to "That berry is poisonous, darling, so don't eat it," and are certainly no less swift and efficient. Senseless, soothing sounds work far better at calming a fractious baby than the most persuasive of verbal arguments. Naturally, when language came along, those soothing sound patterns would have been co-opted to form part of the very specialized genre employed by mothers and other caregivers to address infants. There are two developmental histories here, however, not one; that these may now have become linked carries no implications whatsoever for their earlier phases.

We are all continuists nowadays – at least in the sense that nobody worth taking seriously believes that human capacities derive from anything but generally accepted evolutionary processes. The people whom I have called continuists in the past would be better described as genre continuists – they believe, with a certainty sometimes bordering on the dogmatic, that every human capacity developed from a similar prehuman capacity (if language communicates, it must have come from prehuman communication). Why don't they come straight out and deny the existence of exaptation? I see no support for genre continuism in the work of Darwin or any other leading evolutionist, but Falk seems to accept it without questioning either its basis or its antecedents.

Falk claims that "vocalizations of hominin mothers would have taken on less emotional and more pragmatic aspects as their infants matured." How? Why? No reason is given, no description or explanation of the process is offered – it is taken on trust. She claims that "prosodic (and gestural) markings by mothers would have helped early hominin infants to identify the meanings of certain utterances." This totally begs the question. For the infant to identify those meanings, they first had to be there, in mother's utterances. But how did she acquire them? Are we in for an infinite regress? Impossible to say, because the cited remarks in section 3.2.1 constitute virtually the totality of Falk's proposals about how meaning got into language.

In her conclusion, Falk expresses the hope that "readers will consider the ideas developed in this paper as possible alternatives to suggestions that language could not have emerged from an earlier primate communication system." However, those ideas cannot be alternatives because they address only the emergence of the speech modality and not that of language itself. Those of us who reject genre-continuist scenarios do so because none of those scenarios have come anywhere near explaining how symbolic units evolved or how syntactic structure evolved. Frankly, I cannot see why the issues involved should be as opaque as they seem to be.

When the obvious becomes invisible, ideological blinkers are often to blame. Usually it is those who reject genre continuism who are accused of ideology. For instance, in a recent *BBS* commentary, Crawford (2002) stated that our species has "a very strong desire to be special," a desire that "sometimes hinders our attempts to understand our nature." It wouldn't bother me one iota if it turned out that humans were as banal as grasshoppers. However, it remains a fact, not a desire or a conjecture, that humans do have one or two unique adaptations, which include symbolic, referential units and the ability to link these in rule-governed (and potentially infinite) structures. Some of us want to have those adaptations explained – not just explained away. What's so special or ideological about that?

Which came first: Infants learning language or motherese?

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Abstract: Although *motherese* may facilitate language acquisition, recent findings indicate that not all aspects of motherese are necessary for word recognition and speech segmentation, the building blocks of language learning. Rather, exposure to input that has prosodic, phonological, and statistical consistencies is sufficient to jump-start the learning process. In light of this, the infant-directedness of the input might be considered superfluous, at least insofar as language acquisition is concerned.

A topic of much speculation among researchers who study language acquisition is the observation that caretakers consistently address their infants with a unique tone and manner of voice. This form of speech has come to be known as *infant-directed,* or *motherese.* The apparent universality of this phenomenon only serves to underscore it as (possibly) a key factor in humans' easy passage through the early stages of language learning. Theorizing about the relevance of motherese to language acquisition began years ago (e.g., Ferguson 1964; Fernald 1984), and efforts to causally link the two phenomena have been a fixture in the language-learning literature ever since. In particular, as questions about the underpinnings of infants' remarkable ability to acquire language have become increasingly complex, appeals to universally available "guides" in this process have become increasingly common. Although there is still no consensus about the relative contribution of the way caretakers address infants to the total language-learning toolkit, there is general agreement that this strange way of talking to infants must serve some evolutionary purpose. In her article, Falk addresses a paradox that is often neglected: If motherese evolved to help infants acquire language, how did those who initially produced it learn to speak? The evolution of language itself is perhaps the more appropriate link between motherese and language learning, as suggested by Falk.

Learning to recognize spoken words is a difficult task. Instances of words vary phonetically and acoustically, depending on the discursive, syntactic, and phonological contexts in which they occur. This is in addition to variations introduced by changes in talker identity, speaker affect, and so forth. At the earliest stages, word recognition (e.g., grouping tokens according to type) must be guided by features of the tokens themselves. Although it remains unclear precisely which aspects of the auditory signal initiate recognition, acoustic prominence – an important characteristic of infant-directed speech – is one factor that has been considered influential in jump-starting this process. Data supporting this view indicate that infants generally prefer to listen to acoustically salient speech, where "salient" can mean either affectively or emphatically so. However, my own and others' recent research indicates that when it comes to recognizing a variety of tokens as instances of a particular type (e.g., a specific word), infants are more sensitive to the acoustic similarity among tokens than to their acoustic salience. Infants appear to preserve substantial memory for acoustic detail from one encounter with a word to the next, which in turn guides early word recognition. If word learning were predominantly guided by acoustic prominence, then we should not see this kind of sensitivity to acoustic differences.

Infants face another difficulty when it comes to speech segmentation. In fluent speech, words are not separated by pauses, and the cues that may serve to signal word boundaries vary from language to language. Nevertheless, and despite these challenges, normally developing infants begin to succeed at recognizing words in fluent speech as early as 7.5 months of age (Jusczyk & Aslin 1995). This has been attributed, in large part, to caretakers' tendency to repeat content words when addressing their infants. In fact, repetition of the full form of a word is perfectly reasonable – even expected – in speech directed to infants, and this repetition is quite distinct from the reduction to pronominal form that occurs across mentions of content words in adult-directed speech. Although repetition is often listed as one of many characteristics of speech directed to infants, it is generally viewed as subordinate to the prosodic quality of such speech. So although repetition appears to be an important feature in guiding speech segmentation, it is not the aspect of motherese that is most often referred to as influential in language learning. However, as Falk points out, naming is a fundamental aspect of theories on the origin of symbolic categorizing, and so should play an important role in theories of language acquisition.

In other work, my colleagues and I have observed that infants' early recognition of highly familiar words (e.g., their own names) serves to anchor them in the speech stream for subsequent parsing. Our data indicate that not only will 6-month-old infants listen longer to a word previously paired with their own name in fluent speech relative to a word paired with another name, but they do not listen reliably longer to the word that followed another name relative to a nonfamiliarized control word. These findings hold even when infants' first names are replaced in fluent speech with the words "mommy" or "mama" (depending on how an infant's caretaker refers to herself when addressing her infant). This is the youngest age at which speech segmentation has been shown to take place, indicating that infants' recognition of their own names and the names of important others is a basic tool that they can use to break into the speech stream early on.

Both sets of findings reported here are consistent with Falk's analysis. Her observations are an important step toward refocusing the debate about the origins of motherese from one about how infants learn language (in all its complexity) to one about how language itself evolved. Although the relevance of one set of questions to the other should be apparent, there has been a general unwillingness on the part of those who study language acquisition to address the language evolution side of the debate. In avoiding that question, we have missed the most logical link between motherese and language learning. Rather than viewing motherese as a bias on the part of caretakers that has led infants to acquire language, motherese may instead be considered the egg that begat the chicken itself. That is to say, without motherese there would perhaps be no language at all. With this analysis, arguments about the underpinnings of language acquisition come full circle (e.g., back to claims about the origins of language). Falk has mapped out an elegant way of thinking about this problem. One can only hope that it will influence how researchers think about the influence of motherese on language learning.

How plausible is the *motherese* hypothesis?

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http://www.semioticon.com/Bouissac/Home.htm

Abstract: Falk's hypothesis is attractive and seems to be supported by data from primatology and language acquisition literature. However, this etiological narrative presents a fairly low degree of plausibility, the result of two epistemological fallacies: an implicit reliance on a unilinear model of causality and the explicit belief that ontogeny is homologous to phylogeny. Although this attempt to retrace the early emergence of prelinguistic capacities in hominins falls short of producing a compelling argument, it does call attention to an aspect of linguistic behavior which may indeed have evolved under the pressure of nurturing constraints.

Dean Falk notes in her conclusion that only the invention of the time machine could bring to a close the academic controversies concerning the origin of language. That may be true, but in the meantime we have no choice but to debate the plausibility of various narratives and to construct arguments based on indirect data. The reasoning may appear more or less compelling and the data more or less relevant. It ensues that theories of the origin of language differ by their degree of plausibility within the confines of commonsense logic or "bounded rationality" (Gigerenzer & Selten 2001). The linguists who promote the genetic mutation hypothesis develop an argument by default: It is not because there is yet any direct evidence that this is the case but, rather, because they cannot explain otherwise the apparent ease with which children universally master language in spite of the assumed incompleteness of the input. Those who prefer the gradualist approach, following Darwin's view that evolution proceeds through small changes selected by the environment, look for the steps that may have led to human language either as an emergent phenomenon or as a cumulative process. Dean Falk proposes a narrative of the latter kind. The question is not whether she is right or wrong – because by her own admission there cannot be any definite answer – but what is the degree of plausibility of her *motherese* hypothesis.

Falk's argument is attractive because it locates the origin of language in the mother-child dyad, which is the locus of language transmission among modern humans, but its degree of plausibility is not very high due to questionable epistemological assumptions. First, the argument follows a unilinear model of causality. Looking for a single cause as the source of an event that has consequences for our survival is certainly statistically adaptive. *Homo* has evolved cognitive strategies to locate quickly the origin of disruptions in its environment as the best way to control a potential danger. If the cause is correctly identified, predicting what comes next is usually easier. Wasting time scanning too much information in order to get a complex picture of various factors can be fatal in real life conditions. Scientific inquiry is likewise driven by the urge to identify causes; however, assuming a single cause for each phenomenon is an epistemological fallacy. There are other candidates, in the same order of possible origins of articulate language, such as primate vocalizations with meaningful acoustic variants (Owren et al. 1997; Rendall et al. 1999; Zimmerman et al. 1995) or intensive vocal interactions aimed at courting, pair bonding (Deacon 1997, pp. 385–410), expressing commitments (Silk 2002), and social grooming (Dunbar 1997), which are not mutually exclusive and are equally plausible as adaptive vocal behaviors leading to protolanguage, and which could even be construed as prerequisites for motherese, rather than the reverse as Falk claims. Her argument arbitrarily isolates the mother-child dyad and locates it artificially in relatively safe surroundings. To many, in agreement with Falk, a gradualist hypothesis appears more plausible, if only because the social nature of language makes it unlikely that a single mutation of this importance in a single individual could have been selected. Since simultaneous identical mutations are highly improbable, the proponents of a sudden emergence now tend to favor exaptation as their explanatory principle (Pinker 1994).

This, of course, is not incompatible with Falk's argument, but neither does it mean that a single cause can account for the evolution of language. Moreover, the single point of origin considered by Falk, in spite of its multimodal framework, fails to explain how the most specific properties of human languages such as referentiality and syntax could have developed from these early phatic vocalizations. Invoking bootstrapping to explain the move from phatic to referential communication begs the question if it is not explicitly shown how it may have proceeded, and under which evolutionary constraints. Finally, the use of the term "motherese" is particularly misleading in this context because, in contemporary pragmatics, it applies to the mother's or other adult's ID verbal productions which tend to distort and simplify already fully constituted languages. If motherese presupposes the possession of a language, does not Falk's logical argument collapse? Or, should she have used *protomotherese* and then explained under which constraints motherese evolved from protomotherese? The root of this aporia may be the second fallacy that permeates this article.

From the kind of indirect evidence the author marshals in support of her hypothesis, she is clearly implying that the observation of developmental behaviors, in both primates and humans, provides reliable information regarding the evolution of these behaviors. The assumption made by Haeckel in 1866 that ontogeny "recapitulates" phylogeny seems to be the reason Falk devotes a good half of her paper to reviewing the abundant literature pertaining to early language learning and to apes' maternal behavior. Although the latter may have changed over time in response to environmental conditions and may even be susceptible to cultural variations (Van Schaik et al. 2003), the former cannot yield any clues regarding the origin of language. To think that the ontogenic development of language learning can be a window on the evolution of language as such is not a tenable option. The idea that ontogeny (the growth of an embryo) recapitulates phylogeny (the evolutionary history of a species) has long been discredited. Yet Haeckel's notorious biogenetic law still provides a powerful metaphoric model to which Falk bears witness in her conclusion: "Motherese . . . is the *only* available model for elucidating how humans universally acquire spoken languages today, and therefore may have acquired them in the past" (sect. 4, para. 1, emphasis Falk's). This statement is either trivial (all children learn their native languages along the same developmental steps now as they did in the past) or a play on words ("acquire" does not have the same meaning in the premise as in the conclusion). This is not a robust argument.

Would only going back in time, as Falk rhetorically suggests in her final paragraph, enable us to discover the "true" origin of language and settle the debate? This is unlikely. We are contemporary of many evolutionary processes that we experience and observe without understanding them in spite of investing considerable resources to solve the problem of their true nature. The conundrum of language origins is only one aspect of our ignorance of the very ontology of language. This does not mean that we should not keep trying to formulate hypotheses, notably regarding interdependent, multilinear evolutionary factors.

Bipedalism, canine tooth reduction, and obligatory tool use

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Abstract: Bipedalism in the earliest hominid specimens is always accompanied by the reduction of projecting canine teeth. Body size is smaller than chimpanzees or humans, but molar teeth are markedly larger. Use of a pointed stick for defensive purposes on the one hand, and digging for USOs on the other, may be why bipedalism was selected for. Passing such learned behavior to the next generation may have played a role in selecting for language.

There is another aspect of the circumstances associated with the adoption of a bipedal mode of locomotion that may well have contributed to the development of the linguistic realm. Hominid bipedalism is slow, and our early bipedal relatives were relatively small of size (Hartwig-Scherer 1993). The survival of small, slow-footed hominids on the African savannas or the adjacent open woodlands would only have been possible if they had possessed a means of defense which transcended that of the other primates that are found in similar kinds of habitats. Baboons defend themselves with truly formidable canine teeth, but the early hominids had canine teeth that did not project beyond the occlusal surface of the rest of the teeth in the dental arch.

The late Sherwood Washburn made the observation that if the baboon were to employ a digging stick to assist in foraging, it could nearly double its food-getting efficiency (Washburn 1959; 1960). This may very well have been the key that allowed the early hominids to compete successfully with baboons and warthogs for survival in the African savannas during the Pliocene. It has been noted that "the digging stick redirected is a more effective defensive weapon than even the formidable canine teeth of the average male baboon" (Brace 1995). The need for carrying such a dual-purpose tool may well have been the selective force that led to the development of habitual bipedalism, as it is awkward at best for a quadruped to move effectively from one place to another when one forelimb is carrying an item essential for survival and is therefore unable to play a role in support.

It has recently been said that "Canines don't just fade away, they must have been actively reduced by natural selection," yet no scenario for their reduction by selection has been suggested (Deacon 1997). However, the case has been made that traits *will* "just fade away" if they are not maintained by selection. Darwin offered a series of examples in the *Origin of Species* (1859, pp. 134–49, 454). Forty years ago, I labeled the process the "probable mutation effect" (Brace 1963; 2000, Ch. 5). This is fully compatible with "neutral theory" in molecular biology (Brace, in press; Kimura & Ohta 1969).

The australopithecine life history pattern as shown by tooth root formation is more like that of a chimpanzee than that of a modern human being (Smith 1992). Newborns, then, may well have had the aspects of greater maturity characteristic of chimpanzee neonates, and also may well have been able to cling to the maternal fur. It has been said that "it is not inconceivable that the first step across the symbolic threshold was made by an australopithecine with roughly the cognitive capabilities of a modern chimpanzee" (Deacon 1997, p. 340), and with a tiny "vocabulary" of 5 or 10 words and only two or three types of combinatory rules like toddlers' syntax (p. 41). Those beginnings may very well have been analogous to what is being called "motherese." From that point on, the adaptive value of symbolic expression can very easily be seen as the selective force that led to the increase in brain size. The co-evolution of language and brain size follows from there to the point where language as we know it characterizes all human groups (Deacon 1997, Part 3).

Oldowan tool-making australopithecines were evidently scavenging in the Late Pliocene in Africa about 2.5 million years ago (Hay 1976; Shipman 1986). By the Early Pleistocene, just under 1.9 million years ago, the Oldowan toolmakers were practicing what has been called "persistence hunting" (Bortz 1985). Two major changes in the australopithecine body made this possible, one clearly documented and the other surmised on reasonable grounds. The first was the achievement of the body proportions of recent members of the genus *Homo.* Early Pleistocene body proportions are remarkably similar to those of living humans (Ruff & Walker 1993). The other change, which we can infer but cannot prove, is the loss of the normal mammalian fur coat, presenting a bare and sweat-gland-endowed skin to the atmosphere. If, as we guess, our early hunters were engaging in persistence hunting, then there should have been strong selection for developing the means of dissipating metabolically generated heat. We know that humans today have more capacity for sweating than any other mammal (Macfarlane 1976, p. 185), and Falk herself has shown that a mechanism for cooling the contents of the cranium was clearly evolving between the time of the late australopithecines and that of the early members of the genus *Homo* (Falk 1990).

The emergence of that toolmaking and hunting member of our own genus also saw a major increase in brain size, putting it about halfway between that of the chimpanzee and the human ranges (Begun & Walker 1993; Vekua et al. 2002). Rate of maturation was also about halfway between the ape and the human condition (Smith 1993). *Homo* was now living the life of a facultative carnivore that had spread out of Africa and across the warmer portions of the entire Old World. As with that other highly mobile member of what Alan Walker has called the "large carnivore guild," *Canis lupus,* the wolf, there should have been mate exchange between adjacent groups throughout the entire expanse of hominid occupation: that is, no isolation and no speciation. The advantages for symbolic communication in a creature so poorly endowed to be a carnivore had to constitute a considerable force of selection. However, the chances are implausibly remote that more than one species of hominid undertook to pursue a way of life that is so wildly atypical for a primate. Now as to why there is no hint of the beginnings of symbolic usage in any other species in the world, it may well be because not one of them uses tools invented by previous generations as elements essential to their survival.

Hominin infant decentration hypothesis: Mirror neurons system adapted to subserve mother-centered participation

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Abstract: Falk's hominin mother-infant model presupposes an emerging infant capacity to perceive and learn from afforded gestures and vocalizations. Unlike back-riding offspring of other primates, who were in no need to decenter their own body-centered perspective, a mirror neurons system may have been adapted in hominin infants to subserve the kind of (m)other-centered mirroring we now see manifested by human infants soon after birth.

A necessary condition for the selective advantage and protolanguage emergence and propagation specified by Falk may have been an emerging infant capacity to perceive, understand, and learn from the gestures and vocalizations afforded by the vigilantly attending mothers. Pertaining inter alia to meaning identification, acquisition, and propagation (sect. 3.2.1), I propose this hominin infant-decentration hypothesis: Compensating for the loss of the body-clinging advantage that enables offspring of other primates to perceive and learn without having to transcend the body-centered perspective shared with the carrying mother, those hominin offspring able to learn to cope and take care by (m)other-centered perception of distal vocalizing and gestural articulation would have had a selective advantage and a contributing impact.

A neurosocial support system has been discovered that may have lent itself to subserve such an emerging capacity. Rizzolatti and Arbib (1998) have identified a mirror neurons system in the modern chimpanzee and in the human brain (see also Stamenov & Gallese 2002), and I have suggested that this system has been adapted to subserve infant learning by other-centered perception in human interaction (Braten 2000; 2001; 2002; 2003a).

Comparative studies of infant-adult interaction in humans and chimpanzees. In conjunction with the pertinent comparative findings referred to in the target article, the virtual absence of prolonged eye-contact in chimpanzees, as stressed by Bruner (1996, p. 163, with reference to Savage-Rumbaugh et al. 1993), should be mentioned. Having compared for a decade infant-adult interactions and infant-carrying modalities in humans to those in chimpanzees, I can confirm this, at least as pertaining to the chimpanzees I have studied in a southern Norway zoo and wildlife park. When clinging to the mother's back, offspring of great apes learn to orient themselves in the world in which they operate from the carrying mother's stance. Moving with her movements, they may even be afforded the opportunity to learn by copying her movements (perhaps in the way that Byrne [1998] terms "program-level imitation") without having to transcend their own (egocentric) body-centered perspective. In my periodic studies of captive chimpanzee-offspring relations, I have observed how an infant, when old enough to cling to its mother's back, not only bodily moves with her movements but often adjusts its head to the mother's movement direction, thereby appearing to be gazing in the same direction as the mother. When a mother holds the infant in front of her for grooming (which adults more often do from behind one another), a sort of face-to-face situation is established, but not for the kind of reciprocal interplay entailing mutual gazing and gesticulation that we observe in human infant-adult pairs.[1]

Before the invention of baby-carrying facilities (attributed by Leakey 1995, p. 94, to early *Homo erectus*), hominid species may have been faced with extinction when turning bipedal, I have submitted, if their young offspring were unable to listen and learn to cope and take care by (m)other-centered mirroring and participation (Braten 2000, p. 275). Such a capacity is at play in early human ontogeny.

On the ontogenetic path to verbal conversation. Regardless of whether they are "hardwired" to process speech and sign language (sect. 3.2.1), human newborns demonstrate a readiness to mirror facial expressions and gestures (Kugiumutzakis 1993; 1998; Meltzoff & Moore 1977; 1998), and young infants' impressive speech perception may entail an innate perceptual-motoric link (Kuhl 1998, p. 306). In contrast to the Piagetian attribution of an *egocentric* point of departure for children's development of language, requiring decentration as the child matures, we believe we have now found evidence of infant capacity for *altercentric* mirroring and self-with-other resonance soon after birth (Braten 1998; Stern 2000; Trevarthen 1998), facilitating the ontogenetic path to speech in the culture into which the infant is born. This path comprises inter alia these steps: The first vocal imitation of /a/ in the first hour of life (Kugiumutzakis 1998), as well as mutually attuned protoconversation in the first months of life (Trevarthen 1974; 1990; 1998), and speech perception entailing that by age 6 months the infant has already begun to "turn a deaf ear" to sound distinctions that make no sense in the ambient language (Kuhl 1998). This is soon followed by the babbling onset of well-formed syllables and production of vowels approaching those of the native language, coinciding with joint attention and acknowledgment of self-other agency at about age 9 months (Akhtar & Tomasello 1998; de Boysson-Bardies 1999; Hobson 1998; Locke 1993; Tomasello 1999a). Such steps are precursory and supportive of verbal conversation to come with its reciprocal and participant characteristics. Not only may the speaker coprocess his own production from the listener's stance (in line with Mead's [1934] notion of anticipatory response). The listener may co-articulate the speaker's production as if she or he were a coauthor, as predicted by Liberman's (1957; 1993) motor theory of speech perception, and by Braten's (1974; 2002) simulation-of-mind model of conversation. Such virtual coarticulation from the other's stance is manifested when a listener completes the speaker's aborted sentence or answers a half-spoken question, supported by the capacity for other-centered mirroring and resonance that we see at play in protoconversation and response to motherese (Braten 1988; 2003b; Stern 2000; Trevarthen 1998).

Neurosocial support. In the primate neurobiology there appears to be a ground for systems that could have lent themselves to adaptation for decentration in the genus *Homo* to subserve such (m)other-centered mirroring. Mirror neurons have been found to discharge in the macaque brain both when another is observed grasping a morsel and when the monkey itself is grasping the morsel (Di Pellegrino et al. 1992). Referring to evidence of a mirror-neurons system in the human brain, Rizzolatti and Arbib (1998) suggest its possible support of the first primitive dialogue, and I have predicted that such a system would be found to subserve learning by other-centered perception and participation, and will be found to be impaired in subjects with autism (Braten 1998; 2002). Entailing an allocation that comprises Broca's area, which is activated not only upon speech but also upon (imagination of) hand rotation, such an adapted mirror-neurons system may thus pertain to the phylogenesis and sociogenesis of both spoken and sign language (see target article, sect. 3.2.1) by subserving virtual (other) participation (Braten 2003a; 2003b) in the performance of observed instructors and partners.

NOTE

1. When chimpanzee infants, however, are nursed by human caretakers and sensitized to face-to-face interaction with humans, they appear able, as Bard (1998) has shown, to imitate human facial models of certain gestures. I have a video record of a chimpanzee infant (age 39 days) engaging in a sort of turn-taking vocal interplay with his foster parent, but I have never observed this in infant-adult chimpanzee interaction. Further, although adult males in the wild may interact relatively little with infants (see target article, Note 1), the captive males I have observed sometimes do. For example, a Beta male is sometimes used as a baby-sitter by one of the mothers when she goes off in search of food (Braten 2000, p. 282). In any event, never have I observed prolonged facial eye-to-eye contact between infants and adults, males or females.

Prosody does not equal language

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Abstract: Prosody, in motherese as in all forms of language, has a very different form and a very different use than the central lexical, phonological, and syntactic components of language. Whereas the prosodic aspects of motherese probably derive from primate vocalization, this does not help us to understand how the more distinctive parts of language emerged.

Dean Falk makes a strong argument that human motherese began with affective vocalization and that "*the use of prosody in human maternal speech is similar to the use of vocal signals by some nonhuman primates*" (Fernald 1994; quoted and given emphasis by Falk). Even though, as Falk makes clear, neither chimpanzee nor bonobo mothers engage in much infant-directed vocalization, I am sympathetic with her argument that the prosodic component of human infant-directed (ID) speech shows continuity with primate communication and I find it plausible that ID vocalization could have formed an important bridge between primate and human communication. Among other things, the early development of ID vocalization in phylogeny could help to solve the puzzle of how vocal/auditory language, rather than a manual/visible rival, became dominant. Most primates have much better voluntary control over their hands and arms than over their mouths and tongues. This should have given a decisive head start to a manual language. If voluntary control over the vocal organs had already been achieved with the help of such things as ID vocalization, a vocal language might have been viable from the very start.

Most of Falk's article is concerned with very early forms of parent-infant communication, and I am in general agreement with her discussion. I feel less comfortable with the sections of the paper, starting with 3.2, where Falk seeks to relate motherese to language. If Falk is right, the earliest forms of human ID vocalization had none of the specifically linguistic features that have been so difficult to account for in an evolutionary framework. Present-day motherese makes use of the same words, combinatorial phonology, and heirarchical syntax that we find in other linguistic styles; it is set apart primarily by its characteristic prosodic features. Falk's hypothesized prelinguistic ID vocalization has prosodic features of the sort found in modern human motherese but lacks its lexical, phonological, and syntactic features. To say "Over time, words would have emerged in hominins from prelinguistic melody (Fernald 1994, p. 65) and become conventionalized" (sect. 3.2.1) seems to beg the question. Just *how* would this emergence have come about?

Tone of voice, the ability of the voice to convey such emotions as joy, excitement, and anger, and the soothing tones of motherese are important uses of prosody, and I find it reasonable to see them as emerging from (and still, I believe, belonging to) a primate call system. However, this prosody lacks the system of contrastive phonology that is characteristic of language. As with other kinds of human and animals calls, the referential potential of prosody is more limited than that of words. Prosody is better at conveying emotions, whereas words are better at reference. To be sure, prosody has become deeply entangled with contrastive phonology in modern languages, but they do remain easily distinguishable. Parents have no trouble extracting their infant's first words from the abundant primate vocalizations that they have been listening to since the baby's birth. Some features of that vocalization will forever accompany their child's language in the form of prosody. In other words, prosody has both a different form and different functions than phonology or the lexicon, and it is the new form and functions of language that need to be accounted for if we are ever to understand how it emerged in phylogeny. I continue to think that the best way to understand what happened is to conclude that "tone of voice [along with the other aspects of prosody] amounts to an invasion of language by something that is fundamentally different" (Burling 1993, p. 30). We ignore the most interesting and difficult parts of the puzzle if we take for granted that all of language somehow emerged from prosody.

I seem to have failed to make myself clear in my 1993 article, for Falk is not the first person to conclude that I believe in the sudden emergence of language. In that article, I did express deep skepticism about finding the origins of language in a call system, but such skepticism need not imply that language emerged suddenly. One could believe, and I do believe, that language emerged very gradually from something other than a primate call system. Human cries, laughs, and screams, after all, constitute a fine primate call system – the call system of the human primate – and neither our own calls nor the calls of other primates show the degree of continuity with language that we might expect if language had emerged from a call system. Falk is right that the phonetic aspects of motherese are derived from primate vocalizations. Sadly, this tells us very little about the origin of the most distinctive parts of language: contrastive phonology, syntax, and the lexicon.

Early hominins, utterance-activity, and niche construction

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Abstract: Falk's argument takes for granted that "protolanguage" used a genetic propensity for producing word-forms. Using developmental evidence, I dispute this assumption and, instead, reframe the argument in terms of behavioral ecology. Viewed as niche-construction, *putting the baby down* can help clarify not only the origins of talk but also the capacity to modify what we are saying as we speak.

Invoking "protolanguage," Falk uses cross-primate comparisons to speculate on how hominins set off toward full-fledged language. *Putting the baby down,* she suggests, prompted words to arise in response to alterations in mother-infant interaction. Use of a comparative method allows due weight to be given to the multimodality of this "utterance-activity." Instead of emphasizing the prosodic, however, Falk's argument stresses conventionalized events. Rejecting this focus on "words" and protolanguage, I use behavioral ecology to reframe the thesis. Stronger arguments arise if caregiver-infant interaction is seen in terms of "niche construction" (Laland et al. 1999).

Taking the folk view that words distinguish us from chimps and bonobos, Falk posits a "genetically driven propensity to produce natural protolanguage" (sect. 3.2.1, para. 7). Did this exist? First, as no other species exploits simple language, words may owe more to brain-culture coevolution than to genes (Deacon 1997). Second, intention attribution is crucial in learning to talk because, without sympathetic others, infant vocalizations make little sense. In Dennett's terms (1987), taking an "intentional stance" may be no less necessary to early talk than infant design (Spurrett & Cowley 2004). Third, not only may babies lack genetic propensities for word production but persons, not brains, seem to sustain early speech. As neural systems self-organize, infants come to control action and perception in ways that prompt vocally mediated interaction. Generally, then, Falk's argument is weakened by the unsupported claim that word-based protolanguage emerged from a genetic propensity. Other problems also arise. Above all, Falk links infant-directed speech to conventional form-based meanings rather than to interpersonal, affective events. By making prehistoric talk sign-based, protolanguage becomes a matter of producing and recognizing speech acts. However, unless communication draws on interpersonal events, syllabic invariants are likely to be products of an individual's recurrent affective states. In modern infants, this is not what occurs. Rather, words arise from iconic-indexical events that integrate activity between persons and across modalities (Cowley et al. 2004). Finally, Falk's appeal to ontogenetic and phylogenetic parallels is often not persuasive. If, say, phonological and semantic bootstrapping occur in ontogenesis, they rely on producing formally consistent meanings. By definition, however, form-based processes cannot *precede* protolanguage.

Many reject the view that species differences depend on words. Neither Chomsky's recent work (Hauser et al. 2002) nor that based on Wittgenstein invoked genetic propensities to explain verbalizations. Whereas Taylor (1997) and Shanker (2001) posited no inner linguistic mechanisms, Hauser et al. (2002) has hypothesized that "most, if not all" verbal aspects of language use "mechanisms shared with nonhuman animals" (p. 1573). For both sets of theorists, what sets language apart is a human capacity for off-line modification of utterance-activity. Hauser et al. (2002) appealed to a neurally based mechanism for "recursion" and Taylor (2000) emphasized our capacity to talk about talk, or "linguistic reflexivity." Remarkably, both sets of theorists agree that what matters is that, in the course of speaking, we modify what is uttered. It follows therefore that (nonverbal) Ur-language emerged as hominins extended bodily expression. Wittgensteinians and Chomskyans concur that no specialized genetic propensities are needed to sustain simple vocal-production. While disagreeing about how to explain off-line modification, they agree that nonhumans share social mechanisms used in language. In defending a continuity view, Falk addresses the wrong target. The folk mislead us: Even if words are unique, they are not the taproot of language.

Given emphasis on multimodality, Falk's argument can be reframed in terms of the origins of utterance-activity or Hauser et al.'s (2002) "language faculty-broad sense." *Putting the baby down* changed ecology in line with both bipedalism and neonates' enlarging brains. The thesis, then, sustains the view that joint behavior is shaped by mother-infant interaction. In phylogeny, as Wray (1998) argued, this may have used holistic vocal (and, presumably, other) patterns. Like social grooming (Dunbar 1996), utterance-activity may have come to dominate social coregulation. Then, as now, in Fernald's (1993) terms it may have "engaged and persuaded" infants by inducing "subtle changes in emotions and intentions" (p. 80). If so, instead of appealing to ontogenetic and phylogenetic parallels, we can ask how interactional events give rise to cognitive outcomes. With Laland et al. (2000), *putting the baby down* may have led to "choices, activity, and metabolic processes" (p. 132) that influenced natural selection through "niche construction." The newly created niche altered both maternal vigilance and the epigenetic processes that affect how infants attend and respond to multimodal expression. As infants became sensitive to the mother's appraisal of circumstances, there would have been a partial decoupling of expression from affect. Real-time feedback could shape the mother-infant relationship and, by extension, the evolution of development. With Owings and Morton (1998), "assessment" would drive an arms race which ensured that increasingly more differentiated expression was being used to "manage" infants. Utterance-activity began to exploit Ekman (1972) and Fernald's (1993) invariants as well as the micro-temporal dynamics of infant-caregiver play (Bateson 1979; Stern 1977). As joint events became affectively coregulated, vocal power and sensitivity increased. In this view, the ability to use words depends not on genes but on mutual adjusting that is supported by neurodevelopmental change.

Niche construction allows *putting the baby down* to be seen as helping prosody and gesture take on new affective, cognitive, and practical roles. Social learning may have used behavioral ecology to reshape both intrinsic motive formation (see Trevarthen et al. 1999) and perception-action systems (Preston & de Waal 2001). Study of this natural history can throw light on, say, coregulation (Fogel 1993), interactional synchrony (Condon & Sander 1974), emotional contagion (Hatfield et al. 1994), accommodation (Giles et al. 1991), and real-time understanding (Cowley 1998; Gumperz 1996). Reframed in terms of niche construction, Falk's argument can promote new thinking about language. Not only does it allow for skepticism about the role of words in Ur-language, but it prompts us to ask how joint behavior induces *belief* in verbal entities. Beyond that, there lies a harder question: Is consilience possible between seeking the taproot of language in neural capacities for recursion and viewing reflexivity as the product of how infants participate in – and talk about – utterance activity?

Continuity, displaced reference, and deception

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Abstract: Falk's contribution to a continuity theory of the origins of language would be complemented by an account of the origins of displaced reference, a key characteristic distinguishing human language from animal signaling systems. Because deception is one situation in which nonhumans may use signals in the absence of their referents, deception may have been the starting point for displaced reference.

Falk's interesting and persuasive argument that human language was built, at least in part, upon a substrate of infant-directed communication is framed in terms of the contrast between continuity and discontinuity theories of the origin of language. However, unless we resort to saltationism, a choice between continuity and discontinuity is as false in the study of language origins as it is in any evolutionary scenario. Although examination of the end points of any episode of divergence will create the appearance of discontinuity, gradual change is the only plausible scenario within a Darwinian framework.

This is not to say that evolution's gradual, continuous, and incremental nature means that "differences between human language and nonhuman primate communication are only quantitative" (King 1996, p. 193). Even a gradual process can result in important qualitative differences over time. Human language differs from nonhuman signaling systems in a variety of ways. Falk shows that infant-directed communication is likely to have had a role in bridging that gap, and King (1996) has provided a similarly plausible gradualist account of the origins of syntax. Another key difference between nonhuman signaling systems and human language is displaced reference – that is, the ability to refer to things and to understand references to things that are absent. Unlike humans, nonhumans can use their signaling systems to discuss only things that are currently in evidence: "There is a predator nearby," "Here is a food source," and so on. Although they can signal the presence of, say, a snake, they cannot use that signal as the starting point for a discussion about snakes or as a way to teach their young about the dangers of snakes. They can express their own hunger, but they cannot have a conversation about the problem of hunger while their own bellies are full.

A gradualist account of the origins of displaced reference might start with the observation that the only circumstance in which nonhumans send signals in the absence of the referent is when they are engaging in deception, such as when birds send false alarm signals in order to frighten competitors from a food source (Munn 1986). Of course, in order for our ancestors to have been able to discuss things not in evidence, the receiver of the signal would have had to be clued into the trick, which would preclude actual deception. Perhaps the line was crossed when two individuals formed a coalition to deceive another, enabling the coalition members to share an understanding that a signal was to be used independent of its referent. Once it was established that a signal could be used without its referent being present, it would have been a relatively short step to real displaced reference, unconnected to deception. Although it is a very long way from coalition-based deception using signals to human language as we now know it, perhaps this was how the transition from an animal signaling system to human language began (see Wray [2002] for more on the evolution of displaced reference). As Knight (1998a; 1998b; see also Knight et al. 1995) has pointed out, such a scenario would require high levels of trust among coalition members. This might have been facilitated by kinship and, in line with Falk's scenario, a signaling system rooted in the trustworthy soil of motherese and its precursors.

Whether displaced reference has its origin in coalitional deception or somewhere else, one thing is certain: Only a continuity theory of the origin of human language can account for this or any other discontinuity between it and nonhuman signaling systems.

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Syntax: An evolutionary stepchild

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Abstract: Dean Falk has strategically explored "mother-infant gestural and vocal interactions . . . in chimpanzees and humans" in order to offer hypotheses "about the evolutionary underpinnings that preceded the first glimmerings of language." Though she offers compelling evidence for many interesting hypotheses as to the epigenesis of language, other possibilities have yet to be explored. Here we explore the role of gestural communication among deaf signers and the neural correlates associated with this type of communication.

In her article *Prelinguistic evolution in early hominins: Whence motherese?*, Dean Falk strategically explores "mother-infant gestural and vocal interactions . . . in chimpanzees and humans" in order to offer hypotheses "about the evolutionary underpinnings that preceded the first glimmerings of language." Though she offers compelling evidence for many interesting hypotheses as to the epigenesis of language, other possibilities have yet to be explored.

One such possibility is whether the structure/syntax of the languages we use today was molded to best fit a preestablished cortical organization for linguistics and the related tasks, and, if so, is this organization modality dependent? Is linguistic structure/syntax a function of the organization of the left-hemisphere? Is language innate; can it be evolutionarily traced? If so, what implications does this have in the ever-present question of the evolution of language?

We know from existing literature and in vivo studies that nonhuman primates communicate using gestures, a type of "signed language," and that humans for the most part communicate using a spoken language. The primary difference between signed and spoken language is that sign relies "on spatial contrasts while speech is linear and non-spatial" (Goldin-Meadow 1999). In verbal communicators, a lesion to the left hemisphere usually produces deficits on linguistic tasks, whereas damage to the right hemisphere usually produces deficits in spatial tasks. Similarly, when human nonverbal communicators sustain damage to the left hemisphere, they perform more poorly on linguistic tasks but do not exhibit the same spatial deficits that signers with right-hemisphere damage do. The implications of these findings are that in humans, sign seems to be processed as linguistic information rather than spatial information; therefore implicating the left hemisphere in linguistics, regardless of transmission (Goldin-Meadow 1999).

When deaf children of nondeaf parents are not taught to sign and have not acquired speech because of their hearing impairment, they independently create a system of gestural communication that takes on a structure similar to that of spoken language and is consistent across cultures (Goldin-Meadow 1999; Goldin-Meadow & Mylander 1998). A possible explanation for why deaf children create linguistically oriented gestures and hearing children do not, may relate to the notion that gesture needs to take on grammatical properties only when it has to carry the full burden of communication. When used in conjunction with speech, gesture does not have to convey (all) meaning; therefore, it does not assume a language-like form (Goldin-Meadow 1999).

A cortical region implicated in nonverbal communication is the superior temporal sulcus (STS). When congenitally deaf signers and hearing expert signers are presented both with sign language and with nonmeaningful gestures, activation of the STS was noted (Allison et al. 2000). Furthermore, while viewing American Sign Language sentences, those who are unfamiliar with the language showed no activation of the STS. These results are indicative of the STS's role in the perception of ASL. Further support of this hypothesis can be seen when studying monkeys. "In monkeys, responsiveness of STS cells was greater to a hand making a movement than to a bar of the same size making the same movement, demonstrating that the cells are preferentially responsive to biological motion" (Allison et al. 2000; Rizzolatti & Arbib1998; 1999; Rizzolatti et al. 1996; 2002). This applies to humans in that the cellular organization of the STS may provide a predisposition for the perception of communicative or meaningful hand gestures, but not for meaningless hand movements.

The cortical response to the observation of action in both human and nonhuman primates is very similar and supports the above findings. In humans, PET studies revealed that the observation of an action, such as grasping, activated the STS, the inferior parietal lobule, and the inferior frontal gyrus (area 45); all activation sites were limited to the left hemisphere (Rizzolatti & Arbib 1998). The activation found in humans parallels that found in nonhuman primates on similar tasks, thereby indicating "that, in primates, there is a fundamental mechanism for action recognition" (Rizzolatti & Arbib 1998). This is very interesting because the stimuli used in these experiments were not tied to linguistics; however, the findings may implicate "that this action-recognition mechanism has been the basis for language development" (Rizzolatti & Arbib 1998).

These findings suggest that the left hemisphere may not simply be responsible for language tasks, but for all linguistic tasks, including the recognition and processing of multiple modalities of communication – one of these modalities being gestural communication, from which it may be possible that language as we now know it has evolved. In Rizzolatti and Arbib (1998), a notion is put forth that the nonhuman primate homolog to the human cortical area known as Broca's is area F5 (the rostral part of the monkey ventral premotor cortex). "The reasons for this view are that both F5 and Broca's area are parts of inferior area 6 and their location within the agranular frontal cortex is similar; and cytoarchitectonically, there are strong similarities between area 44 (the caudal part of Broca's area) and F5" (Rizzolatti & Arbib 1998).

The major difference in conceptualization of these two areas is that Broca's is commonly associated with speech, F5 with hand movements. However, it is only the dorsal part of F5 that is responsible for hand movements, not inclusive of the ventral part, which is representative of mouth and larynx control, the prerequisites for speech (Rizzolatti et al. 1998). Furthermore, PET studies (such as the ones mentioned above) have implicated Broca's area in action-recognition of certain hand movements (e.g., Rizzolatti et al. 1996). It is possible that this hand movement recognition was the precursor to the recognition of meaningful hand movements (e.g., pointing or indicating danger), which are also processed in the left hemisphere. Furthermore, these meaningful hand movements are a basis for communication, a gestural communication that, coupled with the development and evolution of controlled mouth and larynx movements, could have evolved into a verbal communication that we use today.

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Motherese is but one part of a ritualized, multimodal, temporally organized, affiliative interaction

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Abstract: Visual (facial), tactile, and gestural, as well as vocal, elements of mother-infant interactions are each formalizations, repetitions, exaggerations, and elaborations of ordinary adult communicative signals of affiliation – suggesting ritualization. They are temporally organized and enable emotional coordination of the interacting pair. This larger view of motherese supports Falk's claim that the social-emotional elements of language are primary and suggests that language and music have common evolutionary foundations.

Falk's article emphasizes the important roles of visual, gestural, and tactile signals to infants, in addition to the vocal aspects that have been the primary locus of language origin studies. Her arguments about the importance of sociality and affect in mother-infant prelinguistic interchanges would be strengthened if they also incorporated provocative evidence that in the interactions these multimodal behaviors are *temporally coordinated.* If mothers "[modify] their vocal and gestural repertoires to shape and consciously control" infant behavior (sect. 3.2.1), it can be pointed out that shaping and controlling are temporal processes.

Infants are born prepared to engage in temporally organized interactions (Trevarthen 1997; 1999). Desynchronization experiments reveal that infants as young as 4- to 8-weeks old (Murray & Trevarthen 1985) expect social contingency, defined as "interpersonal sequential dependency," in which the behavior and affect of both partners (as expressed in face, voice, and bodily movement) are coordinated or "attuned" (Jaffe et al. 2001, pp. 13–14; Stern et al. 1985). When normal ongoing playful interaction via dual video is experimentally desynchronized (i.e., the baby is presented with a slightly delayed replayed recorded sequence of just-experienced positive interaction with the mother), 6- to 12-week-old infants show signs of psychological distress such as averted gaze, closed mouth, frown, grimace, fingering of clothing, and the displacement activity of yawning (Murray & Trevarthen 1985; Nadel 1996; Nadel et al. 1999). This emotional/behavioral coordination is more than "social." It is *relational,* and, like motherese (which is but one element in the engagement), it has developmental benefits and adaptive implications.

I have argued (Dissanayake 2000; 2001) that mother-infant interaction is a ritualized behavior like those described by ethologists (e.g., Eibl-Eibesfeldt 1989, pp. 439–40; Tinbergen 1952) for other animals, in which behaviors from one context (here, ordinary communicative indications of adult friendliness or readiness for contact) are altered – simplified or stereotyped, repeated, exaggerated, and elaborated – and take on new meaning in a new context (here, mother-infant interaction). The "ritualized" facial expressions of adults in interactions with infants typically include widened eyes, raised eyebrows, and a sustained open mouth or smile, all of which in their unritualized form indicate affiliation or friendly intention. Gesturally, adults sharply bob back their heads or nod rhythmically to infants, again presenting an exaggeration of head movements that conventionally signal affiliation in adults. Adults lean toward and away from an infant and give rhythmic touches and pats – again, friendly human gestures that are also common in many nonhuman primates. Vocalizations to infants by human mothers, as Falk describes, are soft, breathy, undulant and inviting, or soothing, with much repetition – that is, exaggerations of nonthreatening and affiliative adult utterances.

These components of mother-infant interaction do not occur in isolation, and they appear to be processed crossmodally (Schore 1994), as the pair co-create and share a common pulse and emotional quality which Trevarthen and Malloch (2000) call "affecting chains" or sequences of expression.

Ritualized, multimodal, temporally coordinated interactions are important in their own right at 4 to 12 weeks of age, long before they are co-opted and altered further for didactic language-learning purposes at age 5–8 months and later. Falk remarks (sect. 2.2) that ID speech contributes initially to emotional regulation, then to socialization, and finally to the organization of speech. If for "ID speech," one substitutes "the package of ritualized behaviors, including temporal, dialogic, and emotional aspects," one further emphasizes the importance of the emotional (prosodic) elements of speech (phylogenetically and ontogenetically), and its dialogic nature – overlooked aspects that Falk seeks to remedy.

Incorporating this additional evidence of the social-emotional nature of the interaction also supports Falk's suggestion that motherese could have been a precursor to (or antecedent of) the social grooming origin and function of language. It additionally supports suggestions that music and language have a common evolutionary foundation (Morley 2002).

Falk describes well in section 3 the anatomical changes in bipedal, large-brained hominins that required new adaptive strategies for the survival of relatively undeveloped infants. If mothers made ritualized affiliative signals in several modalities to their infants, they would concurrently reinforce affiliative circuits in their own brain; infants in turn would respond affectively, displaying their interactive lovability and thereby attracting maternal care. Co-creating a dialogue within a common pulse would further coordinate the affective state of the participants, promoting willing maternal care (i.e., infant survival and maternal reproductive success). Even today, neurobiologists describe the pathological effects to infants of defective interactive abilities of either infant or mother (Aitken & Trevarthen 1997, Koulomzin et al. 2002; Schore 1994; Trevarthen & Aitken 1994) corroborating others' findings about the beneficial effects of mother-infant interaction.

I suggest that putting the baby down and interacting vocally at a distance would have come, evolutionarily, *after* the establishment of ritualized mother-infant interaction as described here. The importance of face-to-face communication is evinced in "still face" experiments with 2- to 9-month-old infants (Murray & Trevarthen 1985; Tronick 1989), in which an expressionless mother provoked infant distress, and also in the prominence of mutual gaze, a striking feature of mother-infant interaction in many if not all cultures. Falk points out that "mothers unconsciously establish eye contact with infants and then use motherese to maintain joint attention" (sect. 2.2). Actually, however, the capacity for "sustained mutual visual regard" – normally a threat signal, although it also appears in affiliative contexts in bonobos – is present by approximately the second month (Beebe 1982, p. 171). Accompanied by adult smiling and soft, repeated vocalizations, mutual gaze in an infant's early weeks accomplishes more than joint attention. Some researchers consider face-to-face communication and/or mutual gaze critically important to subsequent infant socioemotional development (e.g., Cohn & Tronick 1987; Schore 1994).

These comments are meant not to challenge Falk's original and stimulating ideas, but, rather, to suggest other supportive avenues for consideration and exploration. Future studies of the nature, function, and origin of language would do well to recognize, as Falk does, the importance of its social and emotional elements.

Chimpanzees are not proto-hominins and early human mothers may not have foraged alone

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Abstract: Modeling the evolution of human behavior, including language, is a complex but important undertaking. The over-reliance on chimpanzees as models to assess basal hominin patterns and the implicit assumption that hominin mothers did not have significant assistance in caring for young weaken this model for the emergence of language from mother-infant vocal interactions.

This very interesting article proposes a scenario for the evolution of human language via a form of vocal contact interaction between hominin mothers and infants. Unfortunately, the hypothesis rests firmly on a series of assumptions about hominin social organization and behavior and anthropoid behavioral patterns that may not be valid. Among these assumptions are that chimpanzees (genus *Pan*) are the most appropriate models for understanding the behavior of hominins in the late Pliocene and early Pleistocene (3 million to 1 million years ago); that female hominins on the human lineage foraged alone; and that alloparenting, paternal care, or other communal care was not a significant factor in human evolution.

Falk uses observations of infant parking in nonhuman primates, mostly prosimians and a few anthropoids (Fuentes & Tenaza 1995; Ross 2001), to emphasize the potential costs of infant carrying in difficult foraging situations. However, our observations of infant parking in the colobine monkeys *Simias concolor* (Fuentes & Tenaza 1995) and *Presbytis potenziani* (Fuentes 1994) may or may not support the cost of foraging hypothesis. We proposed the cost of infant carrying as a possible explanation of a rare behavior for an anthropoid (parking), but also suggested that the parking of infants may have been an antipredator strategy (ease of escape for the mother) or, alternatively, a response to relaxed predation. Only some females parked infants, and our observations were too limited to establish any clear relationships between the parking and specific foraging strategies. Obviously issues of milk quality, weight of infant, predation threat, allocare and cooperative care, and activity patterns affect significantly infant parking in primates, especially humans. In her overview of parking and carrying in primates, Ross (2001) suggested that in humans, nonhabitual carrying of infants may be related to the availability of nonmaternal caretakers.

For the basal component of the proposed hypothesis, Falk relies on information from a few studies of wild and captive chimpanzee, some "ape language" studies, and a very general conceptualization of late Pliocene/early Pleistocene hominins. Although the exact timing of the lineage split between hominins and the ancestral lineage of the genus *Pan* is contended, most would agree that it occurred in the vicinity of 6 to 8 million years ago. By at least 2.5 million years ago, the Bouri hominins (either *Australopithecus* or *Homo*) were using stone tools and thus manipulating their environment in a way no other primate had (de Heinzelien et al. 1999). By the undisputed appearance of members of the genus *Homo,* approximately 1.8 million years ago, dramatic anatomical and, assumedly, behavioral changes appear evident in the fossil record (Aiello & Wells 2002; Gabunia et al. 2001). Given this, one should exert caution when making direct comparisons between modern members of the genus *Pan* and modern members of the genus *Homo.* In both these genera, locomotary patterns, brain structures, group structure, and social interaction patterns have diverged under varied selective pressures and trajectories. Chimpanzees are not proto-hominins, and all of the hominins, although sharing some behavioral patterns in common with *Pan,* may have been encountering selectively different challenges (or at least dealing with similar challenges in different ways). The relative success of humans using language and broadscale extrasomatic manipulation, versus *Pan* not using language and manipulating the environment in diverse yet less complex ways, suggests that there are some distinct evolutionary patterns at play. Obviously, due to their relatively recent common ancestry, humans and chimpanzees share much of their adaptive history, but in those aspects that differentiate them (e.g., spoken language) we can expect that the underlying patterns and evolutionary pathways might be different. It is also noteworthy that chimpanzees themselves display remarkable diversity in behavioral patterns both within and between species (Boesch et al. 2002).

It is popular to model single female foraging as a baseline for hominoid behavior (Wrangham 1979), and Falk (citing chimpanzee researchers Stanford [1998] and Nishida [1968]) suggests that hominin mothers traveled in the company of dependent offspring and a small number of other individuals. However, given what we know from the fossil record and from comparative studies of hominoids, it is far from clear that adult female hominins, especially early members of the genus *Homo,* foraged alone, or even relatively alone, with their offspring (Aiello & Wells 2002; Fuentes 2000; O'Connell et al. 2002). Mothers may have been accompanied by older children or related adults, thus siblings or other kin may have played a role in infant care, and some individuals may have stayed behind during foraging to care for dependent young. Food may have been shared among group members or there may have been some form of provisioning of mothers with dependant offspring, or both. Unfortunately, we do not have clear evidence about what types of nonmaternal care, if any, occurred in the hominins on our lineage. A wide array of possible forage targets would have affected the patterns of foraging and thus the placement of offspring relative to the mother or other caretakers as well (Aiello & Wells 2002; O'Connell et al. 2002; Wrangham et al. 1999). Using digging sticks to extract underground tubers, stone tools to process plant and/or meat items, and picking and transporting fruits or herbaceous matter over long distances all have distinct implications for the positioning of a dependant child and the relative impact it had on the mother or other caretaker. In short, it is not at all clear that the simple foraging patterns assumed by Falk as a baseline and driving factor in the *putting the baby down* hypothesis did indeed characterize early humans.

It is also not clear that the aspects of behavioral variation suggested as the raw material for selection to act on are as robust as Falk proposes. Simply assuming that variation in the attention mothers provided their infants acted as the "raw material" for selection creates an overly simplistic, linear notion of natural selection. What are the variables for "attention" and what are the costs? Can attention to infants really be treated as a trait independent of foraging patterns, group demography, individual life histories, and size, health, and behavior of the infant?

Not all of this critique is to say that the scenario proposed by Falk is incorrect. It is an attempt to reconstruct a very complex and important episode in our evolutionary history. The connection between foraging pressures, motherese, and human language may well be a fertile area for further investigation, but the hypothesis proposed by Falk rests on too many assumptions to be effectively treated as testable.

Aspects of human language: Where motherese?

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Abstract: Human language is a peculiar primate communication tool because of its large neocortical substrate, comparable to the structural substrates of cognitive systems. Although monkey calls and human language rely on different structures, neural substrate for human language emotional coding, prosody, and intonation is already part of nonhuman primate vocalization circuitry. Motherese could be an aspect of language at the crossing or at the origin of communicative and cognitive content.

To paraphrase Gibson (1995), Falk succeeds here in collecting and assembling pertinent new pieces to help solve the language origins puzzle. In presenting possible alternatives to suggestions that language could not have emerged from an earlier primate communication system, Falk takes a view that contrasts with hypotheses emphasizing the origin of language as a cognitive adaptation. As suggested by Jerison (1977; 1986; 1988; 1991), human language as an adaptation for communication is peculiar because of the huge amount of nervous tissue involved in human language processing. Communication exists everywhere in the animal kingdom and involves few nervous cells. As a consequence, if human language evolved as a cognitive adaptation comparable to vision or hearing and most probably to a multimodal "supersensory" system for knowing the outside world, then the huge amount of neural tissue involved in language is understandable and is comparable to the situation that prevails in other cognitive systems. This view is close to the one of Geschwind (1965; 1970) who argued that language is based on the expansion of angular and supramarginal gyri in humans. The angular gyrus region in particular receives input from all cortical sensory areas and thus supports cross-modal integration. Furthermore, the anatomical and functional relationships between the supramarginal gyrus and Broca's area in humans suggest that language processing is related to working memory networks (Aboitiz & Garcia 1997a; 1997b).

Besides these views of human language with roots in noncommunicative sensory function, in the building of a world image or as a model of "sensory enhancement" (Jerison 1986), another view relates the emergence of language to nonlinguistic motor actions and their representation. Rizzolatti et al. (1996) observed that, in the premotor cortex of the monkey (area F5), neurons that elicit the performance of an action also discharge when the monkey observes a similar action made by another monkey or by the observer. The activity of these "mirror" neurons represents the observed action and is the source of the understanding of motor events. Interestingly, the observation of motor actions activates the posterior part of the inferior frontal gyrus in man (Broca's area), a region most probably homologous to area F5 in monkey. Rizzolatti et al. (1996) therefore suggested that human verbal communication derives from a prior communication system essentially involving the recognition of hand and face gestures. The hypothesis that action recognition and verb generation share a common functional architecture in the inferior frontal gyrus has recently been successfully tested (Hamzei et al. 2003).

In a comparable scenario, Wilkins and Wakefield (1995) suggested that linguistic capacity in humans is separated from communicative abilities and that language-centered cortical areas initially evolved to fulfill complex manual (nonlinguistic) activities. These cortical regions, including Broca's area and Wernicke's parieto-occipitotemporal complex, were subsequently reused ("evolutionary reappropriation") for linguistic activities.

A detailed discussion of these alternative hypotheses is out of our scope. The point here is that all of them require large portions of the neocortex as structural substrate for human language emergence. Moreover, in elaborating these hypotheses, researchers look at what constitutes the anatomical substrate of human language and then look at the function of homologous structures in nonhuman primates. Based on Falk's views, it would be possible to do the reverse – that is, look at what constitutes neural substrate of monkey vocalizations and then search to discover whether homologous structures are involved in human language.

Neural structures controlling vocal calls in monkeys and speech in humans only partially overlap. The first are mostly subcortical structures and involve diencephalic, midbrain, and brain stem components. The cortical structures that play a role in monkey phonation, the anterior cingulate cortex (anterior limbic mesocortex) and the supplementary motor area (neocortical area), are on the mesial surface of the hemispheres (Ploog 1988; Sutton & Jürgens 1988). Human speech is essentially controlled by the activity of a circuit formed by the Wernicke's and Broca's regions, which are located on the dorsolateral part of the neocortex. The neocortical face area on the lateral surface has a role in motor control over oral and laryngeal structures in monkey, chimpanzee, and gorilla, but with the exception of the cingulate cortex, the role of the neocortex in nonhuman primate vocalization appears to be negligible. In addition, there is a direct connection between the primary motor cortex and the laryngeal motoneurons in humans. Such a connection is lacking in monkeys (Deacon 1989; Sutton & Jürgens 1988). It seems therefore that most of the brain structures involved in human speech control are dispensable for monkey call production.

It must, however, be emphasized that limbic and neocortical regions that play a role in nonhuman primate phonation circuitry also play a role in specific aspects of human language. The anterior cingulate cortex is responsible for the voluntary initiation of voice in monkeys. Monkeys as well as apes have voluntary control of the initiation of species-specific calls, although they have very restricted control of acoustic structure of phonations (frequency and amplitude modulation). In contrast, the human anterior cingulate cortex is responsible for the control of prosody and intonation and for the coordination between speech and emotional content. The supplementary motor area participates in the initiation of global motor programs and seems to be involved in the initiation of behavioral patterns not directly triggered by external stimuli. In humans, damages to this area in the dominant hemisphere cause transient mutism and dysarthrophonia (Jürgens 1988; Penfield & Roberts 1959; Ploog 1988). Although we cannot demonstrate whether there is a link between monkey calls and motherese, it appears that the neural substrate for emotional coding, prosody, and intonation, and hence for essential aspects of motherese content, is largely present in nonhuman primate phonation circuitry. It has been suggested by Deacon (1989) that the vocalization circuits that play a central role in nonhuman primate vocalization became integrated into the more distributed human language circuits. These old circuits were neither eliminated nor supplanted, but still play a role at some level of the language processes. It is possible that motherese illustrates one aspect of human language besides other aspects involving communicative as well as cognitive processes. The ideas developed by Falk could therefore be seen as an interesting possible link between noncommunicative (cognitive) human language and communicative human language emergence hypotheses.

Beyond prosody and infant-directed speech: Affective, social construction of meaning in the origins of language

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Abstract: Our starting point for the origins of language goes beyond prosody or infant-directed speech to highlight the affective, multimodal, and co-constructed nature of meaning-making that was likely present before the split between African great apes and hominins. Analysis of vocal and gestural caregiving practices in hominins, and of meaning-making via gestural interaction in African great apes, supports our thesis.

Falk joins the origins-of-language theorizing game by focusing on daily, routine interactions between mother-infant dyads in chimpanzees and bonobos versus those in early hominins. In doing so, Falk weaves together a number of hitherto disparate strands in primatology and developmental psychology into a unified hypothesis about the role of motherese in the evolution of speech.

Unlike many other scenarios (e.g., Corballis 2002)), Falk sees hominin communication as about more than resource acquisition and predator avoidance. Hominins, in her view, had emotional ties with kin and other social partners that influenced their daily activities, including their social communication.

We admire this approach to modeling hominin social life. Understandably, such an ambitious undertaking raises a number of issues where one might want to challenge some of the assumptions the author makes. We will, instead, confine our remarks to two major aspects of Falk's thesis: the role of motherese in the evolution of speech/language, and the suite of abilities in modern-day chimpanzees and bonobos that may be used to reconstruct a starting point for the origins of speech/language.

Falk is arguing for a continuity view of the development of motherese, whose origins lie in simple "prosody," which, in the earliest stages, the caregiver uses as a mechanism for soothing and regulating the baby, first proximally and then distally. As the baby develops, the caregiver's prosody becomes more complex and serves to establish joint attention and coordinate activities. Finally, in humans, motherese takes on the didactic role made famous by Bruner's (1983) original argument about the "scaffolding" role played by motherese.

A problem raised by this last step is clear: Insofar as this didactic function for motherese is typically seen as contingent on the adult's language competence, Falk's argument is circular. We would argue, however, that Falk presents a more interesting hypothesis than such a knee-jerk response acknowledges; for what she is really talking about is the central role of affect in coregulated communication (see King & Shanker 2003; Shanker & King 2002).

In Falk's use of the term, "prosody" is synonymous with "affective" (sect. 1). Rather than seeing the development of motherese thus construed as only "the result of prior selective pressures" (sect. 1), however, we argue that the key communicative advances taking place were socially conveyed through the consolidation and extension of caregiving practices (see Greenspan & Shanker 2004). Furthermore, we would stress that these affective interactions involved not only vocalizations but also gestures, body movements, facial expressions, and so forth. This is not to deny that the voice enables us to produce a wide range of different sounds that can convey subtle affective variations, but neither should we underestimate the subtle emotional variations that can be conveyed through facial expressions, gestures, body movements, and so forth.

Most intriguing about Falk's hypothesis is the suggestion that affective interaction would have originally occurred through touching, holding, smelling, and rhythmic rocking, and then progressed to the stage wherein caregivers were able to maintain the same sense of closeness and feelings of nurturing in their infants through distal communicative behaviors. On this hypothesis, the origins of language would have had its roots not in the "exchange of information" but rather in the pleasure and security provided by basic nurturing social interactions (see Greenspan & Shanker 2004). Using such an approach, one considers not what linguistic gestures *represent* but, as we have argued elsewhere, what they mean to the participants. Meaning is thus conceptualized not as the transfer of some symbolically encoded information, but as the mutual transformation in the thoughts and actions of two partners in the contexts of ever-changing interactions (see Shanker & King 2002).

That meaning emerges, for social partners, from affective social interaction, is an idea with significant implications for modeling the origins of language. Elsewhere, we have presented data (King 2002; 2004; King & Shanker 2003) in support of the claim that the African great apes, too, participate in coregulation rather than in the mere exchange or transmission of information. Whereas Falk emphasizes (sect. 2.1, last para.) that bonobos may "engage in more language-like exchanges of information about their internal states than do common chimpanzees," we highlight a different suite of abilities, one centered on coregulation and expressed routinely by wild and captive bonobos, chimpanzees, and gorillas.

Let us continue with bonobos as an example. Captive bonobo infants make arm and leg extensions that become social request gestures only when the infants interact with their siblings or mothers. Meaning is not in the movement – rather, it becomes a social gesture, with meaning, only when the infant-caretaker dyad acts together around the movement. This meaning-making itself develops gradually from the frequent dancelike adjustments made by infants and their social partners to each others' actions, starting in the hour after the infant's birth (King 2002).

This process is confined neither to enculturated bonobos nor to captive ones, as demonstrated by Kuroda's (1984) analysis of rocking behavior of bonobos in the Democratic Republic of Congo. Wamba bonobos make a variety of motions in which they rock the upper body and head back and forth or side to side. Rocking occurs in seven contexts including mother-infant behavior, sex, grooming, and aggression; at least four varieties can be distinguished in male courtship alone. Bonobos attend to a constellation of factors when confronting a rocking companion, including whether the rocker also arm-raises or leans back; whether the rocking is slight or vigorous; and what the rocker's facial expression and arousal level are. The social partners adjust their actions to each other's actions and, as Kuroda made clear, together converge on a meaning for the rocking as they interact.

Across environmental and rearing contexts, African great ape social partners co-create meaning from gestures, leading to a "jumping-off point" for language-origins theorizing that is different from Falk's. Assuming, as anthropologists routinely do, that modern-day ape behaviors point reliably to behaviors of the ape-hominin common ancestor, it becomes clear that we need to look beyond infant-directed behavior or even reciprocity to understand the evolution of language. To the degree that vocal motherese played a role in this evolution, it developed in primates already highly skilled at participating in mutually constructive meaning-making from very young ages.

Trickle-up phonetics: A vocal role for the infant

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Abstract: Falk claims that human language took a step forward when infants lost their ability to cling and were placed on the ground, increasing their fears, which mothers assuaged prosodically. This claim, which is unsupported by anthropological and psychological evidence, would have done little for the syllabic and segmental structure of language, and ignores infants' own contribution to the process.

Falk asserts that when ancestral infants lost their ability to cling, mothers put them down, increasing the infants' isolation fears, which the mothers proceeded to assuage prosodically. Her proposal thus appears to offer a possible maternal solution to problems arising from motoric altriciality, dependency, and mother-infant separation. Unfortunately, anthropological accounts indicate that most hunter-gatherer mothers rarely put their babies down, and then did so for no more than a few seconds, usually remaining within a meter (Draper 1976; Hill & Hurtado 1996; Konner 1976; Lee 1979; LeVine 1980). Any separation cries immediately evoked pick-up and breast-feeding (LeVine & LeVine 1966). When infants cannot be carried, they are usually left in the care of others (Blurton Jones 1972). Therefore, there are reasons to question the three major premises of Falk's proposal: that hominid infants were frequently separated from their foraging mothers, that they were frightened and in need of reassurance, and that they were mollified vocally.

If mothers had *engaged* and *interacted* with their infants vocally – not merely crooned to them – this could help explain the modality of languages but it would do little to explain the structure of languages, which achieve their diversity and creativity through the use of syllables and segments (Studdert-Kennedy, in press). It makes more sense to appeal to a behavior such as lipsmacking, which involves mandibular oscillations that are effected with audible labial and lingual contact in affiliative contexts (Redican 1975), in gross resemblance to spoken syllables (MacNeilage 1998). However, maternal vocalization probably would not have been used to ease infants' distress, for this typically has little effect, whereas being picked up usually helps (Bell & Ainsworth 1972).

If the proposal is to be rescued, amendments are needed. I will suggest two. The first recognizes the fact that the ongoing vocalizations of mothers and infants constitute a system of "tonic communication," a term suggested by Schleidt (1973), who reasoned that by continuously emitting signals at a rate corresponding to particular interindividual distances, attending individuals are instantly apprised of changes and thus kept together. Some of the more vocal primate groups have such a system. In geladas, Richman (1980) noted, "the channel of communication is always open . . . for any type of sudden message" (p. 239). There are reasons to suppose that human mothers and infants use their voices in this way, too (Locke 2001).

The second amendment holds that mothers vocalized to distract the older, weaned and ambulatory infants who were about to drift away or get into trouble, recognizing that infant-directed lipsmacking (as Falk cites) produces a following response in physically separated monkeys (Harlow et al.1963; Maestripieri & Call 1996); or to attract the attention of infants for instructional purposes. Primate mothers have been observed preventing their young from eating alien substances and threatening young animals as they approached toxic fruits (Caro & Hauser 1992). These and other kinds of instructional opportunities would have increased with a lengthening of the interval between infancy and the juvenile period – now measuring four years in humans – in which the young are motorically independent but remain unable to locate and consume food without assistance (Bogin 1999). Falk's proposal would benefit if the applicable developmental period were shifted from infancy to *childhood.*

This second amendment invites consideration of the possibility that hominid infants played an active role in evolutionary change. Mother-infant dyads are maintained, to some extent, by turn-taking and other forms of vocal meshing (cf. Locke 1993). In this context, the significance of maternal vocalization stems from its structural similarity to the preexisting vocal behaviors of *infants.* Monkey mothers, as we saw, lipsmack to their infants to get attention, but infants begin to lipsmack in the first few days of life (Kenney et al. 1979) and would already have been doing so themselves. In pygmy marmosets, the calls that evoke parental attention and care frequently contain elements that are found in the adult repertoire (Elowson et al. 1998). If one of the parties is imitating the other in these cases, which is it? In our own species, infant attention is facilitated by *adult* imitation. Meltzoff (1990) found that 14-month-olds attended to, and smiled at, an adult if he precisely replicated the infants' own actions, doing so far more frequently than when the adult performed an unmatching action. In a group of 17- to 43-week-old infants, Pawlby (1977) found that more than 90% of the phonetic matching was attributable to mothers imitating their children, commenting that infants "pay special attention (in that they laugh and smile and appear to be pleased) when the mothers themselves imitate an action which the child has just performed" (p. 220).

This sort of "trickle-up phonetics" can have lasting effects. In a number of disparate cultures, parents use specialized "baby words." The constituent consonantal sounds are primarily stops, nasals, and glides, frequently recurring, reduplicatively, with low vowels (e.g., "dada," "mama," "wawa"; cf. Locke 1983). These items resemble the familiar forms of babbling, a behavior that is valued by parents and may have been selected for (cf. Locke, submitted). Such standard lexical items as "mommy" and "bye-bye" further illustrate the strength of the tendency to incorporate infant vocalizations into the adult repertoire – that is, language.

Falk may not have been wrong to suggest that maternal prosody played a role in hominid life, but was it an evolutionary linguistic role, and were children's own vocalizations irrelevant? At some point, as we know, social vocalization went syllabic. In the other primates, nonvocal behaviors have been observed in infants before they entered the repertoire of adults (Kawamura 1959). If a similar progression occurred in the more neotenous and vocal – and no less orally repetitive – hominid young, they and their mothers may have contributed to the ultimate form of human language.

In the beginning was the song: The complex multimodal timing of mother-infant musical interaction

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Abstract: In this commentary we raise three issues: (1) Is it motherese or song that sets the stage for very early mother-infant interaction? (2) Does the infant play a pivotal role in the complex temporal structure of social interaction? (3) Is the vocal channel primordial or do other modalities play an equally important role in social interaction?

In her target article, Dean Falk focuses predominantly on one side of mother-infant interaction. She eloquently illustrates the contribution that mothers make to the development of communication and speculates in fascinating ways about the evolutionary roots of motherese, or infant-directed speech. In this commentary, we raise three issues: (1) Is it language or an even more fundamental form of communication, song, that sets the stage for very early mother-infant interaction? (2) Does the infant also play a pivotal role in the complex temporal structure of social interaction? (3) Is the vocal channel primordial or do other modalities play an equally important role in social interaction?

First, we consider whether motherese or song might lie at the basis of very early infant-mother interaction. We argue that one crucial difference between motherese and song is that motherese tends to stress meaning alongside social interaction, whereas the actual semantic content of songs is often completely irrelevant. What is crucial about songs is the rhythmic and segmental characteristics of the vocal message, and this may make it primordial over early linguistic interaction. Indeed, in a longitudinal, microdevelopmental study of infant-mother dyads at 3 and 7 months of age, Longhi (2003) made an in-depth analysis of the temporal structure of the songs mothers sing to their infants as well as of the temporal structure of the infants' responses. Her analysis included several modalities – vocal, visual, kinaesthetic, and tactile – and focused on the spontaneous segmentation of songs into hierarchically organized units. She showed not only that songs are used to regulate the infant's emotions, but, critically, that they also serve a structural purpose in helping the infant anticipate the segmental units of the mother's songs. While songs bear a clear-cut relationship to language due to their hierarchical structure, the more regular musical syntax of songs makes it possible for simpler segmental units to emerge: a song can be broken down into units of three or four notes, phrases, and larger units, and mothers convey these units to their infants. The fact that songs are very repetitive also plays a role.

Another important aspect of musical interaction turns out to be tempo, which again differentiates song from language. Longhi found that mothers vary the tempo of their songs according to the infant's behavioral state. In particular, they sing at a fast allegro tempo for attentional purposes – that is, to attract the infant's attention. On the other hand, mothers sing at a slower andante tempo for interactional purposes – that is, to maintain the infant's attention. Tempo also helps to create regularities that are crucial in the interaction. When analyzing the duration of the phrases of the song, Longhi (2003) found that the mothers also differentiate the two tempos in terms of which phrase is longer: for allegro, the second phrase of the song is significantly longer, whereas for andante it is the fourth phrase of the song that is significantly longer. Thus, infants can use these different tempos to anticipate the structure of the musical interaction. Mothers also stress the duration of upbeats significantly longer than downbeats, creating a gap effect, and thereby marking the segmental units of the song. Therefore, it could be that, alongside motherese, song plays a far more important role than hitherto realized. This might be worth considering from an evolutionary point of view, as well. Prior to the use of lexical terms, it is possible that mothers used structured melodic outputs to reassure their infants that they were close by – any time they had to put them down during foraging.

It is becoming increasingly clear that infants do not listen passively to their mother's songs. Rather, they actively participate in the synchronous timing of movements, thereby anticipating the song's segmental units. Thus, the temporal structure of mother-infant interaction via song does not only emanate from the mother; infants also play a pivotal role. Infants react not only by emotional responses such as smiling and cooing, but they also coordinate their movements with the temporal structure of their mother's song. Already at age 3 months, they seem to have a mental representation of the musical interaction, displaying synchronous behaviors with the stressed segments of the song significantly more often than with the nonstressed segments (Longhi 2003). However, there are also developmental differences. At the age of 3 months, infants tend to respond by clustering their behaviors around the main parts of the song (the beginning, middle, and end), whereas by 7 months they organize their synchronous behaviors more smoothly in time with the beat across the different phrases of the song. Moreover, with time, infants learn to anticipate the stressed elements, thereby increasingly demonstrating their sensitivity to the hierarchical structure of songs. It is possible that this helps them in their efforts to structure linguistic interaction also.

The importance of the mother's use of multimodal channels has been stressed with respect to speech (e.g., Gogate et al. 2000; Papousek & Papousek 1981), but the use of multiple modalities during singing is even more striking (Longhi 2003). Longhi carried out a musical analysis of the mother's beat, a frame-by-frame behavioral analysis of the mother's and infant's behaviors, and a musical plus behavioral analysis examining the synchronization of the partners' behaviors with the musical beat. She found that when mothers are singing, they mark boundaries between phrases while simultaneously shaking their heads, rocking their bodies, and patting their infant's bodies in an intricately timed fashion, to which their babies respond with similarly tightly synchronized movements. More interesting are the developmental changes that mothers introduce when singing to their infants. Longhi's study showed that when infants are around 3 months of age, their mothers use a great deal of synchronous physical contact with their infant while singing. By the time infants are 7 months of age, mothers produce more synchronous actions in contact with toys and other external objects while singing, significantly reducing those in direct contact with their infant. This highlights a change in the terms of the interaction from dyadic to prelinguistic triadic interaction through song.

In sum, it is worth considering the possibility that, with its simpler, regular structure, musical interaction in general, and song in particular, may have played a greater role in evolution and ontogeny than Falk's target article would suggest.

Baby talk and the emergence of first words

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Abstract: Words denoting "mother" in baby talk and in languages usually include nasal sounds, supporting Falk's suggestion that infant nasalized demand vocalizations might have motivated a first word. The linguistic contrast between maternal terms and paternal terms, which favor *oral* consonants, and the simple phonetic patterns of parental terms in both baby talk and languages also suggest parental terms could have been first words.

Falk has presented a very plausible scenario regarding the communicative context for the first spoken words. Early hominid mothers needed to park their babies while foraging, she argues. The resulting need for parental care at a distance created selection pressures for an elaboration of the dyadic vocal communication pattern. Long-standing properties of the mother-infant communicative dyad could induce a participant to link a specific vocalization with a recurring aspect of the context, as a word requires. Those properties typically include a nonthreatening environment (in which the participants know each other well) and highly focused attention. The actions involved are stereotyped, simple, and frequently repeated.

Falk designates infant nasalized demand vocalizations (of the kind noted by Goldman 2001) as originally serving to name the recipient of those vocalizations. We add phonetic evidence for the correctness of Falk's hypothesis, focusing on a relatively neglected linguistic genre that originated in the parent-infant communicative dyad – the phenomenon of baby talk. Ferguson (1964) defines it as "any special form of language which is regarded by a speech community as being primarily appropriate for talking to young children and which is generally regarded as not the normal use of language" (p. 103).

Baby-talk words (e.g., "mama," "bow-wow," "wee-wee") have a number of characteristics relevant to the question of the nature of first words. They tend to be phonetically simple because most are produced by infants as well as adults. Presumably, simple forms are favored in the first words. Also, many baby-talk words are probably old, a prerequisite for their being potential early words of language. Ferguson (1964) cites evidence of "the persistence of baby talk words for food, drink, and sleep for two thousand years in the Mediterranean area" (p. 104).

In addition, baby-talk words provide two specific phonetic sources of evidence of their relevance to the origin of first words. This evidence comes from Ferguson's (1964) sample of 213 baby-talk words derived from six language communities: Arabic, Comanche, English, Gilyak, Marathi, and Spanish. The words were grouped into four categories: kinship terms (for "mother," "father," and "infant"), words for body parts and functions, "qualities" (descriptive words), and words for animals and games. The first evidence is that all the words in Ferguson's corpus for female parent contained a nasal sound, whereas none of the words for male parent did. This not only supports Falk's suggested linkage between nasal sounds and the word for female parent but also suggests the development of something that might be expected in a true linguistic system. There is a clear phonetic *contrast* between the words for female parent and the words for male parent: the former are linked with the nasal airway (one of the two basic speech airways) and the latter are linked with the oral airway.

The second source of evidence comes from our analysis of the overall phonetic structure of 80 consonant-vowel-consonant-vowel (CVCV) words in the Ferguson baby-talk corpus. We show that they fit the pattern suggested for the first words in the Frame/Content theory of the evolution of speech (MacNeilage l998). In particular, the baby-talk words show three CV co-occurrence patterns that have now been repeatedly found in babbling and first-word corpora of infants (Davis & MacNeilage 2000) and are also widespread in languages (MacNeilage et al. 2000). They are coronal (tongue-front) consonants with front vowels; dorsal (tongue-back) consonants with back vowels; and labial (lip) consonants with central vowels. These patterns suggest biomechanical constraints against tongue movement from consonant to vowel that were probably present in the first attempts at words. In the baby-talk corpus, we obtained the following observed-to-expected ratios of the three patterns: coronal-front, 1.30; dorsal-back, 2.20; labial-central, 1.33. (Ratios above 1.0 indicate above-chance occurrence.)

In addition, as in the babbling and first words of infants, we also found three similar patterns in vowels and *following* consonants (VC) in Ferguson's baby-talk words (1.50, 1.64, and 2.38, respectively), consistent with the fact that first and second syllables in all these samples tended to be reduplicated (repeated), as we assume they tended to be in the earliest words. In contrast, in modern languages, there are no such VC co-occurrences, which is consistent with the fact that successive syllables in evolving languages tend to be different, presumably associated with the evolution of the syllable as a separate functional entity, in the service of increases in the size of the message set.

One could contend that baby-talk words are not real words, and therefore could not have been first words. However, it is likely that parental terms now considered legitimate may have typically derived from baby-talk words, as suggested for English by Jakobson (1960). He noted that the intimate, emotional, childishly tinged words of baby talk coexist today with more general and abstract, exclusively adult parental terms. Thus, in English, various forms of "mama" and "papa" or "dada" differ in use from the higher terms "mother" and "father." Jakobson then suggested that "in Indo-European, the intellectualized parental designations *mater* and *pater* were built from the nursery forms with the help of the suffix *-ter* used for various kin terms"(1960, p. 60). Then, as he described it, a sound change occurred in *pater* that made the initial stop [p] and the intervocalic stop [t] into fricatives (hence "father"), while another such change had the same effect on the [t] of "mater" ("mother").

In addition, there is direct evidence that the use of the nasal airway for maternal terms and the oral airway for paternal terms is present today in languages proper, as would be expected if they were derived from baby-talk terms. In a study of kinship terms in 474 languages, Murdock (1959) found that 78% of the words for "mother" begin with a nasal consonant and 66% of the words for "father" begin with an oral consonant. He also presented data on vowel frequencies, using a slightly different categorization of vowels than our own. Using these data, we found that the first syllables of Murdock's words showed three patterns of consonant-vowel co-occurrence constraints similar to the ones we have found (coronal, high front 1.34; dorsal, high back, 2.27; labial, low vowel, 1.12). (Most low vowels in language are central [Maddieson l984].) Murdock did not present data on the second syllables of these words, but we predict that, given their probable origin in first words, these terms, though now in languages proper, are more likely to involve syllable reduplication than are other typical words of modern languages.

How exactly were the phonetic forms originally linked with the concepts of male parent and female parent? Falk suggests, with respect to the maternal term, that the infant's nasal sound put a name to the face of the caregiver. However, it was necessary for the *mother* to make the connection (i.e., "this stands for me") and to use the result of this pairing in communication with others in order for the nasal form to function as a true word. Then, perhaps by default, the infant's *oral* vocalizations were deemed to signal "male parent." Conscious reflections on these pairings might eventually have led to the "naming insight" – the insight that things could be given names (McShane l979).

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Affective prosody: Whence motherese

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Abstract: Motherese is a form of affective prosody injected automatically into speech during caregiving solicitude. Affective prosody is the aspect of language that conveys emotion by changes in tone, rhythm, and emphasis during speech. It is a neocortical function that allows graded, highly varied vocal emotional expression. Other mammals have only rigid, species-specific, limbic vocalizations. Thus, encephalization with corticalization is necessary for the evolution of progressively complex vocal emotional displays.

Falk's contribution to the discussion of the evolution of language is a complex review of communication and infant-rearing characteristics in which the continuity hypothesis is invoked. It is clear that motherese speech is an important element of modern human communication and must have its own evolutionary origin and a connection to language. Falk's model raises important issues addressed in this commentary (mechanisms/evolution of modern motherese; contemporary infant parking, neurology of affective prosody, and species-specific emotion displays in relation to evolution of language).

Motherese characteristics may be more important to a discussion of the evolution of language than Falk's emphasis on chimpanzee/primate rearing behavior. Motherese, or infant-directed speech (IDS), compared to adult-directed speech (ADS), is characterized by simpler phrases, longer pauses, more repetition, wider tone range, and higher overall tone when addressing an infant. Higher overall tone and wider tone range are speech characteristics of happiness, and are the most salient cues in IDS (Frick 1985; Scherer 1974; Scherer & Oshinsky 1977). These changes are *injected into speech automatically and unconsciously.* IDS is thought to be a universal human trait (Fernald 1992), and has been documented in diverse language groups including click, tonal (e.g., Mandarin), nontonal (e.g., English), and even sign languages (Ferguson 1964; 1977; Fernald 1991; Fernald & Mazzie 1991; Fernald et al. 1989; Masataka 1992; Papousek & Papousek 1992). A nonhuman primate homologue of motherese has been found in which squirrel monkey adults addressed infants with an acoustically different utterance (Biben et al. 1988). Infants prefer IDS in any language (Cooper & Aslin 1989; Colombo et al. 1995; Cooper et al. 1997). *Premature* infants have been shown to respond to IDS with calm awareness, in contrast to other forms of stimulation, such as stroking, which overwhelm their immature nervous systems (Eckerman et al. 1995). Infants under 6 months of age have been shown to grow more rapidly if their primary caregiver speaks high quality/quantity IDS (Monnot 1999). Automatic prosodic changes, when addressing anyone who elicits caregiving concern, reveal the speaker's emotion, so IDS appears to be a form of affective prosody.

The use of motherese to explain the transition from emotional vocalizations common to all extant primates to human language is plausible but complicated, given the neurology of paralinguistic attributes. Spoken language conveys both semantic messages and emotion information. Affective prosody (AP), a paralinguistic feature of language with acoustic features such as pitch/tone, intonation patterns, stress, timing, rhythm, and differential pausing, gives the listener information about the speaker's emotional and attitudinal states (Bolinger 1980; Crystal 1975; Kent & Read 1992; Monrad-Krohn 1963; Ross 2000). Modulation of both comprehension and expression of affective prosody appears to be a dominant function of the *right* hemisphere (Blonder et al. 1991; Bowers et al. 1993; Meyer et al. 2002; Mitchell et al. 2003; Ross 1997). Right hemisphere lesions produce aprosodias (syndromatic deficits in comprehension or production of affective prosody, or both) that may be accompanied by severe communication and social/emotional difficulties (Ross 1982; 1997; Ross & Mesulam 1979) based on the patient's inability to impart affect into speech and/or to understand affect in the speech of others (Carton et al. 1999). If the linguistic message is at odds with the AP content, the affective prosodic message usually takes precedence (Ackerman 1983; Bolinger 1972). Honest signals are hypothesized to be very important to human communication, especially because words and syntax can convey other messages; human survival and reproduction have been hypothesized to be dependent on vocal communication in general and on language specifically (Foley 1995).

Falk's review of modern motherese infers that the automatic modulation of vocalizations when addressing infants is very similar to the automatic changes in voice that occur when a vocalizer of *any species* experiences emotion such as fear or joy. However, affective prosody is a right hemisphere, *neocortical,* function that allows graded and highly varied emotional expressions that are under considerable conscious control. Other mammals have only rigid, automatic species-specific emotion displays that are predominantly *limbic* in origin (Fulton 1941; Harlow 1936; Jerison 1985). Progressively complex emotion displays may have become true prosodic utterances but this required encephalization, with corticalization allowing the change from primitive rigid responses to complex variable responses specific to each species (Jerison 1985; Jurgens 1979).

Because chimpanzee/bonobo vocalizations to infants are both *rare and simplified* compared to humans, Falk insists that some mechanism must be found to explain the transition to IDS during hominin evolution (hominin parents put undeveloped altricial hominin infants down while foraging, necessitating a new form of reassurance to the infant). "Occam's razor" caution must be applied here. Modern apes rarely put infants down, and the infants themselves resist this vigorously and vociferously.[1] Were hominin infants, subject to the same pressures of natural selection as their mothers, really as inadequate as Falk suggests? Perhaps these infants became cognitively precocious before birth so that they elicited more communication cues from mother to compensate for physical prematurity. If modern infants still retain a strong grasping reflex, how long ago did they really lose the ability to cling to mother's fur/hair? And when did hominins lose the body hair so important to infant grasp and thus survival? Clothing may be a recent innovation, implying that abundant fur/hair was present until quite recently (Kittler et al. 2003).

A more parsimonious explanation is that the bipedal mother foraged with her infant clinging to her back as she strode upright, necessitating complex enticing vocalizations to the infant when the dyad was not face-to-face. Because motherese speech is the most effective way to stimulate *premature* neonates to "calm awareness" (Eckerman et al. 1995) and to encourage faster infant growth (Monnot 1998; 1999), stimulating emotional utterances to a hominin child resulted simply from the necessity to ensure *infant growth and survival* (Monnot 1999). Emotional/prosodic vocalizations certainly seem to have laid the foundation for propositional language (Ploog 1992), but infant "parking" seems to be a less-than-efficient explanation for the evolution and encephalization of IDS, affective prosody, and human language.

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NOTE

1. Personal communication from Janette Wallis, Ph.D., based on years of observing chimpanzees at Gombe Stream and other chimpanzee settings (wild and captive populations).

Motherese by any other name: Mother-infant communication in non-hominin mammals

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Abstract: The definition of motherese is extended to infant-directed vocalizations in non-hominin mammals. In many species, vocal interactions between mothers and their infants are common. The neural substrates mediating these interactions include the rostral limbic cortex of the frontal lobe. Spoken language may have arisen from hominin females vocalizing to their infants.

Because behavior doesn't leave a fossil record, statements regarding the evolution of behavior are inevitably inferential and based largely on comparisons between related groups of living species. In the case of humans, this is particularly difficult as we have no close living ancestors. Behavioral adaptations thought to be specific to the tribe Homini (*Australopithecus, Ardipithecus, Paranthropus,* and *Homo*) within the Homininae are generally assumed to have arisen after the time period during which the Homini shared a common ancestor with the genus *Pan* (chimpanzee and bonobo), around 5 to 7 million years ago. We can only speculate at which point in the evolution of the Homini the various behavioral attributes that are exclusively found in *Homo sapiens,* our species, actually arose. Speech and language, as typically defined, are unique to humans. Because they do not occur in the genus *Pan,* it may reasonably be concluded that these attributes arose within the Homini. That speech and language are unique to humans, among existing animals, can be assumed based on numerous studies of nonhuman primates and other animals. (Whether the antecedents of speech exist in other animals is a separate issue, for which there is compelling, although controversial, evidence.)

Falk, in addressing the origins of a form of speaking directed at infants that is typically referred to as *motherese,* likewise presents the case that this attribute is unique to humans, based on its apparent absence in the genus *Pan.* However, Falk fails to look beyond *Pan* to other animals. Had she done so, she would have discovered that mother-infant communication is common in mammals (and also present in some birds). This includes vocal behavior that is clearly directed at the infant, which is the criterion she uses to describe and define the characteristics of motherese. Even in human mothers, one form of infant-directed (ID) vocalization is humming. Is this so different from the purring that everyone associates with felines (but is also found in other mammals, such as the squirrel monkey, when an infant is nursing and that is given by both mother and infant)? Even where evidence for ID vocalization by mothers or other caregivers is lacking, mammalian infants universally make vocalizations that are structurally and functionally similar to the crying of human infants (cf. Newman 1985b; 2003a), and are clearly directed at their mother or other caregiver. In some species, evidence exists for mother-infant communication that takes the form of a dialogue. In squirrel monkeys, for example, mothers make vocalizations (mutters, chucks, err chucks, caregiver calls) and infants respond with peeps, oinks, and chucks (cf. Biben 1992; Newman 1985a). Thus, ID vocalization in nonhominin mammals may be the evolutionary precursors of the motherese found in humans. I have argued elsewhere (Newman 2003b) that the brain circuits underlying mother-infant communication arose early in mammalian evolution and have had a conservative evolutionary history. In primates, a region of the rostral midline (limbic) cortex is important for the expression of "crying" sounds (isolation calls) (Newman 2003a; 2003b). Recently, evidence has emerged indicating that this same region is activated in human mothers upon hearing infant cries (Lorberbaum et al. 2002). Thus, as MacLean suggested many years ago (1985), there appears to be brain circuitry dedicated to mother-infant communication that is part of his "thalamo-cingulate" division of the limbic system, and part of the "paleomammalian" component of his "triune brain" model of mammalian brain organization (MacLean 1990).

None of this is to detract from the basic outlines of Falk's proposal that motherese served an important function in hominin females – namely, to quiet infants that had been "parked" so that the mother could forage. The main issue of contention presented here is how ancient the antecedents to present-day motherese really are. Falk argues that motherese arose with our hominin ancestors, originally as ID-affective vocalizations from earlier hominins. As I argue above, ID-affective vocalizations are widespread in mammals, hence their apparent absence in *Pan* is the real mystery. Perhaps further, careful observation of free-ranging chimp or bonobo groups, with the specific focus of identifying ID vocalizations, would reveal that they are more common than might be concluded from studying single mother-infant pairs in captivity. How humans came to use hyperarticulated vowels embedded in words to communicate with preverbal infants is also unknown. The origins of spoken motherese are as clouded with mystery as are the origins of speech. Falk's hypothesis that selection for vocal language occurred after early hominin mothers began engaging in routine affective vocalization toward their infants may not be far off the mark. Many hypotheses of the origins of spoken language have become discredited; one hypothesis which suggests that spoken language arose out of ID vocalizations by hominin mothers, although not formally presented in Falk's target article, has some merit worth further consideration. It seems likely that female hominins, like female mammals in general, had evolved for some functions more advanced brains than their male counterparts. Certainly this would seem likely to include infant care, including ID vocalization. Brain circuitry for ID vocalization would already have been in place due to the likely presence of ID vocalization over a long period of mammalian evolution. Given the importance of the rostral limbic cortex (anterior cingulate gyrus) in speech (cf. Brown 1988), the fact that this same region is involved in mother-infant communication perhaps presents the neural circuitry required to explain the ID incorporation of speech sounds as affective stimuli. The fact that "fatherese" appears to be rare also suggests that the brains of mothers (and other female caregivers) have specializations for ID communication that evolved in females but not in males.

NOTE

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Walkie-talkie evolution: Bipedalism and vocal production

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Abstract: A converging pattern of evidence from laughter, tickling, and motherese suggests that bipedal locomotion plays a critical and unanticipated role in vocal evolution. Bipedalism frees the thorax of its support role during quadrupedal locomotion, which permits the uncoupling of breathing and striding necessary for the subsequent selection for vocal virtuosity and speech.

Dean Falk reviews several new, converging themes in vocal evolution and offers a synthesis of this material based on motherese and related infant-mother interactions. I will focus on the critical role of bipedality, a secondary but pervasive theme in Falk's presentation, because its contribution is both unappreciated and central to many aspects of primate and human vocal behavior. Bipedalism, as Falk notes, is the definitive trait of hominins. The proposed benefits of walking upright on two legs range from efficiency in locomotion, predator detection, genital display and cooling, to freeing the hands to throw, manipulate objects, make and use tools, gesture, forage, and carry infants or objects. Missing from this list is the essential role that bipedality plays in a completely different realm, uncoupling the acts of breathing and locomotion, setting the stage for the subsequent evolution of human speech. Falk cites research (Provine 2000) that describes the important role that bipedality and resultant breath control plays in the emergence of vocal competence, using laughter as an example. I will provide additional details about the bipedal ("walkie-talkie") theory of speech evolution (Provine 2000), focusing on *why* bipedalism affects vocalization. Essential insights come from the comparative analysis of laughter.

A point of agreement in the often-contentious area of ape language is that chimpanzees cannot learn to produce human speech. Although they may have formidable skills in manual signing and recognizing human speech, they cannot talk. Laughter is an ideal subject for the study of primate vocal evolution because, unlike the case of spoken English, laughter is in the vocal repertoire of both chimpanzees and humans, which permits comparative analyses. In important details, chimpanzee laughter differs from that of humans (Provine 1996). Laughing humans chop an outward breath into a series of short (1/15 second), vowel-like blasts ("ha") that repeat about every 1/5 second ("ha-ha"). The sounds have a marked harmonic structure consisting of a fundamental frequency and its overtones. Chimpanzee laughter, however, is breathy, lacking the vowel-like sounds, clear harmonic structure, and clean onset and termination of the human "ha." Chimpanzee laughter ranges from a low amplitude panting sound ("pant-pant") to more intense and guttural "ah-grunting." Unlike the chopped exhalations of human laughter, chimpanzee utterances have only one sound produced per inward and outward breath. As in speech, humans modulate an outward breath to produce the sounds of laughter. Chimpanzees and probably other great apes lack such vocal control, being more confined in syllable production per exhalation. Although many investigators from Darwin to the present have reported laughter in great apes, they seldom described the distinct sound of ape laughter, and never noted the nonhuman means of laugh production or its ramifications for speaking.

The characteristics of laughter in chimpanzees point to a critical constraint on the evolution of speech and language in the great apes. Chimpanzees are captive to an inflexible neuromuscular system that is still tied to the ancient and essential labor of breathing. They share this characteristic with other quadrupeds whose breathing and running are closely synchronized (one stride per breath) so as to brace the thorax for forelimb impacts. (Without full lungs and breath-holding at the instant of impact, the thorax would be a weak air-filled bag, and the running animal might collapse headfirst into the dirt.) This respiratory pattern may be more limiting to the evolution of speech than the more publicized structures of the tongue, larynx, and vocal tract. The evolution of bipedalism in human ancestors permitted natural selection for greater flexibility in the coordination of breathing and locomotion because the thorax no longer was required to absorb forelimb impacts during running. A human runner, for example, may employ a variety of patterns. According to Bramble and Currier (1983), the ratio of strides per breath in humans can be 4:1, 3:1, 5:2, 2:1, 3:2, or 1:1, with 2:1 being the most common. Breaking the rigid link between stride and breath allowed the subsequent natural selection for utterances in which individual sounds were no longer tied to single breaths, permitting speech as we know it and, incidentally, the characteristic human laugh.

Although a powerful probe into the mechanisms of vocal production, laughter also provides one of the best cases of how a specific human vocalization evolved. Literally, *laughter is the sound of play.* The rhythmic panting of chimpanzee laughter is the sound of the labored breathing during tickle games between mother and infant or rough-and-tumble play with peers. The panting sounds of chimpanzee laughter later came to symbolize ("ritualize") the labored panting of the physical play even in the absence of physical exertion. The primal "pant-pant" of our chimpanzee cousins evolved into the human "ha-ha." Along the way, the range of stimuli for laughter expanded from the physical contact and tickle of chimpanzees to the more subtle symbolic play of humor. My candidate for the most ancient joke, and the only one that works as well with chimpanzees as human babies, is the "I'm going to get you game" of feigned tickle. Mothers playing this game with their babies are engaging in one of our species most ancient rituals.

Prosody as an intermediary evolutionary stage between a manual communication system and a fully developed language faculty

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Abstract: Based on the motor theory of language, which asserts an evolution from gestures along several stages to today's speech and language, we suggest that speech ontogeny may partly reflect speech phylogeny, in that perception of prosodic contours is an intermediary stage between a manual communication system and a fully developed language faculty.

The precise mechanism of speech evolution is still unclear to a large extent. It has been proposed that Broca's region mediates higher order forelimb movement control in humans, which resembles the neuronal mechanisms subserving communication (Binkofski et al. 2000). These data – together with the finding of "mirror neurons" in area F5 of the monkey's brain (Di Pellegrino et al. 1992; Galaburda et al. 1982; Gallese et al. 1996; Preuss et al. 1996; Rizzolatti et al. 1996) – support the idea that this observation-evoked motor resonance could be the functional expression of a brain mechanism involved in "understanding" actions made by others. Thus, human language could have evolved from the ability to recognize abstract motor behavior relevant for communication (Liberman & Mattingly 1985). Within this action-perception network, communication may have arisen from a mirror system for grasping to a manual-based communication system, and then moved on to articulatory gestures (protospeech) and from there to today's elaborate language system (Corballis 1992; Hewes 1973; Lieberman 1979).

Rizzolatti speculated that communication occurred through oro-facial gestures with a variety of different concepts being communicated (Rizzolatti & Arbib 1998). Oro-facial movements are also used for communication by other primates. Dean Falk describes the role of facial expressions in the mother-infant communication in chimpanzees and humans. The vocalization system evolved into the originally manual- and facial-based communication system. The combination of orofacial communication with vocalization might lead to a higher level of expression. Prosody served to broaden the initially limited spectrum of vocalization by adding another dimension to communication and to compensate for the reduction in sustained mother-infant physical contact. For instance, Falk notes that by around 3 months of age, human infants develop the ability to modulate their cries to express different emotions.

We previously examined whether, and to what extent, language activates the hand motor system. Using transcranial magnetic stimulation (TMS) we showed that speaking, covert reading, and listening to speech bilaterally activate the hand motor system (Floel et al. 2003). This indicates a direct link between the language and the manual/facial action systems, a link far more extensive than previously thought and one that may still be functionally relevant in humans. If language gradually evolved from gestures along several stages, listening to prosodic utterances without semantic content should activate the extended action-perception system. In a subsequent neurophysiological study using TMS, we found that whether subjects are listening to variable prosodic contours without meaning or to sentences with meaning and grammar, the hand motor cortex is bilaterally activated to a similar extent. Furthermore, the pitch variability of the sentences correlates selectively with the size of the MEP amplitudes after right motor cortex stimulation (Rogalewski et al. 2003). In addition, pilot data from our lab using functional magnetic resonance imaging provided converging evidence for this preactivation of the hand motor cortex during perception of prosodic features and normal sentences (Rogalewski et al., submitted). This shows that the prosodic aspect of speech is sufficient to activate the manual gesture system.

Behavioral studies in infants show that children learn the phonology and prosodic intonation contours of their mother tongue during the first year, before they learn the meaning of single words and the rules governing how to combine single words into sentences (Jusczyk & Hohne 1997). For example, 4-day-old neonates and 2-month-old infants discriminate sentences spoken in their native language from sentences in a foreign language. When the prosodic contour is not available, because the stimuli are played backwards, the preference for the mother tongue is no longer observed. Other studies showed that cotton-top tamarin monkeys discriminate between languages just as humans newborns do (Ramus et al. 2000). This may reflect the parallelism of ontogeny and phylogeny.

Our data provide strong evidence for a joint neural system that processes manual as well as prosodic gestures. We observed that both listening to sentences and listening to prosodic contours activate an extended cortical network. Our data cannot prove the causal link between the sensory-motor system and the language faculty. However, the studies do support the theory that language did not evolve as a separate module but rather within a more domain-general action-perception network. The findings establish a close link between the prosody and the motor system. Furthermore, we suggest that today's language may have evolved from a prelinguistic protospeech including prosodic contours, a competence that is shared with nonhuman primates. Only the last step in the evolution with production of linguistically complex speech seems to be uniquely human.

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Did australopithecines (or early *Homo*) sling?

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Abstract: Two arguments are critiqued here. The first is that hominin mothers "parked" their offspring; the evidence does not support that position. The second is that motherese developed to control the behavior of nonambulatory infants. However, Falk's case is stronger if we apply it to children who are already walking and more likely to be influenced by verbal information.

Falk raises the intriguing, if untestable, hypothesis that about 2 million years ago our bipedal ancestors, whose babies were becoming increasingly helpless with the evolution of secondary altriciality, put their babies down while they foraged and then communicated with them in the form of prosodic vocalizations to provide reassurance and keep them content. She proposes that these vocalizations were the precursor to language. Although we appreciate Falk's attention to the early stages of infant development and to the mother-infant relationship, two important aspects of human life history that are often ignored in models of human evolution, we are uncomfortable with several aspects of her argument.

Although infant parking or caching ("putting the baby down") occurs among many other mammals, it is very rare not only among primates as a group, as Falk acknowledges, but also among humans in particular. Western cultures today provide a wide range of devices in which to place a small infant (cribs, swings, playpens, infant walkers, bouncy seats), but such behavior is rare cross-culturally. The norm is that mothers (or other members of the family) carry their infants in their arms or on their bodies most of the time for the first year, in a sling, inside the clothing (especially in cold climates), or tied to their trunk with a piece of cloth or net. Tracer (2002) has argued that crawling, which is often viewed as an inevitable stage in children's development in western cultures, is not in fact universal because children in many other cultures are not put down long enough to crawl until they are old enough to walk. It seems unlikely to us that hominin mothers 2 million years ago routinely would have set their children down, and it seems more probable that they would have carried them in their arms or, more likely, in a sling while they foraged. In fact, it has long been proposed that one of the simplest and probably earliest pieces of human technology was a carrying device (such as a net bag or sling) that could accommodate either infants or food to be shared with other members of the group (Isaac 1978; Lovejoy 1981). Furthermore, if hominin children 2 million years ago were indeed hairless, they would have had the same problems with thermoregulation as modern children have, an additional reason for their parents to keep them close to their bodies.

If, in fact, hominin mothers did put their babies down, there certainly would have been a selective premium on being extra vigilant, as Falk suggests. Because such infants would be immobile and not able to follow maternal directions, hominin mothers' vocal communication would simply have had the purpose of comforting fretting infants, not of warning them of dangers that they were incapable of responding to on their own. These reassuring vocalizations would not have to be conveyed with language per se. That is, modern primates and many other mammals vocalize to their infants in ways that apparently provide reassurance. Although it might be desirable for mothers to be able to offer reassurance and comfort to fretting babies with whom they are not in physical contact, it seems to us that a much higher selective premium would have been on linguistic communication *in the other direction.* That is, there would have been a real advantage to babies who could communicate specific information to their mothers ("I'm hungry," "there's a leopard," "the sun is too bright," etc.). We suggest that if selection favored information exchange between mothers and infants, it would have been much more valuable for babies who were not yet ambulatory to provide specific information to their mothers than for mothers to provide information and reassurance to their babies. Indeed, recent research has observed the birth of a language – a sign language – in Nicaragua among its deaf citizens (Senghas & Coppola 2002). Children have been responsible for adding grammatical nuances to the burgeoning language; their elders have not. Perhaps, turning the argument around, selection favored those children who were capable of turning inchoate vocalizations into structured linguistic elements.

In addition, there is the question of whether motherese is universal. Schieffelin and Ochs (1983) describe two cultures (the Kaluli of Papua, New Guinea, and the Samoans) in which motherese is apparently not employed. Moreover, in some cultures, motherese has a different complexion than the more frequent type of motherese that Falk describes. Among the Kiche Mayan, it takes the form of whispering (Pye 1986). The usefulness of whispering to a baby who is not in close physical proximity to its mother is questionable.

In sum, Falk's argument that language emerged out of motherese because infants were parked can be criticized on two counts. First, there is little evidence for parking infants among humans and probably among prehistoric hominins, and, second, even if there is a form of motherese in all societies (and that in itself is a controversial position), it may be that some forms of motherese could not serve the function that Falk specifies of keeping distant babies safe.

Although we question Falk's model as she applies it to nonmobile, dependent infants, it may be more appropriately applied to later stages of child development. That is, perhaps the origin of language can be found in maternal communication to their offspring in the years immediately after they begin to walk, when children are larger and more independent in their mobility and may more often be out of physical contact with their mothers. At that point they might benefit from their mothers' vocalized warnings and instructions ("stay away from the cliff," "don't eat that berry," etc.). The selective advantage of providing such instructions at this age may be less obvious, however, given the propensity of human 2-year-olds to ignore such verbal input and pursue their own agendas. In any event, it would certainly be in a mother's reproductive interests to have a more distal way of controlling her offspring's behavior. Perhaps motherese emerged to increase the likelihood that mothers' directions would be understood. After all, mothers know best.

Cached, carried, or crèched

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Abstract: We believe that "caching" a baby would have been too great a danger in human prehistory, and thus could not serve as the context for prelinguistic vocalization. Rather, infants were most likely carried at all times. Thus, the question arises of why the cry of an infant is such a loud vocalization.

Many years ago, Blurton Jones (1972) did a comparative analysis of the physiology of mother-infant caregiving in mammals and distinguished between those that "cached" their infants, such as seals and ungulates, and those that carried them, such as primates (Jones 1972). He then looked at the physiological characteristics of the relationship between human infants and their caregivers and came to the conclusion that human infants were designed to be "carried" rather than "cached." Since that time, a consensus has developed (Barr et. al 2000) that intimate physical association between infants and their caregivers is an essential feature of human prehistory, an association that modern feeding arrangements contradict to the detriment of both infant and mother.

Dean Falk's theory of language evolution challenges that consensus. It is based on the novel premise that hominid infants were *less* physically attached to their mothers than either their australopithecine ancestors or their contemporary hunter-gatherer descendants. Sometime between the adherence to the feed-as-you-go strategy of our ape ancestors and our switch to the center-point foraging strategy of our hominin ancestors was a time when infants were less physically intimate with their caregivers, and this period has left its traces in language development.

Despite some very attractive features of Falk's arguments, we remain convinced that a human baby is not the sort of creature that can be long away from the physiological support and protection afforded by a human body. Nor do we think Pleistocene Africa was likely to have been the sort of place where caching a baby made much sense. Moreover, we doubt that putting a baby down would substantially increase foraging efficiency. Given that our ancestors were doing center-point foraging at that time, any food that was gathered had to be transported back to the home base. Therefore, at the point that carrying the baby would interfere most with foraging – when the fruits of foraging were being transported to the home base – the mother would have no choice but to put down whatever she was carrying and pick up the infant.

Finally, given what we know about tool use in chimpanzees and early hominins, Falk's idea that a primitive language would have evolved before a simple sling seems implausible. Wild chimpanzees use and sometimes carry tools as diverse as crushed leaves for soaking up water to drink, to simple stone hammers to open nuts (Beck 1975; 1980; Warren 1976). Basic Oldowan stone tools have been found in sites dating as old as 2.5 million years, associated with the fossils of *Homo habilis* (Klein 1999). These tools included rock tools that were carried to other sites, and hammerstones or rocks that were struck against other hard objects to make stone flakes. That tools were carried to other sites implies some form of carrying mechanism. Surely a creature that is carrying rocks could manage to create a simple sling, if only from vegetal matter (as Falk cites, Zihlman 1981). All these considerations lead us to prefer "carrying baby" to "putting baby down."

However, having admitted our allegiance to the carrying hypothesis, we also admit to having had nagging doubts about it, doubts arising from the nature of infant crying. Why should so loud a vocalization ever be deployed in so intimate a relationship as that between an infant and a mother who bears that infant pressed to her body 24 hours a day? One solution to the anomaly of loud human crying is that infants were crèched in the Environment of Evolutionary Adaptedness (EEA) as part of a group-selected (Thompson 2000; Thompson et. al 1996; Sober & Wilson 1998) co-rearing strategy that became available when humans made the transition to center-point foraging about 2 million years ago. In this account, infants are left in the charge of some mothers and juvenile females while other mothers join foraging partners in gathering for the group. Under these circumstances, infants are put down, but in the familiar surroundings of a home base, not in random points in the bush. This idea implies that mothers would have shared in the nursing of one another's infants, and it creates opportunities for an arms race amongst criers that would explain the loudness of human infant crying. It would explain the odd observation that crying in hospital nurseries tends to be contagious.

A compelling part of Falk's argument is based on Kawai's (1965) observations of the transmission of novel behaviors among Japanese macaques. After a juvenile discovered the benefits of washing sweet potatoes and wheat, this activity caught on among other group members, namely older females and siblings (the "Period of Individual Propagation"). Also observed is a "Period of Pre-Cultural Propagation," in which, as behaviors become fixed among a group, infants learn the behaviors from their mothers and pass the behaviors on to future generations. Following Falk's model, early language-like vocalizations of hominin mothers would have spread throughout the group via their infants and children.

Falk's ideas imply that motherese might not be a one-way street. We are exploring the idea that whining is a form of motherese that children use with their parents (Sokol et al., submitted). We are in the early stages of examining whining and find that it shares properties with infant-directed speech, specifically with increased pitch and slowed production. Further work needs to be done, but we are beginning to wonder if all human nervous systems, not just those of infants, are strongly affected by the properties of motherese.

Is it always really mothers' fault?

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Abstract: Falk's paper provides a nice cross-species perspective and an interesting background to formulate a theory of the evolution of human language. However, the author does not provide a complete overview and analysis of the origins of language and takes for granted the "continuity hypothesis." Also her "infant parking theory" is questionable, as it is not well supported by observations.

The target article by Falk addresses the important issue of the origin and the evolution of language. In order to investigate what counted as the origin of the process, one should delimit the phenomenon of language and assume that language can be recognised and distinguished from other forms of communication. Language is more profound than speech and its realisation may take different forms. Falk discusses the different communicative aspects of language, such as speech, gestures, and facial expressions including laughter, crying, and so on, without defining what she really means by language. Indeed, different people mean different things by the word "language": language can be thought of as the visual information conveyed in gestures and facial expressions, or as the tactile information exchanged by touch, or as the auditory information in speech (Gogate et al. 2000; Jouanjean-L'Antoune 1997; Meltzoff & Kuhl 1994). With Liberman (1996) a narrow sense of language, defining language as constituted of a sensory-motor system and pure linguistic computation, became available. Hauser et al. (2002) proposed two restricted conceptions of language: the faculty of language-broad sense (FLB), which includes sensory-motor system, conceptual-intentional system, and computational mechanism for recursion; and the faculty of language-narrow sense (FLN), which is the linguistic computational mechanism alone. The FNL plus the sensory-motor system would then correspond to Liberman's definition of language.

It is only after defining the distinctive characteristics of human language that separate us from all other species, including the other great apes, that we can try to understand the evolution of language. Indeed, it is not the ability to communicate that distinguishes us. Other species communicate and depend for their continued survival on successful communication. Linked to this issue is also the question of why, then, was the evolutionary move forward to language made only by humans, a question that Falk appears to address only superficially. If it is of value for the survival of a species, as it clearly is, then why has only one species succeeded in acquiring such a sophisticated and efficient language system? Falk's hypothesis about the prelinguistic substrates of human language is quite questionable. She proposes that human protolanguage might have evolved from "ID vocalizations similar to those of chimpanzees" (sect. 3.1). She suggests that these primitive forms of communication have progressed into a more complex linguistic system thanks to the evolution of bipedalism and the associated increase in human brain size. However, the brain evolution alone cannot explain these fundamental archaic changes in communication, which enabled the hominid brain to acquire a great vocabulary, to produce unlimited numbers of novel utterances, and to register millions of verbal memories. In addition, Falk argues that bipedalism and the increase in human brain size, the two characteristics of human evolution, can explain her "infant parking theory," which is interesting and entertaining. Bipedalism allows mothers to engage in other activities, parking the baby someplace. The evolution of the brain implies that human neonates at birth are not completely developed because mothers could not give birth to babies with huge skulls. The motherese, then, in this situation could be a substitute for mother contact and it could be selected for. Cooper et al. (1997), however, have found that neonates are able to recognize and tend to prefer the voice of the mother, even if she is not using the motherese. Therefore, the familiar sound of the voice, rather than the ID speech, seems to represent the most important factor for the child to realize that the mother is nearby. Furthermore, it is difficult to take seriously Falk's "infant parking theory" as it is not well supported by observations. The author herself mentions that "infant parking is extremely rare in anthropoids" (sect. 3.1) and "it is a rare event in monkeys, apes, and non-Western human cultures" (sect. 3.1.1). How can this theory explain the evolution of human language, if there are not enough observations suggesting an adaptive value of parking the baby and if the proposed relation with motherese is not so evident?

Finally, what is most obviously missing in Falk's review is a critical account of alternative schools of thought about the origin of the language. Falk does not even mention one of the most influential language-origin theories, the Chomskyan proposal of a uniquely human, biologically based, complex innate language capacity that cannot be explained through natural selection (Chomsky 1972; 1995). Instead, she briefly dismisses the "discontinuity hypothesis" by saying (citing Callaghan 1994) that it views "language backward through the lens of contemporary linguistic theory rather than in the context of how evolution operates" (sect. 1). Nonetheless, any language-origin proposal that fails to deal directly with the universal features of human language, such as its phonology, syntax, and semantics, is likely to be inadequate as it oversimplifies the evolutionary processes involved and neglects fundamental characteristics of human language.

Falk's paper brings attention to many interesting ideas related to the origin of human language and provides an interesting cross-species perspective for its evolution. Indeed, the evolution of language can be understood if researchers follow a cross-disciplinary approach as suggested by Hauser et al. (2002), who reminded us that the living apes, especially chimpanzees, are typically used as models or surrogates for our ancestors because they are considered the best referential models for early hominin behavior. By comparing apes to us, the author tries to identify which aspects of communication changed through evolution from the prelinguistic foundation of protolanguage to the human language. Falk, however, reads the behavior of nonhuman primates with anthropocentric eyes and she appears to take for granted that chimpanzees and bonobos have intentions. However, the question of whether nonhuman primates have intentions is still open (Byrne & Russ 1998; McGrew 1998; Povinelli 2000; Whiten et al. 1999).

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Putting infants in their place

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Abstract: The interests of mother and infants do not exactly coincide. Further, infants are not merely objects of attempted control by mothers, but the sources of attempts to control what mothers do. Taking account of the ways in which this is so suggests an enriched perspective on mother-infant interaction and on the beginnings of conventionalized signaling.

Falk's proposal, although promising, underplays the role of the infant. Both of the "fundamental premises" of the "putting down the baby hypothesis" concern the mother – one suggesting that "hominin mothers that attended vigilantly to their infants" would have a selective advantage, and the other that such mothers would "have had a genetically based potential" for the gestural and vocal demands of the distal comforting and control required in the absence of direct touch (sect. 3.2.1). Two reasons for placing greater emphasis on the contribution of the infant strike us as especially significant.

First, the interests of mothers and infants, despite the considerable genetic material and energetic investment of the former in the latter, do not completely coincide. Mothers must determine an appropriate trade-off between their own survival requirements and the demands of rearing, and also between the requirements of other actual or possible offspring and those of any single infant. This begins before birth (Haig 1993). Under conditions of severe scarcity, or when the relative viability of different infants varies significantly, the costs of getting the trade-off wrong could be high. Conversely, any given infant embodies interests that from its own perspective trump those of siblings and its mother, and stands to gain, within limits, from maximizing its share of maternal resources at their expense (Trivers 1974).

This noncoincidence of interests is important because, as well as being the subjects of maternal attempts at comfort and control, infants are the producers of various affective displays that coregulate maternal behavior. Thus, the attempts of mothers to exploit ways of calming their infants sometimes take place in competition with infant behaviors such as crying or smiling that influence maternal affective state (Wiesenfeld & Klorman 1978) and can motivate actions such as feeding and holding. Falk suggests that mothers who were good at vocal comforting may have been freed to forage more effectively, but it is also possible that infants whose cries were more effective at eliciting maternal care over and above distal comforting could have been fed more. *Both* parties, that is, stand to gain from producing more compelling vocalizations and from better ability to appraise those of the other. The appraisal in question is complex, because neither participant is able to rely on any invariably effective behavior – feeding or holding do not always calm an agitated infant, and a crying infant does not always secure immediate maternal attention. Factors such as fatigue, fear, hunger, and habituation to a recently repeated vocal action help explain why this is so.

The above considerations could apply (and do apply in the case of modern humans) even in cases where the signaling currency is provided by relatively universal indicators of approval, disapproval, and so forth (Ekman 1972; Fernald 1992). What of situations where one is imagining the early construction of semi-conventional protolanguage? This brings us to our second major point.

The earliest indications of contingent, partly conventionalized signaling between mother and infant in contemporary humans can be seen in at around the age of 3 months. By the time a modern human infant is 14 weeks old, mutual gaze, shared facial expression, and prosodic vocalizations between it and its mother sustain pleasurable bouts of coordinated interaction between them. Many investigators make the mother-infant dyad their object of analysis, and focus on dyadic properties such as attunement and coordination, phenomena wherein the individual actions of either partner are best accounted for if they are seen as contingent responses to the anticipated activity of the other (e.g., Stern 1977). That is, just as caregivers effectively attuning with their offspring learn to *anticipate* and *creatively exploit* their infants' activity and responsiveness in particular expressive contexts, so infants interacting with caregivers learn to do the same. Both can learn creatively to exploit the patterns of activity and responsiveness in the other for their own interests.

Examples of non-universal signals that we have observed at this age include maternal requests for infant behaviors such as being quiet, or slightly later protorequests from the infant, for example for being lifted. (At this stage the signals are often multimodal, including vocal and gestural components.) The fact that these signals are not universal suggests that they have been constructed in interaction, either as local inventions peculiar to the dyad, or as culturally contingent patterns introduced by the mother. A conventionalized mother-to-infant command that can be obeyed (some of the time) can also be disobeyed. An infant vocalization or gesture that has come to be treated as a distinctive request not only can be granted, it can also be refused. Protoconventional signals, that is, can be seen as new tools in the ongoing battle for occasional control of the other described above. Innovations from either party in attempts to exploit or control the other lead to more sophisticated patterns, setting the stage for further innovation.

The sorts of innovation we have in mind can be described in terms of attaching more refined conditional probabilities for the success of this or that signaling strategy given an increasingly sophisticated command of relevant contextual details. Laboratory chimpanzees that point toward inaccessible but visible food only when humans are present and in a position to give it to them (Leavens & Hopkins 1998), show this sort of attention to context. So do mothers that shift from direct comforting to an attempt to distract a distressed infant when comforting seems ineffective. We are familiar with attempts at parental manipulation in modern humans by older, speaking children, who pave the way for requests they suspect would not be granted with bouts of generous cooperativeness. We suggest that these are different in degree but not in kind from the earliest forms of infant innovation in signaling, and that granting a more active role to the infant could enrich Falk's account of contemporary mother-infant interaction and perhaps her proposal regarding the evolution of motherese.

Language from gesture

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Abstract: The hypothesis that language began as a multimodal, gestural complex finds support in data from spoken languages on the connection between intonation and gesture, as well as from the process by which intonation becomes codified into grammar. Also, data from signed languages show a similar process at work, in which gestural elements become incorporated as intonation and conventionalized as grammatical markers.

Falk presents a compelling argument for the role of motherese in the evolution of language, weaving a range of scientific evidence from anthropology, linguistics, neurology, and psychology into a solid case for her "putting the baby down" hypothesis.

Two significant elements of Falk's argument are her claims that (1) mother-infant communicative interactions are massively multimodal, "encompass[ing] visual, vocal, gestural, and tactile communication" (sect. 1, para. 3) and (2) prosody and intonation formed an important substrate for the natural selection of protolanguage. In my commentary I will explore further implications of this first claim, suggesting that the multimodal nature of communicative interactions and, indeed, of human language is evidence of their gestural origins. Falk's claim that intonation played a significant role in infant-directed speech, and thereby in the evolution of language, can be further supported by studies of the conventionalization of intonation in signed as well as spoken languages.

The deep psychological connections between speech, gesture, and thought are well documented (Duncan 2002; Kendon 1972; 1980; McNeill 1992; 2000). In spite of this massive evidence for the contemporary linking of speech and gesture, the two are often severed in evolutionary accounts of the origins of language. This is the position favored by Chomsky (1972), who suggested that, although human gesture and animal communication do share properties, human language and animal communication (and therefore human language and gesture) are based on "entirely different principles" (p. 70).

An alternative account begins with a multimodal, gestural complex. This view regards communication as essentially gestural in nature: Articulatory gestures of various kinds produce acoustic, optical, or tactile signals that are perceived by others.[1]

Critics mistakenly assume that a gestural theory of language evolution requires that a purely optical (e.g., manual or facial) gesture language preceded speech. The gestural-complex scenario does not require such a gesture-first hypothesis. Components of the gestural complex, such as acoustic versus optical gestures or segmental versus suprasegmental aspects of each, possess different properties and come to serve different functions. Thus, unlike the first scenario, which requires an evolutionary mechanism responsible for the integration of distinct systems, the gestural-complex scenario predicts functional differentiation. I regard this as a more plausible evolutionary account.

Falk brings to light several facts suggesting the early ancestry of the gestural complex, such as noting that infant crying increases the strength of the grasping reflex, that maternal speech is tied to facial expression, and that mothers' communications with infants are overwhelmingly multimodal. Also, because her data suggest a way in which mothers' ability to modify their vocal and gestural repertoires in interaction with infants could have led to a selective advantage, Falk's study demonstrates how evolutionary differentiation could have taken place.

One of the most appealing aspects of Falk's argument is her suggestion that intonation was an important substrate for the natural selection of protolanguage. Linguistic studies investigating the conventionalization of intonation support Falk's claims and also provide further evidence of the gestural complex. Bolinger (1986) regarded intonation as a master thread running through the fabric of speech and proposed that intonation is intimately linked to

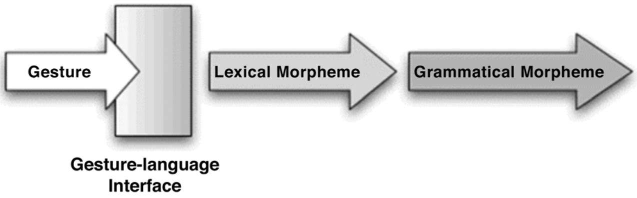

Figure 1 (Wilcox). First route from gesture to language.

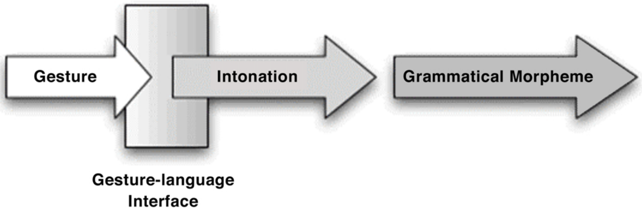

Figure 2 (Wilcox). Second route from gesture to language.

gesture: "Intonation is part of a gestural complex whose primitive and still surviving function is the signaling of emotion" (p. 195). Both intonation and gesture, according to Bolinger, are specialized, biologically built-in adaptations that allow us to read the visible and audible signals that are symptomatic of emotion.

As Falk points out, these instrumental signals may become incorporated into the linguistic system through a process of conventionalization. Intonation is an especially telling case. Haiman (1998a) noted that intonation lies on the border between paralinguistic and linguistic behavior, and that the stereotyping of intonation – motherese being an example – provides a glimpse into the genesis of language. Both Haiman and Bolinger regard ritualization as the driving force in language genesis, a process that transforms "actions into gestures, gestures into words" (Haiman 1998b, p. 132).

Data from signed languages reveal how intonational aspects of the gestural complex take on grammatical function. My colleagues and I have identified two routes by which gesture is incorporated in signed languages. In the first route (see Fig. 1), a quotable gesture becomes a lexical item; these lexical items then acquire grammatical function (Janzen & Shaffer 2002; Wilcox 2002).

The second route is more relevant for this discussion. Here, a gestural element first exhibits primarily intonational function; it then acquires grammatical function, and the language eventually exhibits morphological patterns marked entirely by the erstwhile gestural element. One example is modification to the manner of articulating a sign's movement. In data from several signed languages, we find that manner of movement serves functions ranging from strictly expressive to purely grammatical. Other gestural elements that follow this second route include facial and eye gestures, which again range from signaling speaker expressivity or emotional state to marking grammatical functions such as speaker's commitment to the truth of a proposition. In this second route the path of development is from gesture to paralinguistic to grammatical (see Fig. 2). It is intriguing to note that because this route bypasses a lexical stage, it suggests a more direct path from intonation to grammar, at least in signed languages.

These data are significant for several reasons. First, the developmental path from gesture to intonation to grammar provides further evidence for Falk's proposal that prosodic elements of prelinguistic vocalizations may have played a vital role in the evolution of language and for her adoption of a continuity model. Second, since the data come from nonvocal languages, they demonstrate cross-modal linguistic evidence for the gestural-complex hypothesis. Finally, they suggest that the remarkable human ability to acquire and use language regardless of modality does not depend on an abstract system of disembodied rules; rather, human language is the highly specialized, evolutionary manifestation of a multimodal gestural complex.

NOTE

1. I regard the issue of whether the signals are intentionally communicative to be a separate issue because unintentional signals may acquire communicative import.

Author's Response

The "putting the baby down" hypothesis: Bipedalism, babbling, and baby slings

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Abstract: My responses to the observations and criticisms of 26 commentaries focus on the coregulated and affective nature of initial mother/infant interactions, the relationship between motherese and emergent linguistic skills and its implication for hominin evolution, the plausibility of the "putting the baby down" hypothesis, and details about specific neurological substrates that may have formed the basis for the evolution of prelinguistic behaviors and, eventually, protolanguage.

Put a baby in my arms and I cannot refrain from producing singsong streams of baby talk, punctuated by attention-getting clicks and breathy intakes of air, all of which are accompanied by a barrage of gentle bouncing. From reading the literature on language acquisition, I began to realize that motherese occurs all over the world, that babies like it, and that it is important for (among other things) their eventual acquisition of language. As a physical anthropologist who had long explored the relationship between brain size and the external morphology of the cerebral cortex reflected on hominin endocasts for clues about cognitive evolution, including language origins, I realized that here was an avenue by which one could approach similar questions from a totally different perspective. I began to think about the evolution of motherese. Where did it come from? Why don't chimpanzee mothers do it? More important, when and why did hominins begin to engage in motherese?

The last thing to click into place (an epiphany of sorts) was the "putting the baby down" part of my hypothesis, which followed only after I realized the potential importance of ongoing selection for bipedalism, reduction of body hair, and loss of infants' ability for sustained clinging to their mothers' bodies. Confident that I was on the right track, I presented my ideas at a seminar for anthropologists. To my surprise, the linguists in the group actually became visibly angry (in an unintended spontaneous display of multimodal communication, one fellow flung his pencil onto the floor). "You haven't proven that motherese has anything to do with language acquisition," he insisted. "Sure, mommies are emoting affection, and that's nice – but there's no evidence that it has anything to do with their infants' eventual grasp of syntax, grammar, semantics, et cetera." "But I'm not claiming to address the details of language origins per se," I protested. "I'm going earlier and trying to formulate hypotheses about the evolution of the prelinguistic substrates that preceded language." They would have none of it. By the time I submitted the first draft of the present target article, I'd researched the linguistics literature and incorporated a good deal of evidence (sect 2.2 of the target article) that motherese does, indeed, act as a scaffold for language acquisition (although a few of these commentaries continue to express some of the same reservations raised earlier by the linguists).

I've worked on this project for about two years, and it's

Table R1. *Headings in Author's Response and commentators specifically addressed*

R1. Mother/infant communication is a two-way street
(Cowley, Dissanayake, Locke, Longhi & Karmiloff-Smith, Rosenberg et al., Spurrett & Dellis)

R2. How far back did prelinguistic evolution go, and who should be the models?
(Bouissac, Dissanayake, Fuentes, King & Shanker, Longhi & Karmiloff-Smith, Newman, Provine)

R3. Did multimodal motherese give rise to (proto)language?
(Bickerton, Bortfeld, Bouissac, Braten, Burling, Cronk, Dilkes & Platek, Locke, MacNeilage & Davis, Monnot et al., Rogalewski et al., Spiezio & Lunardelli, Wilcox)

R4. Baby riding, parking, and slings
(Brace, Fuentes, Monnot et al., Rosenberg et al., Sokol & Thompson, Spiezio & Lunardelli)

R5. Some evolutionary considerations
(Bickerton, Bortfeld, Brace, Braten, Cowley, King & Shanker, Provine)

R6. Neurological substrates of communication
(Aboitiz & Schröter, Brace, Braten, Dilkes & Platek, Gilissen, Monnot et al., Newman, Rogalewski et al.)

R7. Suggestions for future research
(Burling)

R8. Conclusion

been a very interesting and surprisingly productive journey. The 26 commentaries are mostly constructive and bring new information from diverse disciplines to the discussion and fill in certain gaps. (Happily, many of them provide data that counter criticisms found in others.) There are only a few assertions with which I categorically disagree, such as the argument by **Rosenberg et al**. that motherese is not really universal (addressed in sect. 2.2 of the target article and in the commentary by **Monnot et al**.) and the statement by **Bouissac** that I assert that "ontogeny recapitulates phylogeny." I hasten to add, however, that a modified version stating that "altering ontogeny formulates new phylogeny" (Goodman & Coughlin 2000) is currently supported by data from the growing field of evolutionary developmental biology ("evo-devo") and fits well with the ideas developed in the target article. These quibbles aside, I find myself uncharacteristically agreeing with much of what even the most critical commentaries have to say (although certainly not with all of their objections). The commentaries sorted naturally into seven areas (see Table R1), each of which is addressed here.

R1. Mother/infant communication is a two-way street

R1.1. Infant communication: The other side of the coin

Commentators **Locke**, **Longhi & Karmiloff-Smith, Rosenberg et al**., and **Spurrett & Dellis** suggest that I have underplayed the role of the infant in mother/infant communication. Although a main focus of the target article is on ID communication from mothers, I have not ignored infants' contributions to the process. As documented in section 3.1.1, by 3 months of age infants modulate their cries to express different emotions, and infant crying (Small 1998) and facial expressions (Schmidt & Cohn 2001) appear to have been important precursors to language. The potential signal functions of early infant crying include manipulation of parents to acquire additional resources, as well as honest signaling of need and infant vigor (Soltis 2003). Significantly, Soltis views infant cries as "in large part adaptations that maintain proximity" (Soltis 2004, Abstract), which is in keeping with the present target article. For mothers who are too busy to pick up crying infants (and in response to Locke's claim that maternal vocalization typically has little effect on crying infants), it bears repeating that "a squealing baby, in fact, can be stopped dead in its vocal tracks by a sudden stream of baby-talk" (Small 1998, pp. 145–46). In response to Soltis's thoughtful analysis of the relevant evolutionary psychology (see also the commentary by Spurrett & Dellis), I have expressed the view that adult-directed (AD) crying of infants and infant-directed (ID) vocalizations of mothers are "complementary behaviors" that "represent prelinguistic substrates that paved the way for the eventual emergence of protolanguage" (Falk 2004b, Abstract).

R1.2. Mother/infant communications are coregulated

The give-and-take nature of mother/infant interactions is emphasized by **Cowley**, who discusses the mutual adjustments required for coregulated utterance activities; **Dis-**

sanayake, who notes that multimodal behaviors are *temporally coordinated;* **Locke**, who stresses the importance of mutual *tonic communications,* and **Spurrett & Dellis**, who provide discussion about the *contingent,* partly conventionalized signaling in which both mothers and infants anticipate and creatively exploit each other's activities and responses within particular contexts. Spurrett & Dellis note that such contingent, partly conventionalized signaling appears when human babies are around 3 months of age, and Dissanayake documents that infants 4 to 8 weeks old expect social contingency. Locke observes that, in the context of vocal turn-taking, human mothers frequently imitate the vocal behaviors of their infants and that this imitation gets the infants' attention. Locke's observation is interesting in light of Maestripieri and Call's (1996) observation (discussed in sect. 2.1.1 of the target article) that, on those rare occasions when they occur in chimpanzees, ID vocalizations of mothers, such as *whimpers* and *hoos,* are similar to the vocalizations produced by their infants. Rather than being amendments to the substance of the target article, I view Locke's ideas about open channels of two-way communication and "trickle-up phonetics" (I like that phrase) as welcome additions. Although I retain the belief that mothers and their nonambulatory infants were a crucial focus of natural selection, I accept the suggestion made by Locke and by **Rosenberg et al**. that communications between mothers and their walking juveniles would also have been of evolutionary significance. It is important, however, to remember that the coregulated communication between mothers and small infants is, initially, primarily affective rather than instructive in nature (Dissanayake).

R2. How far back did prelinguistic evolution go, and who should be the models?

R2.1. From music to meaning

Because all normal humans engage regularly in language but may or may not participate frequently in musical activities, the evolution of language has usually been given hypothetical priority over the evolution of music (Falk 2000a). **Longhi & Karmiloff-Smith**, however, suggest that musical interaction in general, and song in particular, may have been primordial over early linguistic interactions. Their argument that ID songs' regular musical syntax, hierarchical structure, repetitive nature, tempo, and multimodal delivery (with rocking and patting) help infants to structure later linguistic interactions, is compelling and supports the continuity hypothesis regarding the evolution of human vocalizations from those of apelike ancestors. Thus, one finds many aspects of ID songs in certain vocalizations of African great apes. According to Schaller (1963), two or more gorillas sometimes repetitively vocalize together in a manner that may foreshadow human singing (Gorillian chants?), and they frequently accompany the conclusions of their songs with rhythmic beating of their chests. Goodall (1986) noted that *pant-hoot* choruses may break out during the night, passing back and forth between chimpanzees that are lodged in different sleeping trees. In addition to such "singing," chimpanzees sometimes repetitively drum their hands and feet on large trees. Rather than being referential, as human words and a few calls of some monkeys are, these ape "songs" entail melodic pitch changes and appear to be emotive and affective. Elsewhere (Falk 2000a), I have speculated that australopithecines may have engaged in a certain amount of chorusing and drumming, similar to African great apes.

Longhi & Karmiloff-Smith's observation that 3-month-old children seem to have mental representations of musical interactions is fascinating, as is their finding that by the time infants reach 7 months of age, their mothers' songs have changed from mostly dyadic (involving direct physical contact with the infant) to more triadic (involving contact with other external objects as well). Importantly, the latter finding echoes the distinction between direct physical contact versus distal communication involved in the *"putting the baby down" hypothesis* (sect. 1), the ontogeny of human gesturing (sect. 2.2.1), and the manner in which the latter differs from most chimpanzee interactive gestures (sect. 2.1.3). (In addition to song and gesture, the direct contact/distal distinction also applies to laughter, as illustrated by **Provine**'s observation that the range of stimuli for laughter evolved from the direct physical contact and tickle seen in chimpanzees to the more subtle symbolic play that characterizes certain aspects of humor in humans.)

Significantly, **Longhi & Karmiloff-Smith** note that motherese tends to stress meaning, whereas the semantic content of ID songs is often irrelevant, and they suggest that, prior to the invention of lexical terms, early hominin mothers used structured melodic outputs to reassure their infants that they were close by. **Dissanayake** believes that music and language probably evolved from a common evolutionary foundation, and her commentary also helps to fill in some of the earlier gaps in the continuity theory. Emphasizing the temporal nature of mother/infant interactions, she argues persuasively that they are ritualized behaviors in which the pair share a common emotional pulse, and that such behaviors were important in their own right long before they were coopted for prelinguistic purposes. Dissanayake therefore believes that the vocal interactions described in the "putting the baby down" hypothesis would have evolved after ritualized mother/infant interactions became established. Along similar lines, **King & Shanker** emphasize the cocreation of meaning in coregulated social interactions of mothers and infants before the split between African apes and hominins, and therefore also before the evolution of vocal motherese. These commentaries accept the fundamental importance of mother/infant dyads for the evolution of multimodal communication, and elaborate on the hypothetical musical/affective/emotional repertoire in the earliest prelinguistic hominins. Consistent with the target article, they also underscore continuity between the behaviors of the earliest hominins and their apelike ancestors. **Newman** pushes prelinguistic behavior back even earlier than hominins, suggesting that affective ID vocalizations (e.g., contact calls) that are widespread in mammals may be similar to deep evolutionary precursors of motherese, a point with which I am sympathetic (cf. Falk 1997). (Relevant neurological discussion appears in R6.)

R2.2. Who should be the models?

Indeed, a strong case can be made for preferentially locating prelinguistic behaviors in mother-infant interactions over the objections of **Bouissac**, who believes equally plausible origins may be attributed to other behaviors such as group integration or courtship. Likewise, it is reasonable to compare mother/infant interactions in chimpanzees and humans, despite **Fuentes**' assertion that the target article relies too much on chimpanzees as models. Such objections ignore several facts including that, because of their close genetic relationship with humans, chimpanzees (*Pan*) are widely accepted as the best referential model for interpreting early hominins based on common descent or homology (Falk 2000b; Moore 1996). Both species of *Pan* are characterized by "fission-fusion" communities, which lack stable grouping patterns other than mothers and their dependent offspring (Nishida 1968; Stanford 1998). Whereas it is widely acknowledged that mother-infant interactions contribute fundamentally to the reproductive fitness of chimpanzees (Goodall 1986; Plooij 1984), the case for group integration is weaker. In fact, females of both species of *Pan* typically migrate from their birth groups at or after puberty and commonly transfer to other groups when they are in estrus. Courtship is not a prerequisite for the successful raising of infant chimpanzees because male chimpanzees have relatively little to do with infants and most matings of *Pan* take place in polygynous rather than consort-pair settings, an observation that is reinforced by an analysis of two decades of data for *Pan troglodytes* from Gombe, which reveals that the majority of conceptions occurred in polygynous settings (Wallis 1997). For these reasons, the notion that the prelinguistic substrates upon which language was eventually scaffolded might have been selected in relatively infrequent adult consort interactions, rather than in constant mother-infant interactions with their much higher impact on reproductive fitness, seems unlikely. However, this is not to suggest that consortships and group integration could not have contributed to reproductive fitness and selection for language at some later point during hominin evolution. (I am, in fact, a fan of Dunbar's [1993] social grooming hypothesis [Falk & Dudek 1993].) What should be kept in mind here is that the hypothesis under discussion focuses on the very beginnings of hominin evolution and asks questions about behaviors that *preceded* the development of language in protohominins. Toward that end, the data from chimpanzees are highly relevant and should not be discounted.

Although the target article focuses on mother/infant pairs of bipedal hominins, the preceding discussion supports placing the seeds of prelinguistic behavior even earlier. I am persuaded that music (song) and temporal coregulation of mother/infant interactions (meaning-making) were fundamentally important for the emergence of the prelinguistic behaviors discussed in the target article.

R3. Did multimodal motherese give rise to (proto)language?

R3.1. Definition of language

Commentators **Bickerton** and **Spiezio & Lunardelli** take me to task for failing to define "language," a term that Bickerton suggests I use synonymously with "speech." Whereas Bickerton defines "language" as a system of expression that may function by various means, I define "language" as a complex system of human communication that, like many neurologically based activities, has sensory receptive (listening to speech, reading visually or by Braille) and motoric output (speech, writing, signing) components. As is typical for the primary somatosensory and motor cortices of the brain, the motor components of language are located rostrally (in and around Broca's area of the frontal lobes) and the sensory components are located caudally (in Wernicke's area and surrounding regions of the parietal/temporal/occipital lobes). These regions communicate with each other, and portions of them are differentially recruited during various language (and musical) activities. As described by **Monnot et al**. (see sect. R6), the propositional and linguistic features of language are subserved mainly by the left hemisphere, although the right hemisphere continually puts in its two cents (sensing and responding to emotional content and injecting information via "tone of voice" into speech production). I do not equate speech and language, but I do believe that the evolutionary appearance of humanlike speech must have coincided with the emergence of the wider communication system (language) of which it is, literally, a vocal motoric manifestation. I also think the brain forms a logical substrate for multimodal communication because areas of focal activity tend to "recruit" nearby cortex – just try talking without gesturing!

R3.2. Are prosody and language fundamentally intertwined or essentially separate?

Although they allow that the prosodic aspects of motherese are probably evolutionary retentions from primate call systems (see **Monnot et al**. for enumeration of the various types of prosody), **Bickerton** and **Burling** argue that motherese does not contain the seeds for the distinctive features of language (contrastive phonology, syntax, lexicon, symbolic referential units, and rules for linking these together), and that language origins must therefore be sought elsewhere. **Bouissac** and **Spiezio & Lunardelli** express similar concerns. (Burling acknowledges, however, that language may have emerged very gradually and that the target article helps solve the puzzle of how the vocal/auditory channel of language came to dominate its manual/visible manifestations.) **Wilcox**, on the other hand, notes that linguistic studies on the conventionalization of intonation support the claim that prosody and intonation formed an important substrate for the natural selection of protolanguage, and his commentary provides interesting examples of how intonational aspects of the gestural complex take on grammatical function in sign language. Significantly, Wilcox supports a *gestural-complex* origin for language, with the important proviso that gesture and speech should not be separated in evolutionary accounts. Instead, he notes, prelinguistic vocalizations are themselves articulatory gestures, and a "gesture-first" hypothesis is therefore unnecessary.

Along similar lines, **Rogalewski et al**. cite experimental data that show that the prosodic aspect of speech is sufficient to activate the cortical representations for manual gestures, and they remind us that infants learn the phonology and prosodic contours of their languages before they learn the meanings of single words or how to combine them into sentences. As discussed in section R6, these commentators believe their data provide strong evidence for a joint neural system that processes both manual and prosodic gestures, and they think that language did not evolve as a separate module but, rather, as a more general action-perception network. Rogalewski et al. are in partial agreement with **Bickerton** and **Burling**, however, when they note that the last step in evolution was characterized by production of linguistically complex speech that seems uniquely human. Finally, **Dilkes & Platek** strike a chord similar to that of **Wilcox** by noting that manual gestures coupled with development and evolution of controlled mouth and larynx movements could have provided the evolutionary basis for today's language. These new data provide further evidence for multimodal, prosodic aspects of contemporary language and, presumably, its earlier forms.

What about the hypothetical path between motherese and the emergence of verbal conversation that is questioned by **Bickerton**, **Burling**, and others? **Braten** addresses this in his discussion of *altercentric* mirroring and self-with-other resonance of newborns by taking us on a tour from 1-hour-old infants' first vocal imitations to 6-month-olds' selective tuning to the sounds of their native languages, which is followed shortly thereafter by babbling. **Bortfeld** elucidates how the acoustic prominence of motherese helps jump-start infant recognition of words in fluent speech streams, at around 7.5 months of age. Importantly, Bortfeld's research emphasizes the role of repetition for infants' learning of names and reveals that recognition of their own names is a basic tool that helps them to begin decoding the speech stream. **MacNeilage & Davis** phonetically analyze baby-talk words in various languages and discuss the implications of their findings for the origin of the first words. Significantly, they document the relationship between babbling and first words, show that certain parental words may have derived from baby-talk words, and document a clear *phonetic contrast* between baby-talk words for female and male parents. **Locke**'s discussion of "trickle-up phonetics" is consistent with these observations. MacNeilage & Davis also address the possible origin of the "naming insight." Logically, it was after they evolved an aptitude for naming that hominins developed the linguistic ability for displaced reference, and **Cronk** raises the interesting possibility that this may have happened within the context of deceptive behaviors. The above commentaries add to data provided in sections 2.2 and 3.2, and reinforce the hypothesis that motherese provided the evolutionary substrate from which protolanguage eventually evolved. That said, it is important to acknowledge the unique nature of human language stressed by **Bickerton**, **Burling**, and others. Is language qualitatively different from nonhuman primate call systems? Of course it is, but this does not mean that it could not have gradually derived from initial neurological/behavioral substrates similar to those underlying these call systems (Cronk) through evolutionary mechanisms such as those discussed in section 3.2.1.

R4. Baby riding, parking, and slings

R4.1. Baby "parking" versus baby "setting"

Several commentators have problems with the concept of early hominin mothers putting their babies down, incorrectly asserting that the target article equates such behavior with the "baby parking" of other primates. Thus, **Rosenberg et al**. state that there is little evidence for baby parking among primates as a group (which is incorrect), living humans, or prehistoric hominins; **Sokol & Thompson** assert that the target article implies that hominin infants would have been cached away from their mothers for long durations (it does not); and **Spiezio & Lunardelli** ask how a behavior (parking) that is rare in monkeys and apes (it is, most of their infants ride) can be a focus of the target article when there are few observations suggesting its adaptive value in nonhuman primates (see, however, sect. 3.1 for relevant citations regarding foraging-related changes in infant carrying in squirrel monkeys, geladas, long-tailed macaques, and yellow baboons). To reiterate the target article (and Ross 2001): Infant *caching* (hiding them in tree holes or nests) is common in prosimians, as is baby *parking* (e.g., leaving infants more exposed in trees for considerable periods of time while mothers forage, frequently at a distance). In monkeys and apes, on the other hand, these behaviors are rare, having been replaced by riding, in which infants (rather than mothers) do the clinging. Human babies are incapable of such riding, which therefore had to have been lost during hominin evolution. In sum, section 3.1 of the target article *explicitly* rejects the notion that hominin mothers reverted to the prosimian-like adaptation of parking their babies far away, and cites comparative primatological and ethnographical reasons for doing so. Instead, mothers are hypothesized to have put their babies down next to them and to have remained in close proximity while they foraged nearby. (One could term this "baby setting" as opposed to "baby parking.")

Contrary to **Rosenberg et al**., human mothers regularly engage in similar behaviors. In our own culture, for example (and despite the wide availability of babysitters), ready-made baby seats are frequently used for just such purposes, whether to keep an infant nearby in the study as mother works on her dissertation or on the seat next to her in a restaurant while she enjoys a meal. Despite the fact that lactating mothers may have been accompanied by older children or related adults as they foraged (**Fuentes**), I have a difficult time imagining early hominin mothers *not* setting their babies down frequently in order to free their hands for noncarrying tasks prior to the invention of baby slings.

R4.2. The invention of baby slings and clothing

Commentators are split in their opinions about when baby slings were invented. **Rosenberg et al**. think that baby slings would already have been in general use 2 million years ago; **Sokol & Thompson** suggest that simple baby slings were created by the time hominins were carrying rocks, around 2.5 million years ago. The suggestion that carrying tools implies a form of carrying device is weakened, however, by the fact that chimpanzees from Bossou, Guinea, carry around their favorite nut-cracking rocks (Matsuzawa 1996) and Gombe chimpanzees are famous for carrying termite-fishing poles to termite mounds (Goodall 1986) – both groups unaided by satchels.

Monnot et al. suggest that hominins may have invented baby slings prior to the loss of their body fur, which they think coincided with a remarkably recent (around 72,000 years ago) invention of clothing (Kittler et al. 2003). **Rosenberg et al**., on the other hand, suggest hominins were already relatively hairless by 2 million years ago, and state that hominin mothers would have been reluctant to put babies down because of the need to keep them warm by keeping them next to their bodies. I do not think that hominins in East Africa had any more trouble keeping warm during the day (nights are another thing) 2 million years ago than they do today (Falk 1990). Tall lanky body types that are built for dissipating heat are, and were (witness WT 15000 from Kenya), adaptive in that climate, which today remains much as it was 2 million years ago.

So what's the answer? When were baby slings invented and how does their hypothetical appearance fit with the "putting the baby down" hypothesis? I do not think baby slings sprang into use full-blown, as if from Zeus's forehead. Given "necessity is the mother of invention," I think that slings were invented as hominids were losing their fur coats and as their increasingly altricial infants were simultaneously (and parsimoniously) losing their ability to cling unaided to their mothers. This would have happened as bipedalism was becoming refined, after its presumed origin some 6 million years ago and before the first certain fossil evidence of essentially modern body builds around 1.6 million years ago. As **Brace** discusses, the body proportions of WT 15000 suggest that the normal mammalian fur coat had been lost before, 1.6 million years ago, causing hominins to become sweat-gland-endowed and bare-skinned. In sum, these relatively late hominins probably had lost their fur coats, had dark skin, were sweaty, and were "standing tall and staying cool" (Wheeler 1988). Did these migrating hominins have baby slings? I should think so. Were they made of vegetal matter? Possibly, although I think it would be fairly difficult to manufacture such a sling prior to the invention of textiles (see Figure R1), which appears much later in the archaeological record. Perhaps the first slings (for babies and other objects) were made from animal hides provided by the nomadic "persistence" hunters discussed by Brace. (In terms of how they made a living, the "facultative carnivore" hypothesis discussed by Brace seems preferable to **Sokol & Thompson**'s assertion that humans foraged around a central home base 2 million years ago, given that most paleoanthropologists now believe that the relevant sites from Olduvai Gorge represent locations where hominins butchered carcasses and cached stone tools [Potts 1984].)


Figure R1. A woman carries her baby in a sling.

R5. Some evolutionary considerations

R5.1. Timing

Although a number of commentaries focus on the relatively recent time span surrounding the initial appearance of *Homo,* it is important to keep in mind that present evidence indicates that bipedalism was refined over several million years of time, during most of which there is no record whatsoever for tool manufacture. (However, **Brace**'s suggestion that the use of pointed sticks for both defensive and digging purposes may have occurred very early in hominin evolution and even provided an impetus for the selection of bipedalism, is consistent with comparative dental data and seems reasonable.) What seems lost in some of these commentaries is the realization that the prelinguistic (as opposed to protolinguistic) behaviors discussed in the target article may have been selected for long before the first exodus of hominins from Africa (but see R2.1). More precise timing of certain aspects of the "putting the baby down" hypothesis should be clarified in the future with new discoveries that shed light on how far back in time tall hominins with modern body proportions existed. Of the commentators, only **Braten** explicitly acknowledges that early hominins could have been faced with extinction as they refined bipedalism in the duration that preceded the invention of baby slings. Happily, they did not become extinct, due, hypothetically, to the evolution of distal mechanisms (for laughter, gesture, voice, and song) for mothers and infants to "keep in touch" (as the phone company says) as they weathered the various anatomical, physiological, and neurological changes that accompanied the gradual refinement of bipedalism. That peculiar form of locomotion, of course, was *the* key (or first domino) that unlocked the cascade of relevant events, as detailed in **Provine**'s important commentary.

R5.2. Exaptation and circular reasoning

Bickerton suggests that the "putting the baby down" hypothesis is antithetical to the notion of *exaptation,* which may be defined as the use of a structure or feature for a function other than that for which it was initially selected. The function of primate calls, motherese, and language is to receive and convey information (usually) among conspecifics. What changed with the emergence of language was not the use of the relevant vocal/neurological apparatus but, rather, hominins' nervous systems and, therefore, the nature and complexity of the information they could process. Bickerton also suggests that my hypothesis is circular because (to paraphrase) a mother who did not already have meaningful utterances could not have taught them to her infants – so where did she get them in the first place? (**Bortfeld** and **King & Shanker** also mention this apparent paradox.) This objection ignores not only the contingent and creative nature of coregulated behaviors attributed to ancestral mother/infant pairs (R1.2), but also the importance of variation and changing environments, both for the selection process itself and for the behaviors that were selected. Natural selection operates in such a way that the frequencies of selected behaviors and their underlying genes shift directionally (increase) over time. As discussed by **Cowley**, the selective value of behaviors (or physical traits) is likely to change with altered ecological/environmental circumstances, such as the shift in maternal care in conjunction with new locomotor patterns and foraging strategies documented for certain monkeys in section 3.1. Behaviors that are (or were) not adaptive for mothers may, under changed circumstances, become important for the survival of their offspring (e.g., humanlike crying). If, on the other hand, a maternal behavior becomes important for infant survival (e.g., an ability to "read" and influence distal offspring), a high percentage of offspring of mothers that lack the selected behavior would not survive (i.e., they would be selected against). Natural selection is not about populations of offspring looking exactly like their parents; rather, it is about them becoming different in precisely those traits that have selective value.

R6. Neurological substrates of communication

R6.1. Global organization

The commentary by **Monnot et al**. provides details about brain lateralization that underlies prosodic and linguistic behaviors in humans, and discusses how the two hemispheres work in concert to convey full meaning. Significantly, the authors document that linguistic prosody depends on the left hemisphere, whereas comprehension and expression of affective prosody are essentially right hemisphere functions (along with "body language"). **Dilkes & Platek** discuss sign language and show that, like spoken language, it relies essentially on the left hemisphere. **Gilissen** remarks on the comparatively large area of the neocortex that is recruited for human linguistic functions in a discussion that reinforces the sensory/motor definition of language provided in R3.1. Consistent with these observations, **Aboitiz & Schröter** propose that the neural substrates for mother/infant interactions depend on coordinated activation of widespread temporoparietal-prefrontal networks that modulate auditory working memory and imitation. They also suggest, quite reasonably, that such networks may have been the precursors for language evolution.

R6.2. Mirror neurons

Gilissen and **Rogalewski et al**. discuss the importance at the cellular level of "mirror neurons" that elicit particular actions, and also discharge in premotor cortex of monkeys (area F5) and its likely homologue in humans (part of Broca's area) when those actions are observed in others (Rizzolatti et al. 1996). **Dilkes & Platek** agree, and also note a similar phenomenon in the superior temporal sulcus in response to observation of hand movements by signing humans and moving hands by monkeys (Rizzolatti & Arbib 1998). These commentators suggest that mirror neurons form the substrates for understanding motor actions in others and are part of an action-perception network that facilitates gestural (orofacial and manual) as well as emergent linguistic communication in co-regulating pairs of mothers and infants. They also point out the important implications of mirror neurons for the neurological substrates that may have been involved in prelinguistic evolution in hominins. **Braten**'s *hominin infant decentration hypothesis* is particularly significant because it specifies how mirror neurons could have been of major importance during the period of evolution when hominin infants lost the ability to ride clinging to their mothers' backs and, thus, to automatically share perceptions from (literally) her point of view. These commentaries are insightful and add a welcome neurobiological perspective (**Aboitiz & Schröter**) to the "putting the baby down" hypothesis.

Although the above-mentioned commentaries focus on mirror neurons that subserve actions of hands, face, and the vocal apparatus and also discharge during observation of similar actions in others, it will not surprise me if additional mirror neurons are eventually discovered more medially in the prefrontal cortex and implicated in motor behaviors based on other parts of the anatomy. As any dancer will attest, watching a dance performance can be a very "moving" experience. In fact, my former tap-dance teacher, Cynthea Bowers, routinely rehearsed for her performances in her imagination (Falk 2004a). After studying tap with Cynthea, I became aware that this form of dance is exquisitely linguistic!

R6.3. Homologous brain areas for vocal communications in human and nonhuman primates

Over the years, there has been a tendency to attribute monkey and ape vocalizations to activation of the medially located (limbic) cingulate gyrus and surrounding (cortical) supplementary motor regions of the brain, and human language to activation of lateral perisylvian cortex (including Broca's and Wernicke's areas), as touched upon, to varying degrees, in the commentaries of **Gilissen, Monnot et al**., and **Newman**. Homologous areas have now been identified for human and nonhuman primates in all of these regions (some mentioned by commentators). As detailed by Galaburda (1984), stimulation of the medial area produces vocalizations in both monkeys and humans, neither of which vocalize upon stimulation of lateral Broca's area or its homologue. Further, aphasic humans with damage to lateral areas are frequently capable of "limbic speech," and may swear with admirable fluency (Crosby et al. 1962). I recently asked Albert Galaburda if he thought that vocalizations of nonhuman primates may be influenced by regions of their cortices that appear to be homologous with Broca's and Wernicke's areas. His response was:

> I think that the cingulate regions drive the animal to vocalize, but what is actually brokering the vocalization is the homologue of Broca's area, in the inferior periarcuate region of the monkey, with access to the appropriate muscles. Stimulation of this region in humans does not produce vocalization, which would suggest that it needs to be driven physiologically from its activators in the pericingulate areas. The periaqueductal grey in the midbrain would be another place where stimulation appears to produce vocalizations in monkeys and humans. (Galaburda, personal communication, October 6, 2003)

Along similar (but more medial) lines, **Newman** notes that the anterior cingulate gyrus is important for expressing isolation calls in young primates, and that it is also activated when women hear their infants cry (Lorberbaum et al. 2002). Newman therefore hypothesizes that the underlying neural circuitry may have been important for the incorporation of speech sounds as affective stimuli during hominin evolution. Although data are harder to come by for apes, recent studies of great apes reveal asymmetries (favoring larger surfaces on the left) that are similar to those of humans for homologues of area 44 of Broca's area (Cantalupo & Hopkins 2001) and the planum temporale (Gannon et al.

1998; Hopkins et al. 1998). All of these neurological studies reinforce the continuity hypothesis of language origins.

R6.4. Brain size, wiring, and sex

The increase in brain size that began in the australopithecine ancestors of *Homo* (Falk et al. 2000) is an important component of the "putting the baby down" hypothesis. **Brace** suggests that, once symbolic expression became adaptive, it may have been the selective force that drove the subsequent coevolution of continued brain expansion and language. **Aboitiz & Schröter** hypothesize that increased brain size was accompanied by more complex and plastic networks, which released barriers that had previously limited reciprocal protolinguistic interactions. They also suggest (rather eloquently) that "this opened the possibility of living in a world of conversations which transmitted internal, emotional states but also referred to the surrounding world." As **Newman** notes, specializations related to ID communication may have evolved differentially in females, which is consistent with documented sex differences for humans and monkeys in mean absolute and relative brain sizes (Falk et al.1999) and for humans, at least, in amounts of gray and white matter (summarized in Falk 2001).

R7. Suggestions for future research

R7.1. More studies on rescheduling of infant-carrying in nonhuman primates

Studies on a few monkey species suggest that mothers stop carrying their infants at earlier ages under difficult foraging conditions (sect. 3.1), a finding that has important implications for the "putting the baby down" hypothesis. Additional studies on foraging-related changes in maternal care on a variety of species living in different habitats could shed further light on mother/infant dynamics in early hominins.

R7.2. Sibling interpreters of babbling

Burling's observation that parents have no trouble extracting their infants' first words from their abundant primate-like vocalizations provoked fond memories from when my youngest daughter, Adrienne, was babbling. In my mind's eye, I can still see her sitting in her high chair, babbling a string of nonsense, and then fastening me with a penetrating stare as if to say, "Well?" "What does she want?" I would ask her sister, Sarah, who is 2½ years older than Adrienne. Unfailingly, Sarah appeared to know what her sister was saying, and I came to think of her as a translator. One possibility is simply that Sarah was better than I at reading her sister's desires from contextual clues. Another (and the one I believed at the time) is that Adrienne was doing a kind of "proto-talking," and that Sarah was able to comprehend it based, at least in part, on her own relatively recent babbling experiences. One might be able to explore the extent to which babbling has prelinguistic regularities that include semantic content by designing tests (perhaps with screens so that big sibling is blind to the identity of desired objects) to determine what, exactly, sibling translators are tuning in to when they interpret babbling. Such a study might, or might not, begin to address Burling's important question about how words could have emerged from the prelinguistic melody.

R7.3. The baby sling challenge

I was surprised at the number of commentators who think that early hominins could have easily fashioned baby slings from vegetal matter, and suggest the following research project (M.A. thesis?) to explore that likelihood: Find one or more lactating, demand-feeding mothers of nonambulatory infants who are relatively athletic and willing to participate. Locate a large park and set up stations that have a blanket, diapers, water, and food at several dispersed locations along a trail of approximately two miles. The object is for the mother to walk the trail while carrying the baby in her arms, or (preferably) by using any means (e.g., a baby sling) that she can fashion from natural materials she finds along the way. Encourage her to take advantage of the rest stations. What does she do with the baby when she gets to them? The researcher(s) should take notes during the entire experiment. This exercise could be repeated with a small but varying number of mother/infant pairs, related juveniles, and/or accompanying aunts. It would also be informative to collect similar data in parks with different climates and flora. Keeping in mind that these are big-brained humans, what are the implications of the study's findings for the invention of baby slings in early (pre-hunting) hominins and for the "putting the baby down" hypothesis?

Another baby sling challenge could be presented to the bonobo, Kanzi. After all, Kanzi was able to learn to knap stone tools and use them to cut through a cord to open a reward box by observing humans (Toth et al. 1993). Could Kanzi also learn to make a carrying device from vegetal matter by observation (once the experimenters figured out how to do it), and use it to carry an object from point A to point B? Results of this experiment could be used to address the questions posed at the end of the previous paragraph, keeping in mind that Kanzi is an enculturated chimpanzee.

R7.4. Imaging studies of the neurological substrates for mother/infant communication

The observations of numerous commentators regarding mirror neurons raises the interesting possibility that future PET or more user-friendly fMRI studies (Keenan et al. 2003) could focus on mothers as they listen to recordings of their infants' crying, babbling, and other vocalizations. It should also be possible to do such studies on mothers as they produce vocal motherese (this would require, however, that mothers' braincases be immobile during data acquisition). For comparative purposes, fathers could be imaged, too. Such studies would further elucidate the neurological substrates of motherese, and the extent to which they are, or are not, differentially represented in female parents.

R7.5. More fossils, please

An unanswered question that is germane to the target article concerns when and how hominins made the transition from bodies with apelike proportions that engaged in facultative bipedalism to taller bodies with humanlike proportions that practiced habitual bipedalism. How far back will paleoanthropologists be able to trace the ancestors of the tall 1.6 million-year-old lad (WT 15000) from Kenya? Future discoveries of relatively complete hominin skeletons are needed to address this question.

R8. Conclusion

The views about prelinguistic evolution and its relationship to motherese developed in the target article have been fleshed out in light of information provided by 26 commentaries. The initial manuscript was influenced by a variety of sources, not the least of which were my earlier interactions with two children and five grandchildren as they went from birth to gradually becoming bipedal while progressively learning to express themselves through multimodal communications that included emergent linguistic skills. After the commentary process, I continue to believe that the seeds of prelinguistic behaviors, past and present, germinated from the progressive evolution of motherese during the long span of time when hominins perfected bipedalism and before they evolved into fully loquacious *Homo.* Although this response has focused on answering their objections, the commentaries have added a tremendous amount of far-reaching and relevant information that largely supports the "putting the baby down" hypothesis. For that, I am grateful.

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Letters "a" and "r" appearing before authors' initials refer to target article and response respectively.

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