

Language and life history: A new perspective on the development and evolution of human language

John L. Locke

Department of Speech–Language–Hearing Sciences, Lehman College,
City University of New York, Bronx, NY 10468.

john.locke@lehman.cuny.edu

Barry Bogin

Department of Behavioral Sciences, University of Michigan–Dearborn,
Dearborn, MI 48128.

bbogin@umd.umich.edu

<http://casl.umd.umich.edu/faculty/bbogin/>

Abstract: It has long been claimed that *Homo sapiens* is the only species that has language, but only recently has it been recognized that humans also have an unusual pattern of growth and development. Social mammals have two stages of pre-adult development: infancy and juvenility. Humans have two additional prolonged and pronounced life history stages: *childhood*, an interval of four years extending between infancy and the juvenile period that follows, and *adolescence*, a stage of about eight years that stretches from juvenility to adulthood. We begin by reviewing the primary biological and linguistic changes occurring in each of the four pre-adult ontogenetic stages in human life history. Then we attempt to trace the evolution of childhood and juvenility in our hominin ancestors. We propose that several different forms of selection applied in infancy and childhood; and that, in adolescence, elaborated vocal behaviors played a role in courtship and intrasexual competition, enhancing fitness and ultimately integrating performative and pragmatic skills with linguistic knowledge in a broad faculty of language. A theoretical consequence of our proposal is that fossil evidence of the uniquely human stages may be used, with other findings, to date the emergence of language. If important aspects of language cannot appear until sexual maturity, as we propose, then a second consequence is that the development of language requires the whole of modern human ontogeny. Our life history model thus offers new ways of investigating, and thinking about, the evolution, development, and ultimately the nature of human language.

Keywords: adolescence; childhood; development; evolution; infancy; juvenility; language; life history; modularity; speech

1. Introduction

It has long been recognized that *Homo sapiens* is the only species that has language. In the late 1800s, there was a great deal of speculation about linguistic evolution, much of it fanciful. In the ensuing century, there were scattered attempts to address this issue – more than four hundred cited in one bibliography (Hewes 1974) – but most of these proposals were also highly speculative.

In the 1990s, work on the evolution of language intensified. At the beginning of the decade, Pinker and Bloom (1990) were pointing to “a wealth of respectable new scientific information relevant to the evolution of language that has never been properly synthesized” (p. 727). Since then, the flow of books on the evolution of language has averaged more than one per year (Bickerton 1990; 1995; Botha 2003; Carstairs-McCarthy 1999; Christiansen & Kirby 2003a; Corballis 2002; Deacon 1997; Dunbar 1996; Gibson & Ingold 1993; Hurford et al. 1998; Jackendoff 2002; Kirby 1999a; Knight et al. 2000; Lieberman 1991; Oller & Greibel 2004; Tallerman 2005; Wray 2002). In this same period, journal articles and book chapters have increased tenfold (Christiansen & Kirby 2003c). Two theorists

JOHN L. LOCKE is Professor of Speech-Language-Hearing Sciences and Director of the Interdepartmental Program in Linguistics at Lehman College, City University of New York, and member of the doctoral faculty at the CUNY Graduate Center. He is the author of over a hundred publications on the development and evolution of language, including *Phonological Acquisition and Change* (1983, Academic Press) and *The Child's Path to Spoken Language* (1993, Harvard University Press).

BARRY BOGIN is the William E. Stirton Professor and Professor of Anthropology at the Department of Behavioral Sciences, University of Michigan–Dearborn. His research area is human physical growth and development. Since 1974 he has worked in Guatemala and with Guatemalan Maya children living in the United States. Bogin has also addressed the evolution of the pattern of human growth. His work has been published in more than 120 books, articles, and book chapters. These include *Patterns of Human Growth, 2nd edition* (1999, Cambridge University Press) and *The Growth of Humanity* (2001, Wiley).

recently labeled linguistic evolution “a legitimate area of scientific enquiry” (Christiansen & Kirby 2003b, p. 300). To a third, Carstairs-McCarthy, the evolution of language has become, for the first time in scientific history, “seriously researchable” (Carstairs-McCarthy 2004, p. 1299).

2. Stages in life and language

For some reason, few of the new proposals have afforded a significant role to ontogeny, though no one doubts that the capacity for language develops, or that languages, to exist, must be learned by the young. This omission is interesting in light of the facts that *Homo sapiens* is also the only species that has a childhood, a biologically and behaviorally distinct, and relatively stable, interval between infancy and the juvenile period that follows (Bogin 1990; 1999b), and that a great deal of language learning now occurs during this stage.

Little attention has also been given to the processes that produced the capacity for speech, the universally preferred modality of language (Locke 1998b). We think vocal and articulatory control, which may be relevant to the evolution of song as well as speech (Merker 2000), evolved as a precursive step in the construction of language (MacNeilage 1998; Studdert-Kennedy 1998; 2005), it making less sense that the capacity for syntax – the focus of many proposals – evolved prior to the physical system responsible for the phonetic units that enable words and massive vocabularies (Bickerton 1995; 2000; Donald 1999; Studdert-Kennedy & Goldstein 2003), or somehow evolved without them.¹

We believe that some selection pressures may have applied early in infancy, and others in childhood. When childhood expanded, new opportunities arose, especially within families, for the negotiation of more structured and complex forms of vocalization. With a premium in this context on honest signaling, benefits would have accrued to families that were able to deploy these more complex forms meaningfully, and thereby to warn, advise, and inform each other.

Here, we envision an evolutionary connection between language, as qualified above, and the life history stage of childhood. We propose that in evolutionary history, growth factors working in concert with selection for reproductive success initially produced a short childhood that was later used for, and extended by, vocal and verbal learning. With continuing increases in the duration of childhood and the complexity of the new proto-linguistic behaviors, both childhood and essential components of language evolved.

One might suppose the contributions of a life history approach end with childhood, given the developmental linguistic importance of that stage, but humans are also the only species that has adolescence, a stage in which the attainment of sexual maturity is accompanied by a dramatic resurgence of skeletal growth. We suggest that although the basic structure and functions of language are instated in infancy, mastery of language as a social tool – a fluent and flexible means of oral communication, manipulation, and performance – does not approach adult levels of proficiency until adolescence. It is at this developmental stage, in evolutionary history, that performative traits would have facilitated intrasexual

competition and courtship. Selection at adolescence would have reinforced the behaviors occurring then, as well as foundational behaviors that emerged in earlier stages. For this reason, we propose further connections between adolescence and all earlier stages of life history, including infancy, childhood, and juvenility. According to our life history proposal, individuals with longer intervals between infancy and sexual maturity, and greater success in intervening stages, achieved higher levels of vocal and verbal behavior and, therefore, greater competitive advantage.

The approach to human life history adopted here was developed by Bogin (1988; 1999b). It is a biological and behavioral model of human development that both complements and departs from the better-known schemes described by developmental psychology. The model is based on a consideration of comparative mammalian biology as well as primate evolutionary history.

2.1. Stage 1: Infancy

Figure 1 illustrates the amount of growth, or distance (upper panel), and the rate of growth, or velocity (lower panel), of healthy human beings. The velocity changes in growth correspond with stages of human life history. Postnatal growth is rapid, as is its rate of deceleration. During infancy, which extends from birth to 36 months, deciduous dentition erupts and the brain grows at a fast pace.

The infancies of humans and other mammalian species are comparable in many respects – for example, feeding by maternal lactation and appearance of deciduous teeth. However, in most mammals and all the other

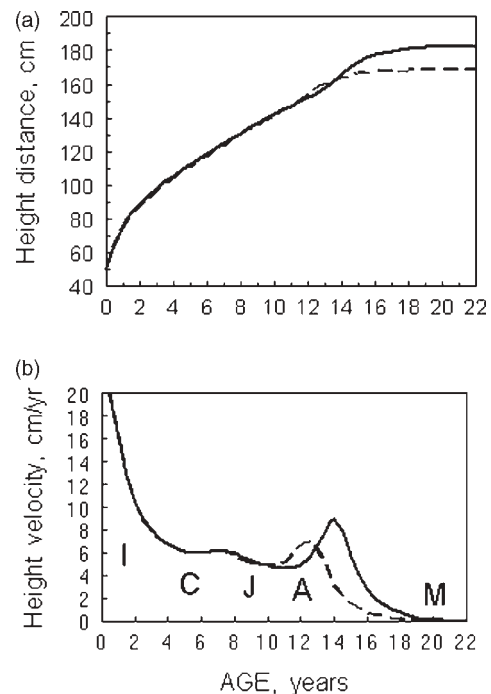


Figure 1. Typical distance (A) and velocity (B) curves of growth in height for healthy girls (broken lines) and boys (solid lines). Postnatal life history stages are labeled as I-infancy, C-childhood, J-juvenility, A-adolescence, M-mature adult (after Prader 1984).

primates, infancy and lactation end with eruption of the first permanent molars (Smith & Tompkins 1995). In humans, by contrast, there is an interval of about three years between weaning – breast-feeding usually is discontinued at 30 to 36 months, according to ethnographic observations in traditional societies and historical accounts from Europe and America – and eruption of the first permanent molars, an event that usually takes place at 5 to 6 years of age.

An important factor in the evolution of human infancy was bipedalism, which realigned the spine and narrowed the pelvis (Leutenegger 1974; 1980; McHenry 1975). This change created an unfavorable ratio between the smaller maternal birth canal and the large fetal head (Leutenegger 1974) – the brain of modern human neonates is larger than the brains of other primates, even though it achieves a smaller percentage of its total growth at birth (Harvey & Clutton-Brock 1985; Lindburg 1982) – and this produced what Washburn (1960) called an “obstetrical dilemma.”² This dilemma was eased when some amount of skull and brain growth – and motor development – were adaptively deferred into the postnatal period, increasing infant dependency and the need of postnatal care. In a number of important respects, these conditions – in danger of being seen as design flaws – offered more and better opportunities for social, vocal, and lexical learning (Bjorklund 1997; Locke 1993; 1999).

This tendency to view helplessness as a socially and cognitively beneficial trait is supported by anthropological accounts, which indicate that most hunter-gatherer mothers rarely put their babies down, and then do so for no more than a few seconds, usually remaining within a meter (Draper 1976; Hill & Hurtado 1996; Konner 1976; Lee 1979a; LeVine 1980). Separation cries usually evoke pick-up and breast-feeding (LeVine & LeVine 1966). When infants cannot be carried, they are often left in the care of others (Blurton Jones 1993; Estioko-Griffin 1986; Hawkes et al. 1997; Hewlett 1991). In most other primate species, infants are equipped to cling to their mother’s body hair, and are less likely to be cared for by other members of the social group. Thus, although the *duration* of infancy is not longer in humans than in some of the other primates, its *quality* is higher because the greater handling required by the human infant produces more intense social stimulation during a period in which the brain grows at a compensatorily rapid rate.

The primacy of brain growth over other body systems is illustrated in Figure 2. In the newborn, 87% of resting metabolic rate (RMR) is devoted to brain growth and function. This has the effect of co-opting, and thus prolonging, the growth of other systems. By the age of five years, the RMR devoted to the brain is still high at 44%, whereas in the adult the RMR figure is 20 to 25%. At comparable stages of development, the RMR devoted to the relatively large chimpanzee brain is about 45, 20, and 9% for a newborn, a five-year-old, and an adult (Leonard & Robertson 1992).

Stages in the development of language correspond to life history stages, to a degree, but language research has not been carried out within a life history framework. Thus, our characterization of language in each of the ontogenetic stages below is based on pre-existing evidence.

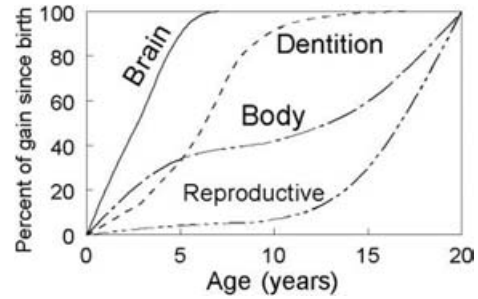


Figure 2. Growth curves for different body tissues (from Bogin 1999b). The Brain curve is for total weight of the brain (Cabana et al. 1993). The Dentition curve is the median maturity score for girls based on the seven left mandibular teeth (I1, I2, C, PM1, PM2, M1, M2) using the reference data of Demirjian (1986). The Body curve represents growth in stature or total body weight, and the Reproductive curve represents the weight of the gonads and primary reproductive organs (after Scammon 1930).

2.2. Infant language

The basic structure of language is laid down in infancy, which is paradoxical since the word derives from the Latin *infans*, literally “not speaking.” In the first phase of development, vocal learning, infants learn and may reproduce aspects of the prosodic and segmental characteristics of the ambient language. This phase commences before birth and continues in infancy (Locke 1997; Locke & Snow 1997). By six months, most infants have heard enough speech to recognize a few words and stereotyped phrases (cf. Locke 1993), and to experience some perceptual reorganization (Kuhl et al. 1992), a process that continues in succeeding months (cf. Werker & Curtin 2005). At seven months, infants typically begin to make alternating jaw movements while phonating (MacNeilage 1998), an act that produces well-formed syllables (Koopmans-van Beinum & van der Stelt 1986; Oller 2000). An apparently universal phonetic repertoire begins to emerge at this time (Locke 1983; 1990; 2000a). Four months later, infants utter sounds in ways that reflect prior exposure to speech (Vihman 1996).

Around the end of the first year, most infants attempt to speak, and may even – then or in succeeding months – improvise sound-meaning relationships that may be treated by the family as invented words (Leopold 1949). A few months later, infants develop a suite of cognitive traits that will enable language to be used at a basal level of creativity and efficiency. These center on the ability to infer, and the disposition to share, the intentions of others (Tomasello et al. 2005). Around this time, several different communicative acts begin to emerge, with many in frequent use by age three or four years (Snow et al. 1996; Wetherby et al. 1988; also see the review in Adams 2002).

Infants usually begin to combine lexical items at age 18 to 24 months. In the following year, having learned something about grammatical structure and rules, infants display the ability to understand and compute novel forms and sequences of words. In the typical English-learning infant, therefore, all areas of linguistic structure – phonological, lexical, morphological, and syntactic – exhibit some degree of development by age

36 months (Locke 1993; 1997). Thus, by the time infancy draws to a close, the rudiments of a structural linguistic system, and basic components of a functional communicative system, are operative.

2.3. Stage 2: Childhood

The childhood stage is peculiar to humans, having been evolutionarily inserted between the infant and juvenile stages that characterize social mammals (Bogin 1990). Childhood is defined by several developmental characteristics, for example, a slowing and stabilization of the rate of growth; immature dentition; feeding characteristics, such as dependence on older people for food; and behavioral characteristics, including immature motor control. The evolutionary value of childhood lies in the mother's freedom to discontinue nursing her three-year-old, which enabled her to initiate a new pregnancy. Doing so enhanced reproductive output without increasing the risk of mortality for the mother, or her infant or older children, for in cooperatively breeding societies others were available to help care for the young.

As shown in Figure 1, the end of the rapid growth deceleration of infancy marks the beginning of childhood, when the growth rate levels off at about 5 cm per year. Stabilization of growth rate is rare in mammals; typically, growth continues to decelerate between infancy and adulthood (Brody 1945; Tanner 1962). In childhood, brain growth tapers off, at least by weight (Fig. 2), with its mass peaking at about age seven years (Cabana et al. 1993), with a small increase occurring later at puberty (Durston et al. 2001; Sowell et al. 2001). Myelination and some nerve proliferation continue into adulthood (Bjorklund & Pellegrini 2002; Taupin & Gage 2002).

In virtually all other mammalian species, and in all non-human primates, maternal lactation continues until the eruption of the first permanent molar (Smith & Tompkins 1995). With adult molars and other teeth in place, the other primates move on to the juvenile stage and must forage for food and otherwise care for themselves with little or no assistance. In the human infant, of course, other foods are supplied prior to weaning. But the cessation of lactation places a great nutritional burden on the weaned infant, with the high metabolic demands of a brain that is still growing rapidly. The typical three-year-old is too motorically immature to forage or prepare its own food, and too limited by deciduous dentition and a small gastrointestinal tract to eat and digest the adult diet.

The solution to this "feeding crisis" is for older members of the social group to provide specially prepared foods that are high in energy and nutrients until self-care becomes possible, and in various hunter-gatherer societies this is what is done (Blurton Jones 1993; Estioko-Griffin 1986; Hewlett 1991).³ Summarizing the data from many human societies, Lancaster and Lancaster (1983) called this type of childcare and feeding "the hominid adaptation," for no other primate or mammal is so actively involved in these ways. The long period of food provisioning, extending from ages three to seven years, largely defines the childhood stage of human life history. By age seven, usually, the four permanent first molars have erupted and the permanent incisors have begun to replace "milk" incisors. With parallel changes in the size and strength of the jaws, and in the muscles of mastication,

children – on the threshold of juvenility – become able to eat the same foods as adults.

During this period, mothers often participate in childhood feeding if they are neither pregnant nor nursing a new infant, but new reproductive efforts are likely to consume most of their free energy and time. This is the case for all other mammals, and it is the reason why the birth interval between successful pregnancies is equal to the age of first molar eruption in species without the human style of social care after weaning. For humans, early weaning (by age three years) relative to molar eruption (age six years) reduces the birth interval and allows the mother to successfully produce two offspring in the time it takes chimpanzees and orangutans to successfully rear one. Thus, we see childhood as an adaptation that enhances the quantity of maternal reproductive output without sacrificing the quality of any offspring. We discuss the other aspects of the evolutionary basis for childhood in more detail later.

On the social front, childhood typically produces new extrafamilial friendships, frequently co-timed with growing disenchantment with siblings (Dunn 1996). In some modern societies, social hierarchies have already developed by the age of five. In these hierarchies, low-status children direct positive behaviors to their higher status peers, evidently without reciprocation (Strayer & Trudel 1984). Children with good communication skills are likely to be particularly popular (Asher & Renshaw 1981; Gottman et al. 1975; Putallaz & Gottman 1981), whereas children with speech and language disorders tend to be unpopular and lonely, and may even be victimized (Blood & Blood 2004; Conti-Ramsden & Botting 2004; Davis et al. 2002). Children with pragmatic or higher-level language processing disorders are at risk of serious peer interaction problems (Botting & Conti-Ramsden 2000), and similar problems may arise in later stages of development (Place & Becker 1991). Significantly, patterns of friendship and rejection in childhood set up modes of relating that frequently persist through succeeding stages into adulthood (Kohlberg et al. 1972).

In what has come to be known as the "five to seven year shift" (Sameroff & Haith 1996), new learning and behavioral capabilities emerge, and these enable greater social independence (Bogin 1999a). Walking becomes adult-like by age seven years (Bogin 1999b). Cognitive and emotional developments permit new levels of self-sufficiency (Tomasello & Call 1997). Seven-year-olds can perform many basic tasks, including food preparation, infant care, and other domestic tasks, with little or no supervision (Rogoff 1996; Weisner 1996). The nonlinguistic traits associated with human childhood therefore include:

1. slow and steady rate of body growth and relatively small body size
2. large, fast-growing brain
3. higher resting metabolic rate than any other mammalian species
4. immature dentition
5. dependence on older people for care and feeding
6. motor and cognitive advances.

No other mammalian species has this entire suite of features, or a developmental period that is comparable to childhood.

2.4. Child language

Some structural developments that begin in infancy continue into childhood, with consequences that affect speech and language. One qualitative change involves the relationship between pharynx height and oral cavity length, which changes from birth until six to eight years, when it reaches, and stabilizes at, the (1:1) ratio that permits adult vowel production (Fitch & Giedd 1999; Lieberman et al. 2001). A second, quantitative change is a decrease in the rate of brain growth by weight. During childhood, there are continuing improvements in phonology, vocabulary, and sentence length (cf. Berko Gleason 2001), as well as syntax (Clark et al. 1986; Karmiloff-Smith 1985).

As childhood draws to an end, a discontinuity in native language learning occurs. Languages acquired after the age of six are often produced with an accent that reflects interference from previously learned languages (Asher & Garcia 1969; Flege & Fletcher 1992). In large epidemiological samples of Midwestern American children, six years of age was also treated as the approximate age of native language mastery, based on standardized tests that are oriented to school performance (Shriberg et al. 1999; Tomblin et al. 1996; 1997).⁴ Thus, in one modern society much of the childhood period is deemed necessary to master the basic structure and elementary vocabulary of a knowledge-based linguistic system. We will see later that if language is delayed at this age, there are likely to be continuing problems in juvenility, adolescence, and adulthood, though these may have less to do with linguistic knowledge than later emerging capabilities in the area of vocal and verbal expression.

But there is more to be accomplished in childhood. One advance involves verbal fluency, which continues to improve throughout this stage (Starkweather 1987). Another development relates to automaticity. If something goes wrong with the sensory system that guides ambient learning during childhood, there is likely to be significant deterioration of speech. Clinical studies indicate that all of childhood is needed to achieve a speaking ability that can tolerate the discontinued stimulation entailed by acquired deafness (Binnie et al. 1982; Cowie & Douglas-Cowie 1983; Plant 1984; Waldstein 1990). Deafness in later life stages poses less of a threat to speech.

Some of the communicative skills arising in childhood do so in tandem with certain cognitive advances. One such development is the “theory of other minds,” which typically emerges between ages two and four years (Baron-Cohen et al. 1993), enabling children to take the perspective of others. Another is an improvement in autobiographical memory, which usually occurs between ages three and eight years (Nelson 1996), allowing children to describe sequential events and to share memories of their own experience. Other skills that improve during childhood include discourse and narration (Girolametto et al. 2001).

Some of the developments that occur in childhood relate to verbal competition and performance. These include joking (McGhee 1979; Shultz & Horibe 1974) and the use of preassembled verbal routines (Gleason & Weintraub 1976). In many cultures, children play verbal games with peers using material learned from family members earlier in infancy, or from unrelated children

and juveniles later on. These games mark the beginning of various sorts of verbal competition (Gossen 1976a; 1976b; Sanches & Kirshenblatt-Gimblett 1976). They also point to a disposition toward verbal creativity that, we will suggest, may have played a key role in the evolution of language (see sect. 3.4).

During childhood, there is a trend for males to speak assertively to get and maintain attention and to make evident their desires, and for girls to speak softly in order to promote interpersonal closeness and harmony (Austin et al. 1987; Cook et al. 1985; Miller et al. 1986; Sachs 1987). The linguistic acquisitions of infancy are thus joined by factors in childhood, and succeeding stages, that influence mode of expression and facilitate development of vocal and verbal skills (Dundes et al. 1970; Gossen 1976b; Sherzer 2002).

Since it begins with weaning, childhood would also have liberated the young from continuous maternal restraint. The freedom of irresponsible progeny to range unsupervised over greater distances elevated the need for parents to warn and instruct, giving them and other kin selfish reasons to send honest signals (see sect. 3.5). But childhood also put the young in a position, for the first time, to know about, and thus to convey information about, events occurring in the absence of others. Therefore, we also suggest that childhood handed children and their extended families a key ingredient of human language – displacement – in the form of new opportunities, and needs, to talk about things not immediately present (Hockett 1977).

Other advances in maturation, learning, and consolidation are necessary for the young to speak informatively, attractively, and persuasively, and hence, competitively. If in evolution, as now, these developments occurred during a stage that follows childhood, communicative ability in *preceding* stages would have been relevant. We propose that individuals with longer intervals between infancy and adolescence would have had more opportunity to improvise and learn vocal material, and any rules of deployment. Selection for vocal ability and, ultimately, for language, would thus have worked reciprocally to extend childhood.

2.5. Stage 3: Juvenility

Juvenility is the next stage of human development. In mammals generally and primates particularly, juveniles are sexually immature but independent of others for survival (Pereira 1993; Pereira & Altmann 1985). It is not unusual in traditional human societies for juveniles to find much of their own food, avoid predators, and compete with adults for food and space (Blurton Jones 1993; Weisner 1987). The beginning of human juvenility is marked by adrenarche and, in some juveniles, a progressive increase in the secretion of adrenal androgens. These hormones may launch the growth of axillary and pubic hair. The physical changes induced by adrenarche are accompanied by cognitive and social advances, and there are sexually dimorphic vocal changes during this stage as well (Wuyts et al. 2003).

In juvenility, rate of growth declines once again, giving this stage the slowest growth rate since infancy (Fig. 1). Frequently, the decline follows a mid-growth spurt, in

those children who experience it, but the rate of growth declines even in children without a detectable spurt. The cause of this decrease in growth rate is unknown, but Janson and van Schaik (1993) have proposed several benefits. The first is that it provides additional time for the brain growth and learning required for reproductive success in various species of social mammals. Social carnivores, elephants, and primates must all learn how to live within the social hierarchy of the group. Juvenility also offers opportunities to learn complex feeding skills such as how to hunt, how to open fruits or seeds with protective coverings, and where and when to find food. Reproductive skills must also be learned, including ways to compete for mates and care for offspring. Joffe (1997) has reported positive correlations between the length of juvenility and both group size and the volume of social areas of the brain.

Janson and van Schaik (1993) also proposed that slower growth reduces feeding competition and maintains a smaller body, which is less threatening to adults. Growing up in a social group that is composed of individuals of different ages and social status can be difficult. This is especially true for juveniles who must compete with older, more experienced, individuals for food, space, and other resources. Fortunately, their relatively small and slowly growing bodies require less food than adult bodies, and may also afford them some protection from adult competition and attack as they present a non-threatening juvenile morphology.

In humans, the decline of growth rate bottoms out at about age 10 years in girls, two years before it does so in males, and this marks the end of the juvenile stage. As for the function of juvenility, it seems reasonable to suppose that in humans, like the other primates, this stage offers opportunities to prepare for the social complexities of adolescence, as well as adulthood. We propose that juvenility also provides the young with chances to learn and perfect skills associated with the social, pragmatic, and performative uses of language.

2.6. Juvenile language

Coates (1986) has pointed out that, for all the advances occurring in childhood, “a knowledge of grammar, phonology and [the] lexicon is not enough – it does not make the child competent; children need to master not only the formal rules of language, but also rules for the appropriate use of language” (p. 121). To be sure, juvenility accommodates additional syntactic advances (cf. Nippold 1998), with some English forms continuing to emerge in early adulthood (Marchman et al. 1991), but many of the new developments affect performance. These include an increase in speech-breathing capacity (Engstrom et al. 1956; Hoit et al. 1990) and further increases in fluency (Starkweather 1987). Prior to the adolescent “voice break,” there are anatomical changes that affect the ratio of the fundamental frequency to the ratio of higher formant frequencies (Sachs et al. 1973; also see Austin & Leeper 1975; Vuorenkoski et al. 1978).

There are changes, too, that occur beyond the sentence level, in the quality of extended discourse and narratives (Bamberg 1987; Burleson 1982; Karmiloff-Smith 1985). These pragmatic advances facilitate a variety of socially relevant activities, from gossip to storytelling, and contribute to successful competition and courtship in the run

up to sexual maturity. In Turkey, boys engage in verbal duels – ritualistic insults and replies that require “skill in remembering and selecting appropriate retorts to provocative insults” (Dundes et al. 1970, p. 135). These duels occur primarily from ages 8 to 14 years, effectively bridging juvenility and adolescence.

In one sense, juvenility is analogous to infancy. Whereas the linguistic knowledge and structure gained in infancy will help to satisfy the informational needs of childhood, juvenility provides opportunities to achieve the persuasive and attractive use of speech, and the ability to fluently manipulate elaborate and socially appropriate utterances, that will be valued in adolescence.

2.7. Stage 4: Adolescence

In humans, uniquely, there is a distinct skeletal growth spurt in both sexes and in almost all skeletal elements of the body after several years of gently decreasing juvenile growth. The onset of this spurt, along with puberty or gonadarche (an event of the neuroendocrine system) marks the onset of adolescence (Bogin 1999b). Neuroendocrinological changes differentially affect the vocal tract and fundamental frequency of the two sexes, females revealing negligible changes, males displaying a significant increase in tract length and decrease in frequency, with further drops in the transition from adolescence to adulthood (Fitch & Giedd 1999; Lieberman et al. 2001; Pedersen et al. 1986; 1990; Vuorenkoski et al. 1978). The critical variable is testosterone, which increases the length and mass of the vocal folds, lowers the fundamental frequency, and alters the vibratory characteristics of the vocal folds (Abitol et al. 1999; Beckford et al. 1985; Titze 1989).

Development of other secondary sexual characteristics and a growth spurt in height and weight also occur in adolescence. These physical changes are accompanied by intensification of preexisting friendships and the development of new relationships. The new affiliations, and membership in peer groups, facilitate intimacy and mutual support (Whitmire 2000). Adolescence ends with the attainment of adult stature and the biosocial skills needed for successful reproduction. This occurs, on average, at about 19 years of age in women and 21 to 25 years in men (Bogin 1999b; 2001).

It is significant that the secondary sexual development of boys and girls progresses differently through adolescence. Boys become fertile about two years after puberty and the onset of the adolescent growth spurt. At this time they still look like boys, as their body hair, stature, and muscularity are still juvenile in appearance. The peak of their growth spurt (called “peak height velocity,” or PHV) is still, on average, one year away, and patterns of body hair do not become adult-like for three years, with a muscle spurt and adult stature still four years away (about age 18 on average). Girls, in contrast, will have completed about half their breast and pubic hair development by the time of their PHV. Menarche occurs about a year after PHV. At this point in development, girls have the outward appearance of women, but they are not fertile. Development of an adult frequency of ovulation and adult size of the birth canal do not occur until approximately age 18 (Bogin 1999b).

Bogin (1999a; 1999b) has hypothesized that these sex-specific patterns of adolescent development confer

significant reproductive advantages on our species, partly by allowing adolescents to learn and practice adult economic, social, and sexual behaviors before reproducing. He noted that girls best learn their adult social roles while they are infertile but perceived by adults as mature, whereas boys best learn their adult social roles while they are sexually mature but not yet perceived as such by adults. The perception of fertility in girls allows them to enter the social-economic-sexual world of adult women, and to practice many skills without the risk of pregnancy. The hormonal status and fertility of adolescent boys primes them to attend to the social-economic-sexual world of adult men. As these boys are still juvenile in outward development, they can interact and learn from older adolescents and adults without seeming to compete for important resources, including women. The younger adolescent boy can “apprentice” to older adolescents and men, make mistakes that would be very costly to adults, and otherwise learn and practice skills that may be essential to adult survival and reproduction.

Without the adolescent growth spurt, and the sex-specific timing of maturation events that occur then, this unique style of social and cultural learning could not occur, but there is considerable variation in the ways adolescence is treated by individual cultures. Human adolescence is therefore best understood in terms of its biological underpinning and its cultural manifestations.

2.8. Adolescent language

In adolescence, there are further changes in linguistic communication in three broad areas. The first is linguistic content, including vocabulary, the more nuanced grammatical operations, and idiomatic phrases (Nippold & Taylor 2002), including slang. The second area of adolescent development involves delivery, including improvement in speaking rate and fluency. There is a huge increase in respiratory capacity at this stage, which may influence some aspects of speech and voice (Cook & Hamann 1961; Hoit et al. 1990). The third area involves a host of functions that begin to surface in childhood but flower in adolescence.

One such function is social talking, a predominantly relational use of speech in which the topic is frequently other people (Gottman & Mettetal 1986). This disposition to gossip steadily increases during adolescence, especially in females (Raffaelli & Duckett 1989; also see sect. 6), whereas the tendency to tease peers is more evident in males (see review in Eckert 2003). Other functions – several, like gossip, falling outside the area of pragmatics as usually defined – include joking, deceiving, mollifying, negotiating, and persuading, with increases in the use of sarcasm (McTear & Conti-Ramsden 1992; Nippold 1998; Paul 1995). These skills are not highly appraised by classroom teachers and language clinicians, who place a higher value on the logical expression of thought (Reed et al. 1998; Reed & Spicer 2003), but they facilitate achievement of two things that matter a great deal to adolescents and adults: status and relationships.⁵

This discussion of the emergence of grammatical and pragmatic functions should not distract us from a basic fact about the role of language in this stage of life. Adolescents do not merely learn additional linguistic features and practice new rules of usage. They also modify material learned in earlier stages, thereby changing aspects of

their native language (Eckert 1999; Labov 2001). Because adolescents are more parentally independent than ever, but still geographically limited, a strong local affiliation tends to influence their personal and social identity. An effective way to signal this affiliation and increasing autonomy is through linguistic markers, particularly phonetic and vocal ones. “The relatively high degree of phonological innovation in the adolescent age group,” wrote Eckert (1988), “is an indication that the development of adolescent social structure provides a major impetus for phonological change” (p. 197).

3. How did vocal-verbal behavior evolve?

Reports suggest that apes and monkeys do not vocalize as often as humans. Wild chimpanzees are silent much of the time (Gardner et al. 1989), evidently preferring the manual to the vocal modality (Tomasello et al. 1985; 1989). Trivers (1974) once commented that gorillas appeared to be “selected for silence.” By contrast, our own species is given to near-constant chatter in familiar social circumstances even when it appears that very little is being said (Locke 1998c). How – under what environmental pressures – did human sound-making capacities evolve?

3.1. Natural selection

To evolve, biological traits must offer a selective advantage, even if it is small and inconsistent, and this advantage will usually be linked to food, defense, reproduction, or some combination of these. Building on key contributions in evolutionary biology (Dawkins 1986; Maynard Smith 1969), Pinker and Bloom (1990) argued that natural selection is the only way to explain the origin of language and other complex abilities. In doing so, they said little about any role that selection might have played in development. But as Hogan (1988) has pointed out, natural selection “should operate at all stages of development, and not only on the adult outcome, since any developmental process that reduces the probability of reaching adulthood will be very strongly selected against” (p. 97). Hence, we begin this section with several new proposals relating to vocal and verbal selection as it may have operated in infancy and childhood.

3.2. Parental selection

With evolutionary changes that narrowed the female pelvis and deferred fetal brain development (sect. 2.1), infants’ need of care would have increased. As care requirements grew, conflict and competition between the infant and its parents would also have escalated. Responsibility for one solution, according to Trivers (1974), would have been borne largely, but not exclusively, by the infant – a behavioral change that included more effective use of care-elicitation signals, and possibly an improvement in the signals themselves.

The *parental selection* hypothesis proposes that some of the vocal ability presupposed by spoken languages emerged from infancy, having been asserted initially by hominin infants and supported by interactions with their parents (Locke 2006). According to the hypothesis, infants who issued more effective care-elicitation signals

(e.g., measured or strategic levels of cry) were better positioned to receive care than infants who issued stress vocalizations noxiously or inconsolably – behaviors that invite neglect and abuse in primates generally, and forecast language-learning problems in humans. The hypothesis also envisions that infants who cooed and babbled at appropriate intervals were more likely to engage with adults, to be liked by them, to receive more sophisticated forms of care as infancy progressed, and to generate and learn complex phonetic patterns. Infants who were able to monitor adult reactions to their behaviors (Chisolm 2003) would have been able to discover which vocalizations had the most beneficial effects, and thus could use structured vocalization to maximum effect.

It is also possible that syllabic and articulatory activity played a “decoupling” role (Oller 2004), making available for recombination the discrete movements, hence the phonetic segments, that make phonological systems possible (Studdert-Kennedy 1998; 2005; Studdert-Kennedy & Goldstein 2003). Further elaboration of vocal repertoires, we propose, would have occurred later in development under different pressures, potentially enhancing fitness in one or more of these stages, particularly adolescence.

3.3. Trickle-up phonetics

We have suggested that heightened dependency, and impending withdrawal of parental support, encouraged more complex and clever ways of vocalizing in infancy. It is plausible that some of these more sophisticated patterns of sound making trickled upwards.

While there is a disposition to think about infants as imitators of adult behavior, there is, in fact, a stronger tendency for *parents* to copy their infants (Uzgoris et al. 1989). One reason that they do this may be to control their infant’s attention. Meltzoff (1990) found that 14-month-olds attended to an adult if he precisely replicated the infants’ own actions, doing so far more frequently than when the adult performed unmatching actions. The infants’ motivation to attend may relate to the fact that contingent responding causes infants to smile, and may be innately pleasurable (Watson 1972; 2001). This arrangement – movements by infants and replications by adults – constitutes a dyadic system that the infants can control (Chisholm 2003).

Such effects are also demonstrable in the case of speech. Pawlby (1977) reported that at age 17 to 43 weeks, more than 90% of the phonetic matching in her study was attributable to mothers imitating their children; Pawlby commented 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).

These interactions can produce durable changes of adult speech, changes that we have termed “trickle up phonetics” (Locke 2004b). For example, in a number of disparate cultures, parents use specialized “baby words” (Ferguson 1964). The constituent consonantal sounds are primarily stops, nasals, and glides, frequently recurring, reduplicatively, with low vowels (Locke 1983). These items resemble the familiar forms of babbling, a behavior that is favorably regarded by parents (Bloom et al. 1993). Such standard lexical items as “mama” and “papa” further illustrate the strength of the tendency to

incorporate infant vocalizations into the adult lexicon (Jakobson 1960; Locke 1985).

Since Mivart (1871) and, later, Garstang (1922), it has been recognized that for a species to evolve, changes must occur in development (de Beer 1951/1958; Gottlieb 1992; Gould 1977; Northcutt 1990). This does not mean that the principal agent of change, or one of the principal agents, must itself be a developing infant or child, but that is exactly what we propose in the case of parental selection and trickle-up phonetics (see sect. 13).

3.4. Instinct for inventiveness

These cases, in which developmental changes appear to influence evolution, suggest that human infants and children may possess “instincts for inventiveness” (Marler 1991, p. 63). Marler was thinking about songbirds when he used that phrase, but it appears that when linguistically deprived children are exposed only to fragmentary symbolic behavior, whether in the form of vocal pidgins or manual gestures, they also improvise lexical material and grammatical structure (Bickerton 1984; Goldin-Meadow & Feldman 1977; Goldin-Meadow & Mylander 1998; Newport 1981; Senghas & Coppola 2001; Senghas et al. 2004). In effect, *they invent language*.

It could be argued, of course, that since *modern* children have all the genes required for language, their vocal and verbal creativity is a *product* of linguistic evolution. But there is evidence that other primate infants and juveniles also come up with creative solutions to environmental problems. These behaviors have included food washing in Japanese macaques (Kawai 1965; Kawamura 1959), food acquisition and social behavior in chimpanzees (Wrangham et al. 1996), and tool use in orangutans (van Schaik 2004). In the macaques, adult animals were later observed carrying out the same behaviors as the infants. Among the chimpanzees, behaviors originating with infants or juveniles tended to diffuse laterally, remaining at the subadult level. But if questions remain about transmission (Galef 1990; Hauser 1988), few seem to doubt the observation that new behaviors frequently originate in the young. One investigator has even raised the idea of a “critical period” for the development of a new skill (nut cracking) in chimpanzees (Matsuzawa 1996).

3.5. Mother tongues

At some point, of course, there had to be pressures not merely to improvise new and more complex signals but also to use them meaningfully, and this is the focus of a recent kin selection proposal by Fitch (2004; also see Brockway 2003, p. 120). Where it had been assumed that breeding was the sole means of gene transmission, kin selection theory proposes that individuals also pass along their genes by helping genetically related individuals on their way to reproductive success (Hamilton 1964), at least if the cost of doing so is not too great (Trivers 1974).

Fitch (2004) extended kin selection theory by proposing that parents benefit by preferentially communicating accurate information to their offspring. He reasoned that in hominin families there would have been a role for “cheap honesty” – the ability of parents to exchange accurate information with their offspring and with other kin who shared their genes. They could do this without significant cost or

effort, Fitch suggested, because speech is metabolically inexpensive. Systems of communication that evolved in the context of kin selection were labeled “mother tongues.”

The better-informed young, according to Fitch’s (2004) proposal, would be more likely to survive into adulthood, passing on to their own offspring genes associated with this improved system of communication. Although he took no position on *how* language evolved, his proposal does address *pressures* within kin groups to achieve some means of exchanging information. These arrangements would have broadened later, according to Fitch, to include genetically unrelated individuals, and elaborated to meet the requirements, and pressures, associated with information transmission.

We suggest, then, that the kin group provided a context in which it was advantageous to exchange information, and that infancy and childhood furnished raw vocal material that would have favored any system of spoken communication. But selection would have needed to operate in other stages if that material was ever to elaborate beyond some restricted core. The performative and creative nature of in-group verbal behavior in juvenility and adolescence suggests that these stages may have played an important role in the process.

3.6. Peer effects in adolescence

In section 2.8 we discussed the fact that adolescents not only manipulate language in new ways, but also revise it. In evolution, similar things may have occurred, whether in song or a more speech-like format, in response to the hormonal and social conditions that characterize the approach to sexual maturity. At the phonological level of language, changes, which frequently involve an increase in the complexity of articulation, serve to identify members of social groups (Labov 2001). Of significance to one of our major claims (see sect. 4.3), nonstandard forms tend to originate preferentially with males, doing so at some point between late juvenility and early adolescence (cf. Eckert 2003).

4. The social context of vocal-verbal evolution

We assume that at sexual maturity, vocal and verbal performances increased fitness by facilitating attainment of social rank and mating relationships, thereby improving access to associated benefits. Links between vocal and social factors may be found in arrangements bearing some resemblance to the contexts in which language evolved – oral societies. We turn our attention to these now, and then look at natural and sexual selection as they may have applied at adolescence.

4.1. Oral societies

Oral societies are of interest because they appear to resemble ancient and evolutionary societies more closely than do other extant groups (see Lee 1979b, p. 32), and may provide a clearer view of the initial benefits of vocal and verbal behavior in our species. Life in modern societies makes it difficult to think of the human capacity for verbal communication as anything but the ability to learn and use a linguistic code. This is largely because the prevailing definition of language, according to Linell

(1982), “is deeply influenced by a long tradition of analyzing only written language” (p. 1), a practice encouraged by “objectivist linguistics” (Lakoff & Johnson 1980). To witness what may be the vestiges of earlier effects, we will evaluate evidence from tribal and other oral cultures.

Fortunately, oral societies have been a popular target of anthropologists, who have noted a belief in the “magical” power of words (cf. Tambiah 1983). This power, and rhetorical force more generally, have been available to those who used an exceptionally broad range of words, and phrases that are “ornamented” by material from outside the more limited repertoires of their listeners (Abrahams 1970c; 1989; Garrett 1993; Sherzer 1990; Strathern 1971). Content has included archaic or esoteric language, metaphors, metonymy, formulas, riddles, and special prosodic patterns as well as over-learned phrases (e.g., Bauman 1975; Comaroff 1975; Gossen 1976a; Malinowski 1935). These devices have been witnessed in places as dispersed as Melanesia, Amazonia, Africa, and North America. Examples come from:

The Trobriand Islands of New Guinea, where Malinowski (1922) noted that lexical “power” was achieved through the use of “archaisms, mythical names and strange compounds, formed according to unusual linguistic rules” (p. 432).

Central Brazil, where the “plaza speech” of Suya Indians “has a special rhythm, sets of formulas, place of delivery [the center of the village plaza], and style of delivery” (Seeger 1981, p. 85). “The phonetic and rhythmic features of speech are altered, generally by exaggerating rhythms and stressing unstressed syllables. All plaza speech is also highly repetitive” (p. 186).

Amazonia (South America), where the Pa’ikwené people are considered “good speakers” based on their “grammatical, rhetorical, and performative competence and vocal quality,” as well as “the ethical and emotional weight of their words” (Passes 2004, p. 8).

Northern Transvaal, where the Venda people’s knowledge of words gives them a “magical power” that “is often sufficient to impress people, and it need have no practical application” (Blacking 1961, p. 4).

Certain neighborhoods of Philadelphia, where the verbal contests of African-Americans use language that is “different from the everyday language of the contestants” insofar as it includes “changes in pitch, stress, and sometimes syntax . . . formulaic patterns . . . rhyme within these patterns . . . and a change of speech rhythms . . .” (Abrahams 1970a, p. 50).

The primary effect of this sort of material, according to Bauman (1975), is that it “fixes the attention of the audience more strongly on the performer, binds the audience to the performer in a relationship of dependence that keeps them caught up in his display” (p. 295).⁶ Reliance on speech formulas will prove significant later, for nonliteral material – which also exists in modern languages in the form of idioms and metaphors – does not approach adult proficiency until late juvenility or early adolescence.

A second interesting property of oral societies is the “extraordinarily agonistic” nature of verbal performance. “Orality,” according to Ong (1982), “situates knowledge within a context of struggle. Proverbs and riddles are not

used simply to store knowledge, [...] but to engage others in verbal and intellectual combat: utterance of one proverb or riddle challenges hearers to top it with a more apposite or a contradictory one” (p. 44). Later we will revisit this “agonistic” property.

4.2. *Speech, attention, and power*

If there are links between speech and attention, as the anthropological literature suggests, then individuals may use speech as “an advertising device,” and “will compete with each other in eloquence to draw attention to themselves and to obtain status from the audience” (Dessalles 1998, p. 142). In many oral societies, speech and status, or power, go hand in hand. These societies are located in places as dispersed as:

New Zealand, where, among the Maori, “oratory is the prime qualification for entry into the power game” (Salmond 1975, p. 50).

Central Peru, where the Amuesha people “describe a true leader as . . . ‘the one who is powerful due to his or her words’” (Santos-Granero 1991, p. 301).

Ethiopia, where, among the Mursi, “the most frequently mentioned attribute of an influential man is his ability to speak well in public” (Turton 1975, p. 176).

Central Brazil, where “plaza speech, described as “a politically important act” (Seeger 1981, p. 185).

Northern Transvaal, where, among the Venda people, “The greatest honour seems to be accorded to those who can manipulate words and sentences” (Blacking 1961, p. 4).

The Trobriand Islands, where the tribal leaders, or “Big men,” have also been called “rhetoric thumpers” (Reay 1959).

South Africa, where the Tshidi people consider oratorical ability as “a significant component of political success and the means by which politicians demonstrate their acumen” (Comaroff 1975, p. 143).

Inner city neighborhoods of Philadelphia, where the African-American “man of words, the good talker, has an important place in the social structure of the group, not only in adolescence but throughout most of his life” (Abrahams 1970a, p. 44).

South America, where “Speaking is more than a privilege, it is a duty of the chief. It is to him that the mastery of words falls.” Throughout the continent, “It can be said not that the chief is a man who speaks, but that he who speaks is a chief” (Clastres 1987, p. 41).

This relationship between speech and power may be linked to a connection between speech and attention, one in which vocal loudness plays a role. “A great Maori orator,” wrote Salmond (1975), “jumps to his feet with a loud call and immediately dominates the speaking-ground” (p. 56). Among the Pa’ikwené, “good speaking” involves speech that is “strong in tone and volume . . . speaking loud-and-strong embodies a person’s health, strength, and, beyond that, humanness” (Passes 2004, p. 8).

The effect of vocal-verbal behavior on attention *and then* status is evident as early as childhood. In a classroom study of three- to six-year-old German kindergartners,

Hold-Cavell and Borsutzky (1986) found that glances were frequently preceded by speech, and that children who attracted attention to themselves by verbalizing early in the school year were far more likely than others to rank highly at the end of the year. In adulthood, individuals who speak in long sentences or hold the floor for long periods of time tend to receive more gazes than others, and to be perceived as unusually powerful (Abramovitch 1976; Bales et al. 1951; Dabbs & Ruback 1984; Exline et al. 1975; Kalma 1991; Kendon & Cook 1969; Mulac 1989).

4.3. *Verbal performance*

Verbal performances and competitions have been documented in oral cultures located, diversely, in Africa, Asia, South America, Mexico, and several different places in North America (Ayoub & Barnett 1965; Dundes et al. 1970; Faris 1966; Gossen 1976b). These performances take a number of forms – in African-American groups, for example, rapping, shucking and jiving, copping a plea, gripping, and sounding (once known as “playing the dozens”). Each of these forms “must be judged as performance art,” according to Abrahams (1970b), the evaluation based less on “the elements of the composition, such as complexity and originality,” than on its “spontaneity, virtuosity, and command” (p. 147).⁷ One also finds in anthropological literatures various references to the use of the *voice* without speech, whether in the songs of the Suya Indians of Brazil (Seeger 1981), the song challenges of the Fiji Indians (Brenneis & Padarath 1975), or the song duels or drum songs of Eskimos (Hoebel 1964; Mirsky 1937).

The social value of performative speech has been attested by African-American teenagers in Los Angeles. Folb (1980) interviewed a black teenage boy who said, “yo’ rap is your thing. I’s like your personality. Like you kin style on some dude by rappin’ better’n he do. Show’im up. Outdo him conversation-wise.” Folb commented, “Who you are (and very often how well you survive) depends . . . heavily on how well you talk.” Words, she said, “are tools for power and gain . . . a good rap can save your life” (p. 90). That rapping is more of a performance than a verbal exchange is suggested by the fact that African-American men in Chicago ghettos rap *to* rather than *with* their peers (Kochman 1969). Kochman found that rapping and the other verbal registers enable the speaker “to manipulate and control people and situations to give himself a winning edge” (p. 34).

It is of more than passing interest that many of the actors in traditional verbal performances *have been male*. For example:

Among the Limba people of Sierra Leone, “it is a specifically masculine quality to be able to ‘speak’ well” (Finnegan 1967, p. 70).

In an Ethiopian village studied by Turton (1975), public speaking was “a prerogative of adult males” (p. 170).

The orators in South Bali, according to Hobart (1975), were “usually adult men aged from thirty to sixty with reputations for their knowledge of law and persuasiveness as speakers” (p. 77).

Among the Kuna Indians of San Blas, Panama, Sherzer (1990) reported, “it is most often men who are the public performers of verbal art” (p. 3).

Among the Suyu Indians of Brazil, plaza speech “is spoken only by fully adult men, and one of its forms is spoken exclusively by chiefs and ritual specialists” (Seeger 1981, p. 85).

Among African-Americans in various parts of the United States, verbal competitions such as rapping and sounding have been carried out predominantly by males (Abrahams 1973; Ferris 1972; Wilson 1969). “Sounding,” according to Abrahams (1970a), “occurs only in crowds of boys” (p. 47).

The male domination of verbal performance in traditional societies has received little recognition. “It is an interesting feature of the scholarship in the field,” wrote Kuiper (1996), “that this fact is seldom commented on” (p. 87).

Verbal performances typically have an “audience,” which makes it possible for status to change following a verbal victory or defeat (Abrahams 1962; 1989; Mitchell-Kernan 1973). These audiences include women as well as men. Finnegan (1967) found that among the Limba people, “a woman is expected to sit and listen, clap to show her respect and appreciation, or join in the chorus of the songs” (p. 70). In Cat Harbour, a small fishing community in Newfoundland, Faris (1966) found that stories were typically told in local shops by men. The women of Cat Harbour “listen intently and inconspicuously to the conversations of the men,” wrote Faris (p. 239), using any new information later to engage other women in social interactions. Similar sexual divisions have been reported by other anthropologists (e.g., Salmond 1975).

Verbal contests tend to create distance between the participants. This frequently appeals to men, who typically place a high value on individualism and autonomy (Kashima et al. 1995). But women are more inclined toward collectivism and intimacy, and they tend to embrace more private forms of speech, ones that reduce the distance between interlocutors. We will see shortly (sect. 6) that there is a female advantage in privately oriented forms of social communication.

5. Natural selection in adolescence

We begin our treatment of natural selection in adolescence by discussing vocal and verbal behaviors that may have facilitated personal rank and social relationships – two critical features of primate societies (Dunbar 1996) – possibly by controlling attention (Locke 2000b).⁸ Most primate species live in rigidly structured groups, with a dominance hierarchy. Males typically earn their rank. Noting that socially dominant primates are usually the focus of subordinates’ attention, Chance claimed that it is the attention-holding ability of an animal that places it near the top of the hierarchy (Chance 1967; Chance & Jolly 1970). One anecdote suggests that sound-making attracts attention and *thereby* increases rank. Goodall (1998) described a subordinate chimpanzee that elevated his rank by frightening high-ranking animals, which he did by loudly banging kerosene cans together.

Primates may also elevate or announce their rank by vocalizing. In young vervet monkeys, high-ranking

individuals have been found to vocalize more frequently than those holding middle and lower ranks (Locke & Hauser 1999). In mature baboons, acoustic properties of the male’s voice (in “loud calls”) have been found to predict age, competitive ability, and stamina, as well as rank (Fischer et al. 2004; Kitchen et al. 2003). These data suggest that primates who listen to adult male vocalizations are likely to pick up important cues to fitness – and they do listen; Cheney and Seyfarth (2005b) refer to primates as “skilled voyeurs.” Primates also derive information about rank from calls made to males by *other* males. In studies of chimpanzees, alpha, high-ranking, and mid-ranking males were discriminable based on the frequency of occurrence of pant-grunts that were directed to them by lower-ranking males (Hayaki et al. 1989; Muller & Wrangham 2004).

If, in humans, status may be elevated by unusually elaborate and fluent uses of the voice, one would expect members of traditional societies to be keenly aware of individual differences in verbal proficiency. Gossen (1976b) found that among the Chamula people of Mexico, “the ability to wage a good verbal duel serves as one of the earliest signs of social maturity, intelligence and linguistic eloquence” (p. 141). Firth (1975) commented that in one traditional society, the Southwestern Pacific island of Tikopia, the people “are very conscious of great individual differences in speaking quality” (p. 41). Turton (1975) indicated that among the Mursi, “it seems to be popularly assumed that men either have or do not have the ability to speak well in public” (p. 177). Other work in Africa and elsewhere indicates that unusually good speakers and storytellers are not only distinguished from others, but honored in various ways, and that poor speakers are subjected to ridicule (Abrahams 1989; Finnegan 1967; Shostak 1981).

In the United States, Labov (1972; 1973) found that African-Americans’ use of the black vernacular, including non-standard or within-group forms, reaches a peak at ages 9 to 18 years – that is, in the juvenile and adolescent periods. Those with poor control of the vernacular are known as “lames.” Lames lack the ability to participate in toasts, jokes, and verbal competitions. According to Labov, they are forced to operate from outside the group.⁹

5.1. Sexual selection

Although Pinker and Bloom (1990) offered a spirited argument for the natural selection of language, there is no reason to think that they meant to exclude sexual selection – a distinct but related process (Andersson 1994; Harvey & Arnold 1982; Mayr 1972), which was originally proposed for language by Darwin (1879/2004, pp. 109–110). Sexual selection takes two forms: an epigamic variant that involves traits appealing to the opposite sex, and an intrasexual form that involves traits advantageous in competitions among members of the same sex (M. E. Hamilton 1985). It is likely that both forms of sexual selection contributed to the elaboration of vocal and verbal behavior in the hominin line.

In early stages of linguistic evolution, it seems reasonable to suppose that sexually mature individuals benefited from some level of control over, and appreciation of, vocal behavior – later from more heavily articulated vocalization and verbalization – and that displays in this modality may have been performed more commonly by

males, since it is generally the case, across the animal kingdom, that females choose their mates on the basis of perceptible traits (Andersson 1994; Mealey 2000), presumably because they have more to lose if they make a bad choice (Trivers 1972). Accordingly, several scholars have sought support for a sexual selection hypothesis, but not without disappointment (e.g., Fitch 2004; Miller 2000), since the literature, read uncritically, has suggested that males perform *worse* than females on a variety of verbal tests, doing so across the lifespan, beginning in the early stages of language development (Fenson et al. 1994; Huttenlocher et al. 1991; Lutchmaya et al. 2002; Morisset et al. 1995). A more comprehensive review of developmental studies, however, indicates that boys soon catch up with girls (Baron-Cohen et al. 2004); and a closer inspection of the tests that are administered to older children and adults reveals carefully timed, verbally instructed measures of anagram ability, vocabulary, verbal memory, word association, and reading comprehension (Hines 1990; Kimura 2002; Maccoby & Jacklin 1974). The requisite skills are not displayed spontaneously and vibrantly in public before an audience of responsive peers, but quietly and obediently in the seclusion of test rooms, typically with a paper and pencil.

Even on these tests, the female advantage has been negligible; in their meta-analysis of 165 studies, Hyde and Linn (1988) call the gender difference “so small that it can effectively be considered to be zero” (p. 64). But where, one might ask, is the *male advantage that biologists have come to expect*? If it exists, male superiority would be found in vocal or verbal skills that are indicative of fitness. One would expect these to be observable in the *public use* of language by adolescents and young adults, and this is where they are witnessed. Consistent with a sexual selection hypothesis, anthropological research, as we have seen, reveals that performative applications of language in the form of speech and voice *consistently favor males*.

Did performative ability increase fitness? Miller (2000) has argued that sexual selection shaped human language directly (epigamically), through mate choice, and indirectly, through its effects on social status.

Verbal courtship can be viewed narrowly as face-to-face flirtation, or broadly as anything we say in public that might increase our social status or personal attractiveness in the eyes of potential mates. Sexual flirtation during early courtship accounts for only a small percentage of language use, but it is the percentage with the most important evolutionary effects. This is the time when the most important reproductive decisions are made, when individuals are accepted or rejected as sexual partners on the basis of what they say. (Miller 2000, pp. 356–57)

Spoken language may also have played a role in sexual selection outside of courtship (introsexually) by publicizing various male qualities. It was through public speaking and debate, according to Miller, that individuals were able to

advertise their knowledge, clear thinking, social tact, good judgment, wit, experience, morality, imagination, and self-confidence. Under Pleistocene conditions, the sexual incentives for advertising such qualities would have persisted throughout adult life, in almost every social situation. Language put minds on public display, where sexual choice could see them clearly for the first time in evolutionary history. (Miller 2000, p. 357)

We agree that “language” helped to exhibit these qualities, but it could not have done so without the

assistance of a powerful accomplice, one whose action has escaped the notice of most theoreticians. It was speech. Although speech is often thought of as little more than a system for transmitting linguistically encoded information, it has qualities of its own, qualities that attract attention. Without attention there will be few listeners, and little exposure to the individual’s language and mind. In the case of speech, unlike language, there are clear and consistent differences between males and females.

6. Sex effects in speech

We have witnessed a strong trend for verbal performances to be carried out by adolescents and adults who are male. At these same stages, however, females are more likely to engage in intimate talk, especially talk that includes self-disclosure (Derlega et al. 1993; Morton 1978), whether in traditional or modern societies.

As we saw earlier, the disposition to gossip – that is, to disclose information about others – also increases during adolescence, especially in females. Studies of women across two educational levels, several different cultures, and eight decades in the twentieth century agree that adult women are also more likely to gossip than men (Bischoping 1993; also see Locke 2005). The reason may have to do with the fact that gossip serves an affiliative function (Emler 2001), and that females tend to come together in times of stress (Taylor et al. 2000). In England, gossip networks have existed for at least five hundred years (Capp 2003). Membership in such networks is required for mutual aid, and the cost of membership is willingness to gossip. The rules are simple, according to a report on modern English networks: “no gossip, no companionship” (Bott 1971).¹⁰

Although sex differences in speaking are frequently attributed to culture (Mey 1985), the patterns identified here cut across cultures. The adolescent male attraction to verbal dueling may also be supported by physiological factors. Consider the widely attested association between testosterone and physical aggression (Dabbs 2000). Since adolescent males, who have relatively high levels of testosterone, need ways to avoid hurting themselves, it may be adaptive for them to use verbal sport and humor in place of combat (Marsh 1978). Consistent with this possibility is the fact that verbal duelists always “lose,” and the contests are always stopped, if the participants become angry (Kochman 1969; 1983). Therefore, we speculate that testosterone promotes verbal dueling (see the reference to trial lawyers in sect. 8).¹¹

When adolescent females wish to aggress against another member of their sex, they frequently use gossip to enlist the support of peers, greatly surpassing males in this practice. Like males’ involvement in public performances, this difference between the sexes surfaces in late juvenility, spans a number of different cultures, and continues through adolescence into adulthood (Björkqvist et al. 1992a; 1992b; 1994; Burbank 1994; also see Crick & Bigbee 1998; Galen & Underwood 1997).

Private disclosures bear little resemblance to public taunts, but their functions are similar. In gossip as well as rap, verbal skill is used to raise one’s own status, and to lower that of competitors, while also broadcasting and enforcing community standards (Abrahams 1973). These

sex differences betray dissociations between language and speech, for, approaching maturity, males and females have roughly the same knowledge of the structure and “contents” of language but deploy that knowledge, through speech, in different ways.¹² In males, moreover, speech appears to play a role in courtship.

7. Courtship

If women deliver their first infant at age 19 but usually become fertile one to two years earlier, as cross-cultural evidence indicates (Bogin 2001), it is necessary to ask what the vocal-verbal behavior of courting males is like during the intervening or preceding period. For it is at this time that females are likely to make a choice.

That the voice may play a role in courtship is suggested by some research in nonhuman primates. Among baboons, for example, there is evidence that males who issue quiet grunts when approaching females are more likely to achieve affiliation than those who approach without vocalizing (Palombit et al. 1999). In humans, Anolli and Ciceri (2002) found that successful (Italian) seducers began addressing their female targets with unusual levels of loudness, “orotundity” having been found in other work on male vocalization to evoke perceptions termed “energetic,” “healthy,” and “interesting,” along with several other attractive qualities (Addington 1968). Then, as the conversation proceeded, the men lowered their vocal intensity and frequency, later returning to initial levels of loudness, and a faster rate of articulation – a variable associated with perceived competence and influence (Ray 1986; Scherer 1979; Smith et al. 1975) – by the end of the interaction.¹³

There is also some anthropological evidence on the role of vocal and verbal behavior in courtship, much of it from the African-American community. The male teenager who extolled rap’s benefits (see sect. 4.3) went on to say, “you can rap to a young lady, you tryin’ to impress her, catch her action – you know – get wid her sex-wise” (Folb 1980, p. 91). Hannerz (1969), who studied rap in Washington, D.C., wrote that “A good line can attract the attention of a woman who passes by in the street and open the way to a new conquest, while at the same time it may impress other men with one’s way with women” (p. 84; also see Kochman 1969). In Philadelphia, according to Abrahams (1970a), words “function powerfully in the sexual battle which is typical of adolescent life” (p. 44).

For speech to figure into courtship, of course, females must also have a corresponding perceptual preference for the speech of courting males (Endler & Basolo 1998; Fisher 1930; Harvey & Arnold 1982). A teenage girl from the same neighborhood as the rapper quoted above said, “I likes to hear a brother who knows how to talk. Don’ hafta blow heavy, can sweet talk you too. Don’ hafta make whole buncha sense, long sounds pretty” (Folb 1980, p. 101).

If females are to evaluate the verbal or vocal qualities of courting males, as Miller (2000) suggested, they need to hear them speak. Males seem only too happy to provide opportunities. When men and women speak, men interrupt more often and hold the floor longer than women, even though females typically speak more often than men when engaged in same-sex conversations (Frances

1979; James & Drakich 1993; Simkins-Bullock & Wildman 1991).

But do women just wait for vocal or verbal cues to fitness, or do they do something more actively? If women choose mates based, in part, on the way they talk, it would not be surprising if they attempted to elicit speech from male suitors (cf. Fisher 1930, p. 152). Ethological research suggests that several behaviors, including female head nodding, smiling, and reclining, may function as displays whose effect is to encourage males to speak (Grammer et al. 2000; Kennedy & Camden 1983), thus to reveal information about their vocal and linguistic skills, along with social, cognitive, and other abilities.

Clearly, a great deal more needs to be learned about the role of verbal behavior in courtship. In the meantime, clues to the role of verbal behavior in courtship emerge from the case of vocal or verbal *deficits*. Studies have consistently observed negative social reactions to speech and voice disorders, regardless of whether the listeners were peers or adults, and the errors were real or faked, or very mild (Crowe Hall 1991; DeThorne & Watkins 2001; Freeby & Madison 1989; Lass et al. 1991a; 1991b; Mowrer et al. 1978; Ruscello et al. 1988; Silverman 1976; Silverman & Paulus 1989). If this finding is taken with the fact that many children with language disorders present, in adolescence, with articulatory as well as pragmatic and performative limitations (see sects. 10 and 11), there would seem to be plenty of raw material for a courtship problem. For, adolescents who cannot produce verbally complex material in a timely fashion, and with appropriate prosody, may be unable to impress, amuse, or dominate in the quest for status or reproductive advantage.

Such would seem to be the case with stutterers, who usually have normal knowledge of language but speak disfluently. Interviews indicate that stutterers, who are predominantly male, fear and avoid courtship situations (Sampson et al. 2003) and have difficulty forming and maintaining intimate relationships (Linn & Caruso 1998). Women, for their part, discover that if they marry a stutterer their social life will be greatly limited (Boberg & Boberg 1990). In a survey of attitudes toward individuals with handicaps, only 7% of respondents said they would be willing to marry a severe stutterer (Shears & Jensen 1969).

8. Reproductive advantage

If speech and language problems can compromise courtship, do they reduce sexual opportunities? Recently, a longitudinal investigation was reported in which individuals with language disorders in childhood were seen again in their mid-twenties. It was found that well over half of the subjects had problems in establishing spontaneous, reciprocal relationships. More than one-third of the subjects had no particular friends and two-thirds had never had sexual intercourse – a marked deficiency compared to statistics on comparably aged members of the population at large. Two-thirds also continued to live at home with their parents (Howlin et al. 2000).

Were evolutionary ancestors with conspicuous vocal and verbal talent reproductively advantaged? It may be worth revisiting two relationships of the sort that undergird competitive and performative applications of speech.

In the first, men who speak in a way that secures attention are also likely to be high in dominance, as we saw in section 4.2. The second relationship is between the attractive or forceful use of speech and testosterone. Testosterone is correlated with, and may increase, the boldness with which individuals enter a room, and the tendency to work in public arenas, such as the theatrical stage or courtroom. Actors generally display high levels of testosterone (Dabbs et al. 1990; 2001), and trial lawyers have 30% more testosterone than other types of lawyers (Dabbs et al. 1998).

The more specific link to speech is that trial lawyers, as Philbrick (1949) wrote, “exercise their power in court by manipulating the thoughts and opinions of others” (p. v). They are, according to Dabbs and his colleagues, “good at presenting concrete details in a straight-talking and compelling way that dramatically captures the attention of a jury in trial court” (Dabbs et al. 1998, p. 91). There are obvious similarities between trial lawyers and the “Big men” of traditional societies. In 1984, there were 3,827 members of the American Association of Trial Lawyers. Men comprised 99.9% of the membership (Walter 1988), which is nearly 20% more males than worked as primary care physicians in the following year (Franks & Bertakis 2003).¹⁴ This research suggests that women who are attracted to men with a commanding way of speaking may get a mate for themselves, and father for their children, who has high levels of testosterone and status, and unusual access to valued resources.

There are other, more specific connections between aspects of the male voice and several indices of fitness. These include links between depth of vocal frequency and both testosterone (Dabbs & Mallinger 1999; Pedersen et al. 1986) and testis volume (Harries et al. 1997), where testosterone levels independently predict coital frequency (Halpern et al. 1993; 1998; Udry 1988), social expressivity (Dabbs & Ruback 1988), and social dominance (Schaal et al. 1996). Reduced formant dispersion is also correlated with skull and body size in primates, the magnitude being greater in macaques (Fitch 1997) than in humans (González 2004). It is thus unsurprising that our adaptive ancestors availed themselves of this particular medium, which could broadcast fitness information while simultaneously transmitting the units of language, to say nothing of the social, indexical, and emotional information that would have been embedded therein (Cheney & Seyfarth 2005b). Recently, it was reported that in *both* men and women, opposite-sex ratings of vocal attractiveness predicted age of first sexual intercourse, number of sexual partners, number of competing sexual relationships, and number of partners that were involved in other sexual relationships (Hughes et al. 2004). The authors concluded that “voice may have been an important parameter of mate choice” in human evolution (Hughes et al. 2004, p. 303).

In the previous sections, we identified several different forms of selection that may have applied across the whole of development, from infancy to sexual maturity, including the uniquely human stages of childhood and adolescence. Our goal in doing so was to offer an evolutionary account of our species’ capacity to improvise, learn, and control complex vocalizations. It is appropriate now that we examine the evolution of the new stages themselves.

9. Evolution of the new stages

We have proposed that when childhood expanded, new opportunities arose, especially within families, for the negotiation of more structured and complex forms of vocalization; and that with a premium in this context on honest signaling, benefits would have accrued to families that were able to deploy these more complex forms meaningfully, and thus to warn, advise, and inform each other. We have further proposed that this material, arising from infancy and expanding in childhood, persisted into juvenility when it contributed to teasing, joking, and gossip in both sexes, behaviors that would have facilitated achievement of group-oriented goals; as well as into adolescence, when performative skills contributed to intra-sexual competition and epigamic selection, reinforcing all previous developments on which those skills depend.

We have proposed relationships between language, a trait unique to humans, and two ontogenetic stages that are also unique to humans. To understand the evolution of language, therefore, we believe it may be necessary to ask how and when these stages came to exist, and this we attempt to do here. In succeeding sections, we look at evidence for developmental continuity between the levels of language, and interconnections between language and the rules and skills that influence its use, offering speculation on how these conjunctions may have come about.

It is obviously difficult to reconstruct the evolution of life history stages from fossil remains alone. Fortunately, it is possible to draw relevant inferences from syntheses of comparative anatomical, physiological, and ethological data, and from archaeological findings. This work is facilitated by parametric data on the brain and body growth of nonhuman primates, as well as of humans and their ancestors (cf. Harvey & Clutton-Brock 1985; Harvey et al. 1987; Martin 1983).

9.1. Evolution of childhood

With an ontogenetic approach to linguistic evolution, structures other than the skull become important. For example, teeth and jaws are useful because of the strong correlation between tooth formation and eruption and other life history events (Smith & Tompkins 1995). Figure 3 is an attempt to represent the evolution of human development, though at present the only reliable data are associated with *Pan* and *H. sapiens*. Known or estimated adult brain sizes are given at the top of each bar. Mean age at eruption of the first permanent molar (M1) is graphed across the histograms, and identified numerically at the base (Smith & Tompkins 1995).

Appearing about 3.9 million years ago, *Australopithecus afarensis* shares many anatomical features with non-hominin pongid (ape) species, including an adult brain size of about 400 cc and a pattern of dental development indistinguishable from extant chimpanzees (Conroy & Vannier 1991; Dean et al. 2001; Simons 1989; Smith 1991). Therefore, the chimpanzee and *A. afarensis* are depicted as sharing the typical tripartite stages of postnatal growth of social mammals: infancy, juvenility, and adulthood (Pereira & Fairbanks 1993). Following the definitions offered earlier, infancy represents the period of feeding by lactation, juvenility represents a period of feeding independence prior to sexual maturation, and

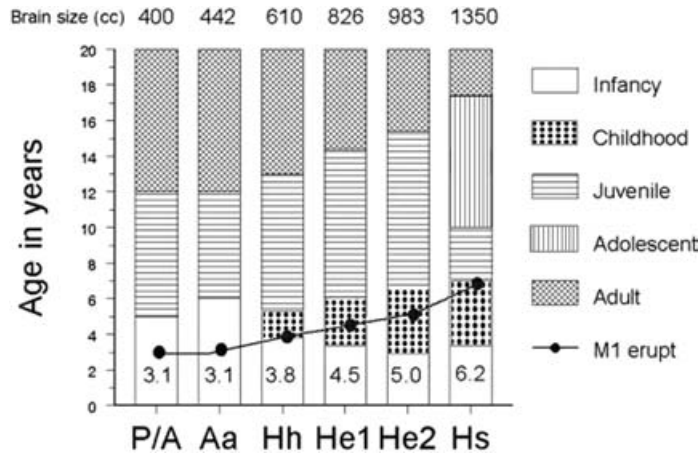


Figure 3. The evolution of hominin life history during the first 20 years of life (original figure from Bogin 1999b; see the text for additional sources of data). P/A = Pan and *Australopithecus afarensis*; Aa = *Australopithecus africanus*; Hh = *Homo habilis*; He1 = early *Homo erectus*; He2 = late *Homo erectus*; Hs = *Homo sapiens*. Mean brain sizes are given at the top of each histogram (calculated from several sources; e.g., Relethford 2006). Mean age at eruption of the first permanent molar (M1) is graphed across the histograms, and identified numerically at the base (Smith & Tompkins 1995).

adulthood begins following puberty and sexual maturation. The duration of each stage and the age at which each stage ends are based on empirical data for chimpanzees. A probable descendent of *A. afarensis* is the fossil species *A. africanus*, dating from about three million years ago. Achievement of the larger adult brain size of *A. africanus* (average of 442 cc) may have required an addition to the length of the fetal and/or infancy periods. Figure 3 depicts a one-year extension of infancy.

As the figure indicates, the first permanent molar (M1) of the chimpanzee erupts at age 3.1 years, even though infancy continues for nearly two more years. Before age 5 years, young chimpanzees are dependent on the mother and will not survive if she dies or becomes unable to provide care and food (Goodall 1983; Nishida et al. 1990). After the eruption of M1, they may be able to manage an adult diet but still must learn how to find and process foods, and it takes time to learn how to open shelled fruits and extract insects from nests. This may be why chimpanzees extend infancy beyond the eruption of M1. It is likely that early hominins, such as *A. afarensis* and *A. africanus*, followed a pattern of growth and development very similar to chimpanzees and also extended infancy for at least one year beyond the age of M1 eruption. Analyses of postcranial anatomy and archaeological records suggest a similarity between the behavioral capacities of australopithecine-grade hominins and extant chimpanzees (Plummer 2004; Potts 1988).

Tardieu (1998) has shown that the pattern of femur growth in *H. habilis* departed from that of the australopithecines but resembled the pattern seen in later hominins. The distinctive femur shape of the more recent hominins, she suggests, is due to a prolongation of childhood stage of growth. Thus, we speculate that the process of linguistic evolution took a step forward about two million years ago with the elongation of childhood. Others have made a similar suggestion, although they were acting on the assumption that the critical variable was enlargement of the adult brain (e.g., Mithen 1996).

A childhood stage for the earliest members of the genus *Homo* is also supported by a comparison of human and ape

reproductive strategies. There are limits to the delay between birth and sexual maturity, and between successful births, that any species can tolerate. Among wild chimpanzees, for example, females reach menarche at 11 to 12 years of age and have their first births at an average age of 14. The average period between successful births in the wild is 5.6 years, as infant chimpanzees are dependent on their mothers for about five years. Actuarial data collected on wild-living animals indicate that 35–38% of all live-born chimpanzees survive to their mid-20s. The chimpanzee thus operates at reproductive threshold.¹⁵

The great apes and fossil hominins, such as *Australopithecus*, may have created this demographic dilemma by forestalling weaning. We suggest that early *Homo* overcame this reproductive limit by reducing the length of infancy and inserting childhood between infancy and juvenility. Free from the demands of nursing and the physiological brake that frequent nursing places upon ovulation, mothers could reproduce soon after their progeny reached childhood, and indeed this is what happens in modern humans. Among the Ju/'hoasi, a traditional hunting and gathering society of southern Africa, a woman's age at first birth averages 19 years. Births continue, on average, every 3.6 years, resulting in a fertility rate of 4.7 children per woman (Howell 1979; Short 1976). Among the Hadza, the inter-birth interval is even shorter, as women stop nursing about one year earlier, and average 6.15 births per woman (Blurton Jones et al. 1992).

A brief childhood stage for *H. habilis* is therefore indicated in Figure 3. This stage begins after the eruption of M1 and lasts for about one year. Even one year of childhood would have provided reproductive advantages to the mother. A behavioral consequence of reproductive selection for childhood may have accrued to the child, that is, learning how to find and process adult types of foods while still protected by older individuals. During this learning phase, *H. habilis* children would need to be supplied with special weaning foods. There is archaeological evidence for just such a scenario. *H. habilis* seems to have intensified its dependence on stone tools. For, there are more stone tools, more carefully manufactured

tools, and a greater diversity of stone tool types associated with *H. habilis* than with any earlier hominins (Klein 1989). There is considerable evidence that some of these tools were used to scavenge animal carcasses, especially to break open long bones and extract bone marrow (Plummer 2004; Potts 1988). This behavior may be interpreted as a strategy to feed children. Such scavenging may have been needed to provide the essential amino acids, some of the minerals, and, especially, the fat (dense source of energy) that children require for growth of the brain and body (Leonard & Robertson 1992; Leonard et al. 2003).

A further increase in brain size occurred during the time of *H. erectus*, which began about 1.9 million years ago. The earliest adult specimens have mean brain sizes of 826 cc, but many individual adults had brain sizes between 840 and 1059 cc (Coqueugnoit et al. 2004). Insertion or expansion of childhood would have provided the time needed for a rapid, human-like, pattern of postnatal brain growth.¹⁶

It should be noted in Figure 3 that the model of human evolution proposed here predicts that from *Australopithecus* to *H. erectus* infancy shrinks as childhood expands. In the time of early *H. erectus* the transition from infancy to childhood took place before M1 eruption. If the new childhood was stolen from infancy, or reduced its length, then *H. erectus* would have enjoyed a greater reproductive advantage than any previous hominin. This seems to have been the case, since *H. erectus* populations increased in size and began to spread throughout Africa and other regions of the Old World (Antón 2003).

Figure 3 also shows later *H. erectus*, with an average adult brain size of 983 cc and a further expansion of the childhood stage. In addition to larger brains (some measuring 1100 cc), the archaeological record for later *H. erectus* shows increased complexity of technology (tools, fire, and shelter) and social organization (Antón 2003; Klein 1989). These techno-social advances, and a parallel increase in learning, may well reflect extended childhood (Bogin & Smith 1996). The evolutionary transition to archaic, and finally, modern *H. sapiens* expands the childhood stage to its current length.

As for how childhood abetted language, we speculate that there was a process of coevolution, according to which an initially short childhood period facilitated the emergence of a small amount of vocal-verbal behavior. Even if the original cause of childhood was nonlinguistic, as we propose, any new time between infancy and juvenility would have provided the young with additional opportunities for vocal-verbal interaction during a time of increased independence, and would have given adults new reasons to honestly inform any dependents in their care (Fitch 2004). The disposition to do so is suggested by the fact that primate mothers appear to prevent their young from eating alien substances, and warn off young animals that approach toxic fruits (Caro & Hauser 1992). Young hominins also would have needed to know about plants as well as game, tools, shelter, and predators. Even a small amount of vocal-verbal behavior would have facilitated warnings and instruction. Childhood lengthened, enabling more language which, in turn, extended childhood, until the new ontogenetic stage reached its present length. Childhood would thus have offered up new behaviors, ones that would also prove beneficial in the run up to sexual maturity.

9.2. Evolution of adolescence

This brings us to the evolution of the other uniquely human stage of development. Nonhuman primates lack childhood, but they also lack a post-juvenile period of dramatic growth of the sort that defines human adolescence. Unfortunately, very little is known about the evolution of adolescence. It is possible, however, to suggest some benefits of this late stage of development in terms of reproductive biology, social ecology, and reproductive success. Our claim, detailed elsewhere (Bogin 1999a; 1999b; 2003), is that adolescence became part of human life history because it conferred significant reproductive advantages on our evolutionary ancestors, in part by allowing adolescents to learn and practice adult economic, social, and sexual behaviors before reproducing. As indicated in section 2.7, the basic argument for the evolution and benefits of human adolescence is that girls best learn their adult social roles while they are infertile but perceived by adults to be mature, whereas boys best learn their adult social roles while they are sexually mature but not yet perceived to be such by adults. The proposed patterns correspond exactly to the course of growth and development taken by boys and girls. On average, healthy girls begin to develop adult-like fat patterns (e.g., breast, hips) at about age 10 to 11 years, which is two years before the peak of the adolescent spurt. Menarche occurs a year after the spurt and is followed by about three years of adolescent sterility, ovulation being rare or absent. The female pelvis also grows slowly during adolescence and does not reach full adult size, a necessity for successful birth, until about age 18 years. Externally, however, these infertile girls look like women and this perception prompts adults to include the girls in a suite of adult social, economic, sexual, and political activities. The girls learn from involvement in these activities and arrive at young adulthood, at about age 19 years, with considerable experience that translates into reproductive success. This may be why humans have the highest rate of birth survival of any species: 50 to 60% in traditional foraging societies compared with 35% in chimpanzees (Lancaster & Lancaster 1983).¹⁷

In the reverse pattern that characterizes male adolescence, fertile sperm are produced at about 13.5 years of age, and yet external features of male adults (body size, muscularity, body hair, and other sexual features) do not develop until about age 18 years. The hormones that cause spermatogenesis may prime boys to be emotionally and cognitively attentive to the behavior of adult men and women. In most human societies, boys pass through several rites of passage that help them learn and practice important adult male economic, social, political, and reproductive activities. By age 20 or so, these boys graduate to manhood, and are expected to compete successfully with other men and to assume the responsibilities associated with marriage and paternity.

As for when adolescence evolved, it is possible that this stage first appeared in *H. erectus*, a hominin that originally evolved in Africa more than one million years ago (Antón & Leigh 2003). The evidence for this is patterns of tooth formation that are not directly linked to the presence of an adolescent growth spurt, but are nonetheless suggestive. Other research indicates that *H. erectus*, later hominins

such as *H. antesor* (800,000 BP) and *H. heidelbergensis* (400 – 500,000 BP), and even the Neandertals of 40,000 BP grew up too quickly to have adolescence (Ramirez-Rossi & Bermudez de Castro 2004). Whenever adolescence evolved, and it will take a good deal more evidence to be sure, an ontogenetic approach would ascribe modern human language to some more recent period.

10. Pragmatics and performance

We have sampled evidence indicating that knowledge of the basic structure of language is usually present by the end of childhood. We have also seen that the skill needed to use language adaptively in social and sexual situations is not conspicuous until adolescence. Thus, we believe it is possible that important aspects of language not only *do not* develop until sexual maturity, but *cannot* do so because biological functions associated with that stage played an evolutionary role in their construction, much as they now play a role in their development.

Many of the changes occurring in adolescence (as we saw in sect. 2.8) fall into the categories of pragmatics and performance. Pragmatics refers to the inference of speakers' intentions from the literal meaning of their utterances (Austin 1975; Searle 1972). Inasmuch as the ability to infer intentions presupposes real-world knowledge, pragmatics is the area of linguistic communication that must be, and is, the last to develop.

It is also the area of human language that has least appealed to Linguistics, which has been more concerned with grammar (Haberland & Mey 1977). With grammar as the central focus, there may have been less reason to analyze the things that people actually say, for, as Newmeyer (2004) wrote, utterance material "is all but useless for providing insights into the grammar of any individual speaker" (p. 698).

Clinicians have reinforced this bias by restricting themselves to standardized tests, which typically exclude pragmatics. Ten years ago, several clinical investigators wrote that pragmatics "defies assessment under standardized conditions" (Tomblin et al. 1996, p. 1286). This combination of biases and constraints facilitated the transformation of "language" from a vibrant form of social action into a stable mental code that fit the educational bias of literate cultures, with additional advantages to scholars, who wished to study its organization, and clinicians, who needed to measure it.

Still, infants who are slow to develop the linguistic code frequently experience pragmatic difficulties in childhood (Ninio et al. 1994; Prutting & Kirchner 1987). In some cases, pragmatic problems are correlated with lingering linguistic deficiencies (Leonard 1986; Tomblin et al. 1996); in other cases, pragmatic deficits seem to emerge after earlier language deficiencies have resolved (Girolametto et al. 2001), suggesting some degree of independence between grammar and pragmatics (Culatta et al. 1983; Schelletter & Leinonen 2003). These differences are partially explained by the fact that pragmatics encompasses a number of diverse behaviors, some more closely dependent on linguistic knowledge than others (McTear & Conti-Ramsden 1992).

In juvenility or adolescence, individuals with a history of developmental language delay may appear to normalize,

based on standardized tests, but many are ineffective when it comes to the verbally performative behaviors that blossom during those stages. Bergman (1987) has itemized these deficits in adolescence:

When communication deficits persist into adolescence, disordered language may produce increasingly noxious social consequences. Inability to keep abreast of verbal exchange usually sets the language disordered adolescent apart socially, with resultant feelings of loneliness and of being misunderstood. These youths are unable to acquire in-group slang expressions; are likely to misunderstand metaphors, jokes, puns, and sarcastic remarks; may be unable to follow verbal dialogues; and are usually poor in rapid humorous verbal exchanges. Speech may be rambling, imprecise, fragmented, and/or tangential. Typically aware of having communication problems, language disordered adolescents may be reluctant to contribute to conversations, be socially reticent, and avoid responding through silence, off-handed gestures, or saying "don't know." (p. 162)

Several of the performative deficits claimed by Bergman have since been documented by researchers (Bishop 1989; Fujiki & Brinton 1991; Ninio et al. 1994; Nippold 1998; Paul 1995). Still, they may escape the notice of teachers, clinicians, and other responsible adults because, as we saw earlier, verbal performances are frequently held when these people are not around.

Individuals who are able to carry out linguistic operations that occur early in infancy, such as lexical storage and object naming, do not necessarily have what it takes to satisfy the performative criteria associated with subsequent stages – at least not on *formal grounds*. But in evolution, individuals who achieved the ability to perform attractively and competitively by adolescence would surely have benefited from doing so, indirectly reinforcing previous accomplishment in earlier stages. As Hogan (1988) pointed out, selection for behaviors in sexual maturity automatically credits relevant developments in earlier stages as well.

11. Language and speech

Insofar as selection for speech reinforced previous linguistic developments, it may also have strengthened connections between articulation and grammar. For one thing, there is evidence suggesting that "language" problems in infancy may persist as speech, or even purely articulatory, problems in adolescence (Beitchman et al. 1994). In a longitudinal investigation conducted in England, adolescents who had been linguistically disordered in childhood scored significantly lower than controls on a variety of language measures, and were poor at repeating nonwords, sentences, and articulatorily complex material (Stothard et al. 1998). In a similar study carried out in Sweden, language-disordered six-year-olds were still behind at the age of 18, especially when it came to repeating long and complicated words, which they did slowly and erroneously (Nauclér & Magnusson 2002). In the United States, a group of elementary schoolchildren with carefully evaluated articulatory disorders was seen 28 years later, at which time there was evidence of continuing problems with articulation (distortions of /s/, /z/, and /r/ were plentiful), as well as reduced performance on tests of language comprehension and intelligence. Significantly, these adults also evinced abnormalities in the area of prosody,

their speech striking listeners as slow and monotonous (Felsenfeld et al. 1992).

Findings in behavioral and molecular genetics also support links between language and speech, while hinting at previously unexamined contributions of speech to other linguistic domains. In studies of monozygotic and dizygotic twins, for example, the highest rates of concordance have come from twins in whom the disorder was primarily expressive; some had disorders that were purely of the articulatory type (Bishop et al. 1995; Lewis 1990; Lewis & Thompson 1992). In typically developing 7- to 13-year-old children, Bishop (2001) also found that MZ twins were more concordant than DZ twins on rate of speeded articulation of polysyllabic words. These findings seem to fit with the possibility that selection acted on performance, thus on factors relating to precision, speed, complexity, and fluency of articulation. In doing so, it may have reinforced those behaviors, indirectly enhancing related acquisitions and developments that had occurred earlier in development.

The role played by production factors has also been highlighted by studies of a particular family in England. In the early 1990s, researchers discovered the KE family, which had serious communication disorders at each of its three living generations. Although these problems included a severe oral and verbal dyspraxia, accompanied by deficits at other levels of language (Fletcher 1990; Hurst et al. 1990; Vargha-Khadem 1990), a grammatically focused investigation of the family found precisely what it was looking for: grammatical problems (Gopnik 1990; Gopnik & Crago 1991). Nearly a decade later, geneticists found a defective gene in the family, *FOXP2*, which is situated on the long arm of chromosome 7 (Lai et al. 2000; 2001). But, in parallel with the genetics work, other teams of clinical investigators confirmed the dyspraxic disorder, which involved both speech and nonspeech movements of the articulators (Vargha-Khadem et al. 1995; 1998). In functional imaging studies, affected family members revealed significant underactivation of Broca's area in both hemispheres, consistent with a deficit of speech production (Liégeois et al. 2003).

What is relevant here is that the primary problem of the KE family was reconceptualized as an oral-motor difficulty that was *accompanied* by grammatical difficulties. Several theorists toyed with the idea that the KE family's oral-motor difficulties *caused* their grammatical and comprehension difficulties. "One possibility," wrote Watkins et al. (2002), "is that the deviant articulation results in poor phonology, rendering morphological production difficult" (p. 461). "It might be the case," Marcus and Fisher (2003) speculated, "that a deficit restricted to the motor system is fully responsible for the wide-ranging profile of impairment" (p. 261). There could have been a "flow-on effect from articulation to syntax to comprehension," wrote Corballis (2004, p. 548).

How did our ancestors get from articulated phonation to syntax? According to Bickerton (2000):

The ability to make and distinguish a greater range of speech sounds would make possible a wider variety of sound combinations, which, given a larger and more efficient memory for words, would give rise to a steadily increasing vocabulary. Undoubtedly, these factors and processes would have combined to yield a much richer means of communication among hominins. (p. 157)

This would not automatically produce syntax, as Bickerton noted, but it may have led to other changes that favored phonology, beginning with the ritualization of vocal patterns (Locke 2004a; in press b; Oller 2004; Richman 2000) and ultimately their segmentation into discrete linguistic units (Studdert-Kennedy 1998; 2005; Studdert-Kennedy & Goldstein 2003).

12. What belongs in the language faculty?

Evidence examined earlier revealed continuity between the lexical delays of infancy – even where they appeared to resolve – and the pragmatic and performative problems of adolescence. If we attempt to account for this continuity, two possibilities emerge immediately. According to the first, pragmatics and performance are social applications of linguistic knowledge, and thus depend on that knowledge. This could explain the developmental association between scores on standard tests of language and experimental measures of pragmatics.

A more satisfying possibility is that delayed lexical development points to a weakened faculty of language, since even the earliest use of words requires the action of mechanisms that belong to this faculty. This is consistent with a paradox about language development. Infants rarely vocalize at normal levels of frequency and complexity during the babbling stage; they imitate aspects of their mother's speech and produce isolated words – behaviors that ostensibly require no grammatical ability at all – and *then* stumble as they enter the domains of morphology and syntax (Locke 1998a). Whatever problems arise at the grammatical level of language are typically forecast by deficiencies in early lexical development (Bates & Goodman 1997), and possibly even the precursors to word learning (Oller et al. 1999). These facts suggest that the earlier and later behaviors, as different as they are, belong to a system of linked neural resources, and that weakness in the expression of an early component indexes weakness in others, including the performative areas that happen to develop late. According to this explanation, early lexical delay predicts problems of usage and interpretation in adolescence even if the delay, by tests of structure and content, seems to resolve long before that stage. The second account is therefore able to handle problems of interpretation as well as usage.

At first glance, it may seem adventurous to assign lexical development to the same faculty as other components of language. For lexical development rests on a number of perceptual, attentional, and other cognitive systems that are not, in and of themselves, linguistic. But a wider perspective on the faculty of language has recently become available. In an attempted reconciliation of evolutionary biology and linguistics, Hauser, Chomsky, and Fitch have proposed a broad linguistic faculty that extends beyond a narrow computational core to include the "biological capacity of humans that allows us (and not, for example, chimpanzees) to readily master any human language without explicit instruction" (Hauser et al. 2002, p. 1571; also see Fitch et al. 2005).

The broad model offered by Hauser and colleagues offers hope to those who might like to see linguistic knowledge and structure accommodated under the same theoretical roof as pragmatics and verbal performance.

If developmental evidence suggests that some pragmatic abilities stand in closer relationship to lexical and grammatical knowledge than others, as it does (McTear & Conti-Ramsden 1992), then the faculty of language should include these related, and possibly interdependent, specializations. Certainly the evolutionary account offered here suggests that it should. For, if pragmatic and performative abilities were selected, it is hard to see how they could have escaped some degree of integration with earlier linguistic developments on which they would have depended.

What belongs in the language faculty is a matter that should ultimately be decided empirically, based on evidence of various sorts, including lesion, imaging, and processing studies, even if the interpretation of some findings proves problematic (Thomas & Karmiloff-Smith 2002). Here, we rely on normal and atypical patterns of development, and an additional line of argument and evidence – evolution itself. For the traits that are present in modern humans are traits that evolved. If language evolved, then the components of language were selected. If selection applied to behaviors affecting care in infancy and childhood, and competition in juvenility and adolescence, then the behaviors that were selected during these stages would now be included in the trait. The net result would be a series of functional interrelationships, since the behaviors that appeared early enabled later developments, which, in turn, reinforced their own precursors. Thus, the human faculty of language would extend beyond the ability to learn a linguistic code and to use it simply to inform; it would extend to the ability to speak skillfully so as to compete and cooperate in social and sexual maturity.

13. Vocal ontogeny, linguistic phylogeny

We have discussed selection as it may have applied in adolescence and adulthood, but have additionally proposed a role for infants and children – and their parents – and a role for juveniles. In doing so, we have introduced proto-linguistic content to two pre-existing conceptions of evolution, one relating to the role of development, the other to the role of behavior. The suggestion that development plays a role in evolution was raised by Mivart (1871) and developed by Garstang (1922), who argued that ontogeny was no “animated cinema show of ancestral portraits” (p. 100), as Haeckel had claimed in his late nineteenth century recapitulatory doctrine, but actually plays a reverse role by “creating” evolution.¹⁸ Gould (1977) and Gottlieb (1992) have discussed developmental contributions to evolution in some detail, the latter also claiming, after Bateson (1988), that individuals’ behaviors play a central role in evolution, especially when they move about and thus alter their environment.¹⁹

Gottlieb (1992) offered a three-stage model of the process by which new behavioral developments produce evolutionary change. In the first stage, a modification of developmental conditions forces a previously unexpressed behavior to the surface, followed in the second stage by morphological and physiological alterations, and, in the final stage, by a change in the genetic composition of the population. If we apply Gottlieb’s model here, bipedalism is seen as a key event in Stage I, for this was a new behavior

that, in time, produced pelvic narrowing. Remodeling of the birth canal caused a shift of skull and brain development into the postnatal period, increasing the degree and duration of infant helplessness. When weaning was brought forward and sibling competition increased, infants – at an age when their brain was developing rapidly – experienced additional pressures to do things that would preserve the flow of care. In Stage II, hominin infants exploited pre-existing but quiescent means of signaling their needs to, and appraising the reactions of, heavily burdened caregivers, some doing so more effectively than others. In the final stage of evolutionary change, Stage III, the capacity to produce more complex vocalizations made its way through the population, acquiring a genetic foundation.

In the example above, evolutionary change applied to the earliest stage of life history, but infants who achieved effective care and engagement signals would have carried some form of the relevant control behaviors into childhood, juvenility, and adolescence, where they enabled additional capabilities – skills that facilitated, among other things, the quest for status, sex, and additional resources. The new skills were reinforced by reproductive success, automatically strengthening, in a second hit, the precursors that had persisted in some form from earlier stages. In doing so, components and specific applications of the human voice became cues to fitness and a genetic specialization emerged, one that would direct the development, learning, and strategic use of complex vocalizations in future generations.

The developmental conditions that favored evolution of vocal-motor control in infancy – helplessness and dependency – would also have promoted perceptual sensitivity and nurturance in caregivers. For, with more competing offspring to care for, mothers were forced to discriminate honest cries from bogus distress signals (now more plentiful and clever than ever) and to infer signs of physical and social maturation from other vocal cues. They were also forced to provide more intensive care to individual infants. There would have been a range of variation in the disposition or ability to carry out these functions, too, with selection acting on the genetic correlates of perception and care.

14. Concluding remarks

The life history approach taken here has produced several observations, speculations, and conclusions. We began by reiterating an earlier speculation that a brief childhood was inserted into the hominin line around the time of *H. habilis*, offering reproductive benefits to mothers. We then speculated that childhood would have facilitated the evolution of language by extending parental investment to their offspring during a period of intense symbolic creativity and increasing autonomy. Noting that many evolutionary theories are built on skeletal remains, we suggested that a life history approach to language – a behavior that relies on soft tissues – makes additional types of evidence available, including findings on bipedalism and pelvic narrowing, continuation of rapid brain growth after birth, growth of long bones, and dentition.

Selection of linguistically relevant behaviors that occur in infancy, childhood, and juvenility (stages that are

rarely invoked in theories of evolution) may assume both a direct and an indirect form. In the direct case, behaviors of the young (e.g., infants' strategic use of creative and complex vocalizations) forestall withdrawal of care, increasing the probability of survival to reproductive age. In the indirect form, it is the behavior of sexually mature individuals that is selected, typically in the quest for status and mating opportunities, but that behavior is only available to be selected because it, or a precursive form, has a prior developmental history. These cases of selection in adolescence or early adulthood automatically reinforce the earlier, enabling behaviors.

In other primates, it has been proposed that the juvenile period is beneficial because it permits developing animals to prepare for the complexities of adult behavior. Similarly, we reasoned that human juvenility may have provided a period in which capabilities emerging in previous stages could be "practiced," and then, in adolescence, more fully exercised for social and sexual purposes. Although we suggested that selection operated throughout ontogeny, we also speculated that in adolescence, performative behaviors (including socially attractive aspects of articulate vocalization) increased fitness, established a preferred mode of expression, and laid the groundwork for speech as the universal modality of language.

We based our speculation, in part, on anthropological reports indicating that in oral societies – which lack the written language bias of modern cultures and modern Linguistics – fluent, rhythmic, and elegant speech attracts attention and facilitates the acquisition of status and power. This trend is most evident in the case of men, in contrast with the "female advantage" that has been reported in the psychometric literature, discouraging theorists in search of a selection-based model in which males display, and are chosen for, their verbal talent. Witnessing a male bias for performative speech, we speculated that selection produced sex differences that remain evident in verbal behavior today.

If childhood entered the human genome first, the amount of vocal-motor control available to our premodern ancestors may have remained limited, even if enhanced in juvenility, until the evolution of adolescence. Then, the performative applications of such behaviors, and the behaviors themselves, would almost certainly have diversified. Hence, we think there may have been a long period in evolutionary history in which vocal behaviors were displayed within a familial context, before adolescence teased them into the open in more elaborate form.

We proposed that important aspects of language cannot develop until sexual maturity because functions that emerge at that stage played, and still play, a key role in its construction. When selection for vocal and verbal performance in adolescence reinforced previous developments, it swept specializations associated with speech and voice, linguistic content and structure, and rules of usage into one large specialization. It is difficult to escape the conclusion that the faculty of language includes several disparate capabilities, and that these capabilities were stitched together in evolution, as they are in modern times, by the whole of human ontogeny.

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NOTES

1. Arbib (2005a; 2005b) has suggested that at some point in evolution, hominins may have used manual gestures and vocal sounds to communicate; the gestures – in pantomime – carrying semantic and possibly sequential information of the sort now conveyed by syntax (Goldstein et al., in press).

2. In human neonates, body weight is nearly twice that of chimpanzees, the difference being due, in large measure, to the abundance of fat. This extra fat provides a source of energy to support the large and still rapidly growing brain of the human infant (Bogin 1999b), which is three times larger than the chimpanzee brain at birth (Martin 1983). In fact, human newborns are neurologically more advanced than eight other mammalian species that have been studied; two months before birth, the human brain is already more developed than the brain of the newborn macaque (Clancy et al. 2001). Further disparities develop at birth, when brain growth tapers off in the other primates, whereas in humans it continues for the next year in a rapid, fetal-like trajectory (Martin 1983). Because of these differences, the brains of human neonates require more nutrition than do the brains of other primate newborns (Leonard & Robertson 1992; see below); and, although comparative data are not readily available, it is clear that social stimulation also plays a significant role in human neurological development (e.g., Rutter & O'Connor 2004).

3. The "grandmother hypothesis" is indirectly relevant to our discussion. Human beings are the only primate species, and one of only a few mammalian species, in which adult females have a menopause and a cessation of ovulation long before death. Women are usually infertile by the age of 50, but may have two decades of post-reproductive life in traditional societies (Pavelka & Fedigan 1991). The "grandmother hypothesis" posits that this post-reproductive stage of life evolved because older women stand to gain more reproductive advantage by helping their daughters and grandchildren than by investing in more children of their own (Bogin & Smith 1996; Hamilton 1966). Hill and Hurtado (1991) tested this prediction against objective ethnographic data derived from their work with the Ache hunter-gatherers of South America. The Ache data show that offspring with grandmothers survive at somewhat higher rates than those without grandmothers, but the effect is not nearly enough to account for menopause. In a review of the Ache data and other cases derived from hunting-gathering and agricultural societies, Austad (1994) found no evidence "that humans can assist their descendants sufficiently to offset the evolutionary cost of ceasing reproduction" (p. 255). Still, interest in the "grandmother hypothesis" continues; Hawkes et al. (1998) used mathematical modeling techniques to show ways that menopause could have evolved under Darwinian selection.

4. When is the human capacity for language, or linguistic communication, fully instated in the young? When does it become fully operational? In the case of printed language, it was once possible to specify the materials that one needed to read, such as the Bible or newspaper, or to link competence to larger individual or cultural and economic goals. In the case of spoken language, there seem to be no clear-cut criteria for mastery. Therefore, the standard that has developed in modern societies, perhaps by default, is linked most immediately to social reactions in childhood and to academic success, including literacy. At the age of six, more than 96% of Midwestern American children pass normed tests that emphasize phonology, morphology, syntax, and vocabulary. These tests are sensitive to language skills that are deemed necessary for success in educational programs (Tomblin et al. 1996).

5. Some of these functions, including sarcasm, joking, and idiomatic interpretation, are handled primarily by the so-called nonlinguistic (right) cerebral hemisphere (cf. McDonald 2000;

Paradis 1998; Van Lancker 1990). This could be taken to mean that the way people talk is not a linguistic matter, but traditional definitions of language have emphasized message content and creativity. If rules of use are subsumed under “language,” then the right hemisphere is also “linguistic.”

6. That powerful public men tend to make frequent use of words that are rare, archaic, or esoteric suggests that a command of this material may be related to some other attribute that underlies the ability to persuade or manipulate people. Studies indicate that in modern societies the use of words that are rare, long, abstract, diverse, or unusual is correlated with formal measures of intelligence (Carroll 1993; Gustafsson & Holmberg 1992; Gustafsson & Undheim 1996; Ullstadius et al. 2002; Vetterli & Furedy 1997).

7. In citing anthropological work that concentrates on separate and sometimes “exotic” oral societies, there is a possibility that subgroups within literate societies will be ignored. In a working-class tavern in southern Wisconsin, according to an anthropologist-customer (LeMasters 1975), social success was dependent on “the ability to ‘dish it out’ in the rapid-fire exchange called ‘joshing’ . . . you have to have a quick retort,” he wrote, “and preferably one that puts you ‘one up’ on your opponent. People who can’t compete in the game lose status” (p. 140).

8. After submitting the manuscript, we encountered elements of a similar proposal by Darwin. In *The Descent of Man*, he suggested that with “varied tones and cadences” our evolutionary ancestors “aroused each other’s ardent passions, during their courtship and rivalry” (1879/2004, p. 639).

9. Discrimination against poor speakers does not necessarily begin in juvenility. When several four-year-olds were encouraged to “play store,” an irrelevant utterance by one – a child with limited linguistic skills – caused another boy to advise a peer, “Don’t talk to him; he’s weird” (Rice 1993). “Preschoolers behave as if they know who talks well and who doesn’t,” observed Hadley and Rice (1991), “and they prefer to interact with those who do” (p. 1315).

10. That females tend to operate covertly should not be taken to mean that they lack the ability to attract attention or to perform. In early modern England, women raised their voices against sexual competitors in a strident and spectacular way. According to Capp (2003), when threats to their marriage arose, wives “showed considerable skill in formulating taunts” (p. 199), calling other women “drunken fuddling fool” and “drunken pocky-faced rogue” (p. 257). When women hurled such insults, it was not unusual for them to be arrested and charged with “scolding” (McIntosh 1998).

11. Clearly, our focus here is on verbal behavior (competition and performance) as enacted by specific activities, such as insulting and joking; particular kinds of material, such as colloquial phrases; and vocal attributes, such as rate, fluency, and rhythm. When it comes to linguistic operations, testosterone – whether naturally high or experimentally administered – may exert the opposite effect by suppressing scores on language tests (Christiansen & Knusmann 1987; van Goozen et al. 1994).

12. However, one might hypothesize that men are superior to women in the use of idiomatic material. It has been demonstrated that the speed and fluency of auctioneering and sports broadcasting reflect use of over-learned material, and men dominate these professions (Kuiper 1996; Pawley 1991). But there may also be a male advantage on measures of speeded articulation; some studies have revealed a trend toward superior performance among juvenile and adolescent males on diadochokinetic tasks (Fletcher 1972; Robb et al. 1985).

13. In young women’s ratings of children’s conversational speech, the highest degree of variance was accounted for by a dynamic factor that included the attributes: excitable, loud, uncontrolled, bold, active, uninhibited, spontaneous, assertive, and dominant. Overall, ratings were more influenced by quality

of speech than sentence complexity and grammaticality (Burroughs & Tomblin 1990). Thus, it is possible that vocal characteristics that are favorably regarded in sexual maturity are already present, to some degree, in earlier stages of development.

14. American trial lawyers are also highly verbal, and voluble, in their personal lives. When Walter (1988) interviewed 34 trial lawyers in her dissertation research, she found that many could not be shut up. In one of her late afternoon interviews, “a lawyer talked for two and a half hours with no sign of concluding, and since he had strayed far from the topic, the interviewer terminated the discourse, or tried to, by physically leaving the office. This lawyer followed and continued speaking up to the door of the elevator” (Walter 1988, pp. 31–32).

15. Goodall (1983) reports that for the period 1965 to 1980 there were 51 births and 49 deaths in one community of wild chimpanzees at the Gombe Stream National Park, Tanzania. During a ten-year period at the Mahale Mountains National Park in Tanzania, researchers counted 74 births, 74 deaths, 14 immigrations, and 13 emigrations in one community (Nishida et al. 1990). Chimpanzee population size in each of these two communities was, by these data, effectively in equilibrium. Any additional delay in age of females at first birth or the time between successful births would probably have produced a decline in population.

16. It must be pointed out that there is uncertainty as to the existence of childhood in early *H. erectus* and its predecessor species. One line of evidence is based on the formation of tooth crown enamel. This method indicates that *Australopithecus*, *H. habilis*, and early *H. erectus* all matured at a rate faster than living humans and closer to living apes (Dean et al. 2001; Zihlman et al. 2004). The “Mojokerto child” from Java (dated at 1.8 million years ago) is attributed to *H. erectus* and is the only infant specimen preserved well enough to estimate age at death or cranial capacity. A recent analysis of the infant calvaria (i.e., top portion of the skull) indicates that this hominid died between 0.5 and 1.5 years of age and had achieved 72–84% of adult *H. erectus* brain size (Coqueugnoit et al. 2004). Another analysis by Antón (1997) estimates an age at death of 4 to 6 years. If the younger age at death is correct, then the pattern of brain growth is more similar to chimpanzees than human beings. In fact, the Mojokerto fossil would have grown its brain faster than living chimpanzees (Coqueugnoit et al. 2004). If, however, the later age at death is correct, then Mojokerto followed the human trajectory for brain growth.

17. There is indirect evidence for the reproductive value of human adolescence in the data on nonhuman primates. The first-born infants of monkeys and apes are more likely to die than are those of humans. Studies of yellow baboons (Altmann 1980), toque macaques (Dittus 1977), and chimpanzees (Teleki et al. 1976) show that 50–60% of firstborn offspring die in infancy (between birth and age one year). In hunter-gather human societies, such as the !Kung, about 44% of children die in infancy (Howell 1979). The human advantage may seem small, but over the vast course of evolutionary time even a 6–16% advantage is a powerful selective force. The !Kung live under very difficult and marginal conditions in a desert environment. Their infant mortality rates are at the extreme high end of human population. For comparison, it may be noted that in most contemporary human societies the infant mortality rate is usually below 20% of live births. The nation of Haiti, for example, is the poorest country in the Western Hemisphere. In 1970 the infant mortality rate was 15% (Bogin 2001). In 1960 in the United States, about 2.5% of all live, firstborn children died before the age of one year (Vavra & Querec 1973).

18. Garstang (1922) also saw phylogeny as “the creation of successive ontogenies” (p. 84), a characterization that prompted Studdert-Kennedy (1991), in recent years, to view human

language as the “product of successive ontogenies” (p. 10; also see Studdert-Kennedy 2005).

19. This process, once termed “niche picking” by Scarr and McCartney (1983), has recently been treated in some detail by Odling-Smee et al. (2003), who rightly regard “niche construction” as a vastly underplayed process in the history of evolutionary thinking. A brief but interesting discussion of niche construction is available in Dawkins (2004), who distinguishes this kind of engineered and adaptive alteration, which is encompassed by his extended phenotype theory, from the less Darwinian processes of “niche change.”

Open Peer Commentary

Invoking narrative transmission in oral societies

Ileana Benga

The Folklore Archive Institute in Cluj-Napoca, Romanian Academy, Cluj-Napoca 400015, Romania.

ileana_benga@yahoo.it

Abstract: The ethnographic description of story-telling and narrative transmission of cultural facts is an aspect of Locke & Bogin’s (L&B’s) article that should be amplified. Innate shared gene patrimony is biased by the kinship structure of particular societies and interacts with the transmission of narratives. Trance experiences are another interesting aspect of verbal and agonistic “performances.”

Language acquisition in both its innate and social aspects must affect the oral transmission of culture within traditional societies. The rules of transmission are certainly a matter for multidisciplinary investigation. Ethnology and the specific description of story-telling including performance style and context constitute only one level of approach to the narrative transmission of cultural facts (Degh 1995). Ethnology, however, is uniquely important as an avenue to the complex syntax that articulates human society on both synchronic and diachronic scales.

Essentially, kin groups across cultures strive to reproduce their knowledge across generations, particularly favoring their peers of the same generation. Ethnologists concentrate on recurrent cultural practices, with the supporting genetic relatedness of kind groups less salient to them. In any case, selection on raw vocal ability, improving widely variant types of spoken communication within the kin group in the very early stages of human history (see sect. 3.5 of the target article), seems logically possible, but can hardly be documented.

Kinship structures inform the mechanisms of cultural transmission. Natural kinship is accompanied in practically every society by cultural kinship (previously called fictive kinship). Conceptually put, natural and cultural kinship may lead to two complementary genealogies, with memory-carriers only partially overlapping in each group. Thus, an important patrimony exists that is not “individually” genetic, but “communitarily” genetic. To insiders following the oral prescriptions of a given society, often the personal aspect of information transmission is very secondary. To the ethnologist, the interesting question is not about the origin of oral transmission, or about its evolutionary trajectory, but about its content and mechanisms, easily searched for in present-day field realities. Ethnographic description must complement evolutionary hypotheses regarding oral cultural transmission. Present-day cultures with primarily oral methods of transmission have never stopped generating transmission

content and are far from the static models that the target article suggests (sect. 4).

Ethnographic evidence is richest in the following categories of cultural transmission: kinship – the transgenerational division of goods, both material (e.g., dowry, inheritance) and spiritual (e.g., descent and widely-accepted institutions such as god-parenting; Rivers 1907); narratives from belief-tales to fairy-tales; and ceremonies – including a wide variety of life-cycle or year-cycle ceremonies. All of these kinds of transmission are observed not only in the case of oral societies, but also in urban and literate ones.

A great deal of attention is focused in ethnology on the relation invoked in sections 4.1 and 4.2, between verbal and agonistic performance, and power. Contests of brilliant performers in story-telling and oral narrative transmission show only one aspect of cultural transmission. Another aspect is trance, which is linked to the special qualities of precious individuals within the community – another widespread form of power.

Locke & Bogin’s (L&B’s) article concentrates principally on individuals consciously manipulating technical ability for power. No less powerful, “ordinary” members of oral societies often achieve high status using transformed linguistic proficiency in altered states of consciousness. I have in mind the many techniques of trance, be it ecstatic trance (whose exemplar model is the classical shaman; Eliade 1951; Humphrey 1996), or induced trance (trances without presumed journeying to other worlds; De Martino 1961). Both types of trances share exquisite performances, complete with assistants/interpreters of often parallel “languages.” The audience is prepared, and the performance must fit the expectancies of the community in the form of local myths or legends. For the individuals performing in a trance state, the ability to significantly change their state of consciousness *accompanies* their linguistic proficiency; it does not originate in such proficiency. The stories of first-hand trance experience surely reinvest local narrative patrimony, after necessarily following its trends in shaping the trance/ecstasy experience.

Language use, not language, is what develops in childhood and adolescence

Derek Bickerton

Department of Linguistics, University of Hawaii, Honolulu, HI 96822.

derbick@hawaii.rr.com www.derekbickerton.com

Abstract: That both language and novel life-history stages are unique to humans is an interesting datum. But failure to distinguish between language and language use results in an exaggeration of the language acquisition period, which in turn vitiates claims that new developmental stages were causative factors in language evolution.

Locke & Bogin’s (L&B’s) unusually long target article has provided an unusually thorough account of how the life cycle of humans differs from those of other primates. Instead of a solution to the puzzle of how and why language evolved, however, we are left with additional mysteries: how and why childhood and adolescence evolved. Furthermore, L&B fail to make a convincing case that any causal connection exists between novel developmental stages and language evolution.

What selected for childhood? L&B’s best suggestion is that it enabled mothers to shorten the interval between childbirths, hence to have more offspring. But since this is desirable for any species, why did childhood evolve in one primate alone? L&B have no answer. When they come to adolescence, what the authors propose does not merely fail to support their claims, it works against them. They characterize adolescence as a period for young individuals to rehearse adult economic, social, and sexual behaviors before being burdened with reproductive chores. Why would such behaviors need rehearsal unless they were noticeably more complex than behaviors of

other species? What could have made them more complex if not the long pre-existence of a language and a complex culture built on it? This suggests that language drove life-cycle changes, rather than the reverse.

The timing of these changes remains highly problematic. Virtually all the evidence comes from teeth. How the owners of those teeth were organized, their modes of subsistence, the environments and ecologies they shared – all these and more remain blank; as in too many works on human evolution, there is very little human evolution.

But the major weakness of L&B's article lies in their treatment of language. They seize upon the distinction by Hauser et al. (2002) between a broad and a narrow faculty of language, and misinterpret this as licensing the subsuming of structural and pragmatic elements under a single umbrella. They would have done better to focus on an earlier distinction of Chomsky's between I-language and E-language (Chomsky 1980). I(nternal)-language is the knowledge of language stored in the individual's brain; E(xternal)-language is the sum total of language use in a linguistic community. The first may (and probably must) have a biological foundation; the second is clearly cultural. If evolution is a biological process, as generally assumed, any inquiry into language evolution should address the first rather than the second. As a minimum, any such study should clearly distinguish between the language faculty itself and the uses to which it is put. Nobody would dream of confusing other things with the uses of those things (e.g., cars with driving, or forks with eating), yet this elementary error occurs repeatedly in work on language evolution.

Jokes, language games, gossip, oratory, extended narrative, and the like are clearly features of language use, whereas phonology, syntax, morphology, and lexicon are components of what is used in the execution of these things. Only by lumping these two sets together can L&B sustain their thesis that language acquisition lasts from infancy to adulthood.

L&B overestimate the time it takes for the structural elements to come on line. Stephen Crain and others (e.g., Crain 1991; Crain & Thornton 1998) have shown by ingenious experiments that most if not all aspects of grammar appear by the end of infancy (if not before; Crain has pointed out that such experiments don't work with children under 36 months). Of course, older children and adolescents use a richer vocabulary and longer and more complex sentences. But this results from interactions between an already-established faculty of language and the demands placed upon it by different facets of normal development. Life experience ensures that older children and adolescents have more to talk about; intellectual growth enables them to deploy their full Piagetian deck of reasoning powers; socialization obliges them to use their linguistic skills in a wide variety of contexts, each demanding its own particular, culturally determined genres, styles and idioms. The "important aspects of language" that L&B in their Abstract see as requiring "the whole of modern ontogeny" are, without exception, not aspects of language at all, but rather aspects of language use. Consequently their whole case is seriously weakened.

Meanwhile, serious questions remain. What led one species, but no other, to break out of the mold of animal communication systems that have proved perfectly adequate for every other species that has ever existed? L&B line up the usual suspects – kin selection, sexual selection, social selection – providing no account about how these have operated on a vast array of species without any remotely similar consequences. How, when, and why did the prerequisites for even a protolanguage – symbolism, predication, displacement – emerge? Was there a protolanguage, and if so what was it like, how did it develop into language? Where did syntax come from, was it adapted from something else? If so, what? If not, where do we go from there? It is such highly specific developments in language evolution that have to be accounted for, not just some amorphous something called "language."

Is it an odd and interesting fact that the only species with language and the only species with childhood and adolescence is the same species? Of course. Could there be a connection somewhere? Possibly. But L&B have not yet showed us one.

The role of developmental immaturity and plasticity in evolution

David F. Bjorklund and Jason Grotuss

Department of Psychology, Florida Atlantic University, Boca Raton, FL 33431.

dbjorklu@fau.edu grotuss@msn.com

http://www.psy.fau.edu/chez/dfb/

Abstract: Aspects of cognitive immaturity may serve both to adapt children to their immediate environment and to prepare them for future ones. Language may have evolved in children's groups in the context of play. Developmental plasticity provides variability upon which natural selection operates, and such plasticity, that likely played an important role in the evolution of language, characterizes human children today.

Locke & Bogin (L&B) should be congratulated for focusing attention on the role that childhood may have played in the evolution of language. Their theorizing is consistent with that of scholars dating back to the nineteenth century and continuing today who postulated a significant role of ontogeny in phylogeny (e.g., Baldwin 1896; de Beer 1951/1958; Garstang 1922; Gottlieb 2002; West-Eberhard 2003). From this perspective, evolution is best viewed not as a succession of changes in adult form or function but as a succession of ontogenies.

Natural selection has surely had as great an impact (or even a greater impact) early in ontogeny as it has had in adulthood. Adaptive characteristics in the adult phenotype do not emerge fully formed, but must develop. Most evolutionary psychologists and anthropologists merely give lip service to selective pressures during pre-reproductive periods of the lifespan in shaping social and cognitive abilities that prove adaptive in adulthood. L&B's account of the evolution of language provides a refreshing contrast and should serve as a model for subsequent theorizing and experimentation on the evolution of language and other abilities that serve an adaptive function in adulthood.

A flexible cognitive system is required for language and the symbolic representation underlying it to evolve. The slow-developing human brain, with its increased volume relative to our hominid ancestors, afforded the plasticity necessary for the emergence of these advanced skills. It is children's brains and minds that are the most plastic and responsive to environmental modifications. Moreover, aspects of young children's immature cognitions may be especially adapted to acquiring information pertinent to the niche of childhood (*ontogenetic adaptations*; see Bjorklund 1997), and may also serve to prepare children for life as adults (*deferred adaptations*; Hernández Blasi & Bjorklund 2003). Examples of such information or skills fostered by immature cognition that have both immediate and deferred benefits include social relations developed during play and language.

Although L&B's account of how language emerges in family interactions during childhood is intriguing, an alternative account is that children invented language in play groups with their peers (in addition to perfecting it in adolescent groups). Combining words in novel, playful ways may have led not only to the invention of words, but to early syntax. In this way, language develops not only within a family, but within a larger social group. Members of these groups will continue to interact throughout childhood and as adults, and will later use their common language to communicate with their offspring. This provides a better context for development and cross-generational transmission of a language than does the family.

Children's ability to invent language is seen when they convert *pidgins* into *creoles* in the course of one generation (Bickerton

1990). Pidgins are protolanguages used by people from different linguistic backgrounds who are brought together to live and work, whereas creoles are true languages. More convincing yet of children's collective ability to invent language comes from a generation of deaf Nicaraguans who had not been exposed to a developed language and who, prior to attending a new school for the deaf, communicated using idiosyncratic home-sign systems. Shortly after arriving at the school, these home signers developed a shared system of signs and grammatical devices. This shared system developed into a full-fledged sign language after several years and several cohorts of typically young, deaf individuals without the need for instructions or adult models (Senghas & Coppola 2001; Senghas et al. 2004).

The emergence of new skills, such as language or its antecedents, in a group of individuals can place them in novel contexts and expose them to new selection pressures. This would surely have been the case with the emergence of language and its underlying symbolic abilities. We argue, as have others (e.g., Gottlieb 2002; Lickliter & Schneider, in press; West-Eberhard 2003), that the neural plasticity of infants and children and their behavioral and cognitive responses to novel environments provide much of the stuff upon which natural selection works, and that this may have been especially important in recent human cognitive evolution (e.g., Bjorklund 2006). Such plasticity may continue to afford the opportunity for phylogenetic change in *Homo sapiens*. For instance, the Flynn effect, a steady rise in IQ (particularly fluid intelligence) over the past century, may be due to accelerated cognitive development (Howard 2001), perhaps in response to an increasingly visual environment (see Neisser 1988). We do not believe that the human race is on the verge of a radical evolutionary change; but the neural plasticity evident in contemporary children in response to changing environments likely also characterized our ancestors and contributed centrally to the emergence of language and related sociocognitive abilities in our forechildren.

Reconciling vague and formal models of language evolution

Henry Brighton, Rui Mata, and Andreas Wilke

Center for Adaptive Behavior and Cognition, Max Planck Institute for Human Development, 14195 Berlin, Germany.

hbrighton@mpib-berlin.mpg.de <http://www.ling.ed.ac.uk/>
~henryb mata@mpib-berlin.mpg.de <http://www-abc.mpib-berlin.mpg.de/users/mata> wilke@mpib-berlin.mpg.de
<http://www-abc.mpib-berlin.mpg.de/users/wilke>

Abstract: One way of dealing with the proliferation of conjectures that accompany the diverse study of the evolution of language is to develop precise and testable models which reveal otherwise latent implications. We suggest how verbal theories of the role of individual development in language evolution can benefit from formal modeling, and vice versa.

Research into the evolution of language is growing rapidly and its study now cuts across several disciplines. Despite the diverse sources of insight which make up this field of study, few would disagree that understanding how and why our species-specific linguistic communication system came to be, requires a consideration of the interactions among three processes: biological evolution, linguistic evolution, and individual development (e.g., Christiansen & Kirby 2003b). Consequently, we were pleased to see Locke & Bogin's (L&B's) target article focus on one often-neglected component – individual development – and its relation to biological evolution. However, in order to understand the implications of a theory of individual development and its relationship to the evolution of language, we must go beyond

vague models whose implications are hard to gauge and move towards more formal and testable models.

Dominating the study of language evolution is the desire to understand the unique form of structural complexity we see in human language. In other words, we seek an explanation of how certain forms of complexity arise from an initial state where that complexity was lacking. As L&B discuss, language is a communication system used in many interesting and unique ways. However, it is misleading to assume that by studying the communicative uses to which language is put we can gain insight into why language is so structurally distinct from other communication systems. L&B emphasize that language is used to support functions which contribute to an individuals' reproductive success. However, the degree to which the *specific* structure of language is *required* for such functioning is by no means clear. First, although most organisms communicate, and those that do so effectively are likely to be at an advantage over those that do not, only one species has language. Second, one can imagine *many* candidate communication systems that fulfill such requirements. Furthermore, language arguably does a fairly bad job as a communication system (e.g., Chomsky et al. 2002). In sum, the evolution of language cannot be explained by its communicative function alone.

To fully understand language and its emergence we have to understand the interacting adaptive systems that have driven its evolution. An important tool in this endeavor is the use of formal modeling, which allows us to explore the implications of precise and testable hypotheses. The growing interest in the evolution of language has been accompanied (some might say spurred) by an upturn in mathematical and computational models (e.g., Briscoe 2002; Cangelosi & Parisi 2001; Hurford 1989; 2005; Kirby 2002; Nowak & Komarova 2001).

We would like to highlight how formal approaches to studying the evolution of language can profit from further consideration of the process of individual development. First, development is a crucial step in determining the class of acquirable communication systems. The ontogenetic development of the cognitive machinery responsible for processing languages may be tied to stages in the life course, and this developmental path is likely to be crucial to understanding the structural characteristics of language. For example, computational modeling of language acquisition has shown the importance of considering how language structure relates to cognitive systems and their development. Elman (1993) used neural network simulations to show how networks can learn certain forms of linguistic structure if memory is started small and then gradually expanded. This mirrors the development of short-term memory capacity in humans and suggests that the mind may be tuned to develop in particular ways to facilitate learning. Elman's work demonstrates how the maturational trajectory over an agent's lifetime can impact on what is and what is not ultimately acquirable. Furthermore, the particular form of inductive bias that defines the language learner has a knock-on effect when we consider which kinds of structure can withstand repeated cultural transmission (Brighton et al. 2005b; Smith 2004).

Second, individual development is characterized not only by changes in cognitive aspects but also in social aspects, such as the structure of social networks. The social networks in which a developing individual is situated impacts on how language is transmitted between generations (e.g., Kerswill & Williams 2000; Ragir 2002). If constraints on how language is transmitted from one generation to the next impact significantly on the distribution of linguistic forms (e.g., statistical universals; for a discussion see Brighton et al. 2005a), then the social networks through which language is transmitted are likely to play a significant role (Smith & Hurford 2003). Hence, the implications of changing social networks that L&B discuss could be explored by investigating how they impact, over a cultural timescale, on the distribution of language's structural characteristics.

Interaction promotes cognition: The rise of childish minds

Stephen J. Cowley

School of Psychology, University of Hertfordshire, Hatfield, Hertfordshire AL10 9AB, United Kingdom; and Department of Psychology, University of KwaZulu-Natal, Durban 4041, South Africa.

s.j.cowley@herts.ac.uk

<http://www.psy.herts.ac.uk/pub/sjcowley/index.html>

Abstract: Life history shaped language as, cascading in time, social strategies became more verbal. Although the insight is important, Locke & Bogin (L&B) also advocate a code model of language. Rejecting this input-output view, I emphasize the interpersonal dynamics of dialogue. From this perspective, childish minds as well as language could be derived from the selective advantages of a total interactional history.

For Locke & Bogin (L&B) childhood and adolescence changed the genetic underpinnings of human talk. Rejecting a learned/innate contrast as simplistic, they posit that our vocal-verbal behavior draws on the sum total of selection advantages. Development has created resources that transformed brains and behavior. L&B's achievement is to have shown why the evolution of language must use the whole of life history.

In L&B's model, childhood and adolescence take on a major role in language evolution. Defending this, they acknowledge that structure, pragmatics, and performance fall "under the same theoretical roof" (sect. 12, para. 4). With Hauser et al. (2002), mastery of human languages depends on a "biological capacity" (sect. 12.). Vocal-verbal signaling is purposeful, pragmatic action used in managing how people act and attend. Going further, L&B in section 4.1, endorse Linell's (1982) attack on the "long tradition of analyzing only written language." Turning from exclusive focus on sentences, linguistic capacities reconnect with action. In facing life's challenges, selection history favors "foundational behaviors" (sect. 2) for persuasion, pragmatics, and attention management. Not only does language require the whole of modern ontogeny but, with Hogan (1988), later behavior "automatically credits relevant developments in earlier stages" (sect. 10, last para.). Evolution thus has *cascading* effects. Today, an infant's cognitive armory includes behaviors whose selection derives from later phases of life. We are psychobiological systems whose lived environment reflects a history of, for example, how children seek nurture and adolescents struggle for status. Language uses the ways in which, in evolutionary time, development links strategic activity with the use of verbal forms. For L&B, language is based in "soft tissues" (sect. 14). So far so good!

L&B nonetheless think that, as early as age 36 months, the "basic components of a functional communicative system are operative" (sect. 2.2). Since language is code-like, speech is merely a "preferred modality" (sect. 2). Taking what Sutton (2004) calls an *expressivist* view, with Fodor, Pinker, and the younger Chomsky, performance depends on linguistic knowledge. Given cascade effects, I fail to understand why L&B commit to this input-output view. Instead, they might argue that, as interactional dynamics changed, language transformed child cognition. Were life history a source of cognitive effects, the evolution of development would have radical consequences. First, it could be argued that, as language is based in soft-tissues, talking uses a total history of social behavior. Second, it could be claimed that, even today, cognitive dynamics emerge both internally and in public language. With Hauser, Chomsky, Fitch, Linell, and many others, we would reject expressivism. The broad faculty of language might be seen to arise from infant use of resources for persuasion, attention-management, and pragmatics.

Anti-expressivists like Carruthers (1996), Clark (1997), Dennett (1991), Linell (1982), Love (2004), and Ross (in press) provide diverse reasons for rejecting code-models. Although taking contrasting views on the "computational core" (sect. 12) of language, all see *thinking* as intrinsic to verbal events. Specifically, Linell (in press) rejects code views because language, mind,

and brains are dialogical. Such a perspective, I think, enhances the life history view. Intentional activity, vocalizing, and attention management come to depend on systems of neural control. With the evolution of *total* development, selective advantage goes to individuals who are skilled in sustaining dialogue. Instead of interrogating such views, however, L&B stick with the input-output picture. This conservatism shows especially in relation to humans under three years of age. Not only are infants seen as largely untouched by childhood or development, but L&B have no interest in how they use attention, affect, and nonverbal expression. Indeed, L&B's life history model ignores the use of cultural norms (Cowley et al. 2004; Trevarthen 1988), joint activity (Tomasello 1999), the narrating self (Dennett 1991; Fogel et al. 2002; Nelson 1996), and how brains accommodate silent thinking (Wheeler 2004). Instead of asking how interaction shapes talking persons, infants are taken to become human when an inner faculty starts to operate on linguistic forms.

Beyond selection due to nature, kin, and sexual choice, L&B emphasize that social sensitivity may be augmented by selected parental abilities. Given commitment to code views, however, no role falls to *cultural* selection. Even though using parental beliefs, human infants differ from other primates only because "social stimulation" gives "quality" (sect. 2.1) to their lives. Indeed, for L&B, cross-specific comparison makes it appropriate to define infancy as lasting to the age of three. By this stage, as noted, the structure of language is thought to be "laid down" (sect. 2.2). Although "some degree of integration" (sect. 12) occurs between pragmatics, performance, and structure, selection sensitizes only parents to expressive biomechanics. This is odd in a theory where code-models are linked with writing and vocal-verbal signaling with primate abilities. It is even more so in cognitive science where, today, many trace verbal forms to social evolution (see Kirby & Christiansen 2003) and grammar is increasingly seen as cultural (Deacon 1997; Tomasello 2003). For L&B, however, the evolution of development benefits infants through mechanisms like trickle-up phonetics, an instinct for inventiveness, and increased parental sensitivity. Cascading facilitates them neither in assessing and managing adults, nor in using affect to shape interaction.

L&B's linguistic individualism blemishes the life history model. If the evolution of development cascades onto modern infants, we would expect sensitive reaction and response to adult dynamics. Given cultural selection, infants would gain from linking verbal patterns with resources used in pragmatics, performance, and attention management. With Skinner, Bruner, Tomasello, and Hauser (among others), interaction might be a crucial *locus* of learning. Torn from an input-output model, indeed, life history might be used to interrogate how dynamics alter human cognition. For example, adults may design interactional events to prompt infants in using selected natural and cultural resources. Learning to talk may draw on how, in real time, adults use verbal patterns to construct social events. No purely internal language faculty could exploit the fluidity of interaction. Accordingly, L&B do not link life history with cognitive dynamics. Instead of challenging linguistic individualism, they focus on a modest goal. Even if we adopt a code-model, they show, the evolutionary process will use the whole of life history.

The phylogeny and ontogeny of adaptations

Thomas E. Dickins

School of Psychology, University of East London, London E15 4LZ; and Centre for Philosophy of Natural and Social Science, London School of Economics, London WC2A 2AE, United Kingdom.

t.dickins@uel.ac.uk

http://www.uel.ac.uk/psychology/staff/tom_dickins/index.htm

Abstract: Locke & Bogin (L&B) rightly point to the absence of ontogeny in theories of language evolution. However, they overly rely upon ontogenetic

data to isolate components of the language faculty. Only an adaptationist analysis, of the sort seen in evolutionary psychology, can carve language at its joints and lead to testable predictions about how language works.

Locke & Bogin (L&B) begin their paper by describing the recent history of scholarship in language evolution. The key point they draw out is that ontogeny has been largely ignored, and their aim is to rectify this omission. What they do not state is that most of the work has been on phylogeny; research has predominantly focused upon the evolutionary transitions that may or may not have led to human language as it is now.

Mapping out phylogenies is not the only use for evolutionary theory. Evolutionary psychology (EP) is in the business of individuating traits through adaptationist analyses, such that organisms are looked at in terms of the ecology in which they live and predictions are made about the kinds of psychological adaptations (mechanisms) required to meet ecologically relevant task demands (Andrews et al. 2003; Dickins 2005). Sometimes this is done against a backdrop of hypothesised environments of evolutionary adaptedness, and such hypotheses are generated from, among other things, comparative data. This kind of functional analysis provides key constraints for subsequent discussion of proximate mechanisms.

If we accept that language has evolved, and there is little reason not to, we can then apply EP reasoning to the subject matter – language itself. By carefully thinking through the adapted functions that language delivers we can begin to individuate components of this faculty. Then, once we have an EP theory of language we can, perhaps, begin to think about its phylogeny, for we know what has been selected for. This is a long project, and not without methodological problems, not least the absence of fossil evidence; but anything else would run the risk of generating just-so stories. However, once the EP project has been completed it is hard to imagine what use phylogenetic hypotheses could be put to other than to demonstrate that the already isolated adaptations could have evolved.

Ontogenetic hypotheses can be used slightly differently from phylogenetic ones, in that they can be tested in the laboratory and, in so doing, aid in the individuation of psychological adaptations. Nonetheless, before one goes into the lab one needs to propose a sound evolutionarily based hypothesis about how ontogeny would pan out. Again, adaptationist analysis should come first.

L&B appear to have operated a somewhat mixed strategy, but one that mostly falls in line with the tradition of speculating on phylogenies. Their initial observations about what language is clearly originate from thinking about its adapted functions. So, as with much contemporary EP, they see language as fulfilling a variety of social signalling tasks. What is more, they move away from the traditional Chomskyan focus upon grammar and content, and note that language is a many-stranded communication system. They rightly point to the qualities of voice, pragmatic inference, and verbal fluency, among many other things, as sources of signal and information. However, they only use this insight to broadly define the aspects of language they are interested in. After this, L&B go on to outline various key features of language development, which they in turn use to speculate about phylogeny. So, they note that as we develop from infancy to adulthood social contexts become more complex and this is matched by increased communicative sophistication. In particular, they claim that adolescence is a period of near-adult social complexity in which the rules of adult life can be learnt and to some extent implemented without the cost. During this period, language develops such that grammar becomes more sophisticated, speech is more fluent, more and more pragmatic communication is engaged in, and the native language is modified. Adolescence sees the onset of gossiping about others, as well as “joking, deceiving, mollifying, negotiating, and persuading, with increases in the use of sarcasm” (sect 2.8). In brief, the social uses of language become more prevalent.

L&B discuss the possibility that human infancy has been foreshortened by natural selection in order to allow maternal resources to be diverted to new offspring more rapidly, and that this in turn led to childhood. Children are semi-independent and require less care, and, importantly for L&B, are able to engage in verbal interactions with adults that will shape their linguistic development. It is during this period that what could be referred to as a Chomskyan basis for linguistic communication is established. L&B further hypothesise that the social practice functions of adolescence were directly selected for and this allowed for the emergence of the other strands of linguistic communication discussed above.

L&B have essentially married detailed observations about language development with a loose thesis about the phylogeny of ontogeny, and without engaging in a detailed adaptationist analysis. They are undoubtedly right that ontogeny is a product of natural selection, and their life-history approach, which looks at maternal trade-offs, makes evolutionary sense. But it is unclear what predictions we can now make about the kinds of proximate mechanism underlying language that we could not make prior to this argument. One reason for this is the slight circularity of the adolescence argument. By observing how adolescents use language, and assuming that this life-stage is a product of natural selection, L&B suggest that the social complexities of adolescence drove selection for the social signalling functions of language. But it is equally possible that social complexities were able to emerge as a consequence of social signalling abilities. There is nothing in the current argument that can resolve this, and no obvious testable predictions are made.

The target article concludes by stating that the various strands of language “were stitched together in evolution, as they are in modern times, by the whole of human ontogeny” (sect. 14). This is a different claim from the authors’ predominant one that developmental stages were selected for – indeed, this is a claim for a role for ontogeny in phylogeny, and is perhaps the main point L&B wish to make. But it does not follow from any of their observations. Developmental stages, as L&B have discussed, are the consequence of evolution through natural selection. Any developmental “decision” made by natural selection will have consequences that in turn may provide selection pressures and lead to phenotypic change, but this is not coded into the developmental process. In this way, ontogeny does not stitch together various capabilities in phylogeny, but rather specific ontogenetic pathways are selected for and this establishes further selection pressures, the outcomes of which are readily observable in contemporary development.

L&B are right to discuss ontogeny and right to think about the multiple strands of language, but they should have moved away from historical speculation and toward EP if they wished to have made substantive and testable claims about the nature of the language faculty.

The evolution of language: Present behavioral evidence for past genetic reprogramming in the human lineage

Robert B. Eckhardt

Laboratory for the Comparative Study of Morphology, Mechanics, and Molecules, Department of Kinesiology, Pennsylvania State University, University Park, PA 16802.

eyl@psu.edu

Abstract: Language and life history can be related functionally through the study of human ontogeny, thus usefully informing our understanding of several unique aspects of the evolution of species. The operational principles outlined by Locke & Bogin (L&B)

demonstrate that the present can provide a useful framework for understanding the past.

My own perspective on “Language and life history” is conditioned by an extended period of familiarity with the writings of one of the authors. For more than a decade I have used two editions of Barry Bogin’s *Patterns of Human Growth* (1988; 1999) as main texts in an upper-level undergraduate course titled Human Growth and Development. On first reading the target article against this background, I recalled the critical comment once offered by Samuel Johnson with ungentle pithiness: “Your work, Sir, is both new and good, but what’s new is not good and what’s good is not new.” However, the work by Locke & Bogin (L&B) merits a much more positive assessment: What is not new (elucidation of the stages, shared and unique, in human life history) remains as good as it ever was, and what is new (the extension of this perspective to furthering our knowledge about the evolution of human language) is even better.

Most readers of *Behavioral and Brain Sciences* are likely to be specialists in functional rather than evolutionary biology; however, as is the case with the authors of the target article, my scientific work overlaps both domains. As a help toward relating these contrasting perspectives, I will paraphrase here part of a keynote address by Bruce Latimer that was delivered to the 2005 joint meeting of the American Society of Biomechanics and the International Society of Biomechanics: Scientists who work with living subjects (from elite athletes endeavoring to set new records to stroke victims and other patients undergoing rehabilitation work) have problems for which solutions must be found. But those of us who study the fossil record of past human evolution can see the adaptive solutions that nature has evolved; it is our challenge to reconstruct the problems that required these solutions in the first place.

The work of L&B is particularly fascinating because it begins with a set of problems, the so-called “obstetrical dilemma” triggered by the assumption of upright posture and bipedal locomotion, that has been the focus of much recent work by my own research group and our close colleagues in several other countries (e.g., Galik et al. 2004). This research has enabled us to establish the origin of bipedalism at about 6 million years before the present, thus bounding the earliest temporal limits of the human lineage that uniquely evolved language. The synthesizing work by L&B goes beyond the limitations of human fossil evidence by using developmental clues still perceivable in human ontogeny to attempt to tease out the stages that must have existed between the rudimentary forms of communication in living chimpanzees and those characteristic of our own species. This sort of approach, escaping the confines of so-called hard evidence by reasoning from soft tissue features and behaviors existing in present populations to comparable attributes in ancestral groups, holds much promise (Eckhardt 2000). It therefore is no criticism to characterize this target article more as a step in the right direction than an ultimate formulation of some end point in our understanding of the evolution of those aspects of brain and behavior science concerned with human language – or even to note that a few of its more unusual ideas have been anticipated (Livingstone 1973).

I suspect that some paleoanthropological colleagues may feel that the approach taken by L&B departs too much from traditional reliance on the hard evidence. But recently the new species *Homo floresiensis* has been hypothesized on the basis of a single skull with a chimp-sized brain of about 400 cc, yet with the supposed behavioral capacity to have manufactured stone microblades as part of complex tools heretofore found associated only with large-brained humans capable of speech. This is a dubious proposition for which there is a better alternative explanation in terms of human biology (Henneberg & Thorne 2004). Appropriate use of developmental clues inferred

from living populations promises to provide an approach to behavioral inference in which broadly based theory trumps a narrow evidential base.

Enduring excitement in the brain and behavior sciences will be found in the solid advance of knowledge through hypothesis generation and testing of the sort offered by L&B, rather than through journalistic sensationalism.

Road to language: Longer, more believable, more relevant

R. Allen Gardner

Psychology Department, University of Nevada – Reno, Reno, NV 89557.
gardner@unr.edu

Abstract: A realistic developmental view of language acquisition recognizes vocabulary and pragmatics as well as grammar with a lengthy period of growth in a favorable environment. Cross-fostering is a tool of behavioral biology for studying the interaction between genetic endowment and developmental environment. Sign language studies of cross-fostered chimpanzees measure development in a nearly human environment.

Theoretical linguists of the last century seemed to deny human development.

We are presenting an “instantaneous model” of language acquisition which is surely false in detail, but can very well be accepted as a reasonable first approximation. (Chomsky 1967, pp. 441–42)

Early followers of Chomsky supported his instantaneous model.

Children all over the world learn to speak their native language at approximately the same time – 3 to 4 years of age. Within a relatively brief period, the child appears to learn a complicated and abstract system of rules . . . without teaching or training, [they] acquire their native language at about the same time – regardless of just about any variable one cares to look at, short of deafness or severe retardation. (Moore 1973, p. 4)

Chomsky’s instantaneous model flattened the landscape of development from toddler to college student. Repeatedly, loyal Chomskians found virtually complete grammar in the speech of the same four-year-olds who cannot yet tie their own shoelaces or use a knife to spread jam on a cracker (Cohen & Gross 1979).

Locke & Bogin (L&B) recognize vocabulary and pragmatics, as well as grammar, and emphasize human development from infancy through adolescence. Their road to language is longer, more believable, and more relevant. They relate detailed aspects of linguistic skill to human development, doing justice to linguistic development as a biological phenomenon. Immature humans hardly spend their lengthened childhood vegetating, they spend it interacting with their parents and their culture.

Evolutionary biologist, Lewontin puts it this way:

We are not determined by our genes, although surely we are influenced by them. Development depends not only on the materials that have been inherited from parents – that is, the genes and other materials in the sperm and egg – but also on the particular temperature, humidity, nutrition, smells, sights, and sounds (including what we call education) that impinge on the developing organism. (Lewontin 1991, p. 26)

Genetic advances in agriculture produce new breeds that are dramatically different from parent stocks. Under contrasting conditions, seeds that are virtual clones mature into dramatically different plants, often so different that they are hardly recognizable as the same species. Animal agriculture reveals equally dramatic interactions between genes and environment. Behavioral development should be more sensitive to environment, and advanced behavior, such as language, should be still more sensitive.

Actual studies of children contradict Chomskian dicta:

[D]escriptions of mothers' speech to young children were undertaken in the late sixties in order to refute the prevailing view that language acquisition was largely innate and occurred almost independently of the language environment. The results of those mother's speech studies may have contributed to the widespread abandonment of this hypothesis about language acquisition but a general shift from syntactic to semantic-cognitive aspects of language acquisition would probably have caused it to lose its central place as a tenet of research in any case. (Snow 1977, p. 31)

Again according to evolutionary biologist Lewontin (1991),

The trouble with the general scheme of explanation contained in the metaphor of [genetic program] is that it is bad biology. If we had the complete DNA sequence of an organism and unlimited computational power, we could not compute the organism, because the organism does not compute itself from its genes. Any computer that did as poor a job of computation as an organism does from its genetic "program" would be immediately thrown into the trash and its manufacturer would be sued by the purchaser. (p. 17)

L&B emphasize lengthy human development from infancy to adolescence. A human child develops by interacting and experiencing rather than by incubating and unfolding like a flower in a pot. In behavioral biology, cross-fostering – parents of one genetic strain rearing infants of another genetic strain – is a tool for studying the critical interaction between genetic endowment and developmental environment (Goodenough et al. 1993; Stamps 2003). Cross-fostered gulls adopt species-specific migratory habits of their adoptive parents (Harris 1970). Cross-fostered cockatoos adopt species-specific flying and feeding habits of their adoptive parents (Rowley & Chapman 1986). Cross-fostered voles adopt species-specific maternal habits of their adoptive parents (McGuire 1988). B. T. Gardner and Gardner (1989) cross-fostered infant chimpanzees in nearly human households to study the effect of a human developmental environment on a closely related species.

In Gardner and Gardner (1980) early sign language vocabularies of chimpanzees Moja, Pili, Tatu, and Dar overlapped with early vocabularies of human children as much as child vocabularies overlap with each other. L&B's lengthy developmental road to language implies a gradual, stage-by-stage process. In B. T. Gardner and Gardner (1998) semantic relations, that appeared in the early phrases of Moja, Tatu, and Dar, appeared in the same developmental sequence reported for human children. Nominative and action phrases appeared first, attributives second, and experience/notice latest in developmental samples of children and cross-fostered chimpanzees.

L&B emphasize pragmatic development. In studies of casual conversation (Bodamer & Gardner 2002; Jensvold & Gardner 2000), cross-fostered chimpanzees used expansion, reiteration, and incorporation to maintain the topic of a conversation as human adults and human children do. Contingencies of chimpanzee rejoinders to probes were comparable to contingencies reported for human children and, in adult cross-fosterlings, more comparable to older children than to younger children.

In Shaw (2000), adult cross-fosterlings integrated gaze direction and turn-taking into conversation the way human speakers and signers integrate gaze direction and turn-taking into their conversation with a pattern of development from infant to adult that resembles human development. Both directional modulation to indicate person, place, and instrument, and quantitative modulation to indicate intensity are essential pragmatic features of human sign language. In Rimpau et al. (1989) and Chalcraft and Gardner (2005), directional modulation to indicate person, place, and instrument appeared in conversational samples of Dar and Tatu as infant cross-fosterlings. In Chalcraft and Gardner (2005), quantitative modulations observed in human sign language also appeared in Tatu's infant conversation.

This article by L&B moves squarely in the path away from doctrinaire theory and points forward to open-ended discovery as expressed so well by Bruner (1978):

bridging of gaps that before were not so much empty as they were filled with corrosive dogmatism. The gaps between prelinguistic communication and language proper as the child develops, the gap between gesture and word, between holophrases and sentences, between chimps signing and man talking, between sign languages and spoken ones, between the structure of action and the structure of language. I think that the renewal of interest in language as an interactive, communicative system has made these "gaps" less like battle grounds where one fights and dies for the uniqueness of man and more like unknown seas to be mapped. (p. viii)

Dynamic systems and the evolution of language

Lakshmi J. Gogate

Psychiatry #1203, State University of New York Health Science Center at Brooklyn, Brooklyn, NY 11203.

Lakshmi.Gogate@downstate.edu

Abstract: Locke & Bogin (L&B) suggest that theoretical principles of ontogenetic development apply to language evolution. If this is the case, then evolutionary theory should utilize epigenetic theories of development to theorize, model, and elucidate the evolution of language wherever possible. In this commentary, I evoke principles of dynamic systems theory to evaluate the evolutionary phenomena presented in the target article.

Locke & Bogin (L&B) underscore the role of ontogeny in evolution, to set it apart from several recent language evolution proposals that have ascribed a less significant role to ontogeny (e.g., Christiansen & Kirby 2003a; but see Johansson 2005, p. 31; also Oyama et al. 2001 for a general theory). L&B's account is comprehensive, with recent, much-needed research constituting its foundation. Specifically, they illustrate an important connection between evolving increases in the duration spanning childhood, culminating in a unique developmental phase in humans – adolescence – and evolving language abilities. The general perspective adopted in this article, however, is not entirely new. It echoes Oyama's (2001) general idea that processes of evolution and development bear striking similarities (Studdert-Kennedy [1991] provides a similar view on language; also see Haeckel 1899).

Throughout the target article, by adopting the life-history framework, the authors advocate that theoretical principles and phenomena of ontogenetic development are applicable to language evolution. For example, articulation and phonology were likely precursors to syntax in language evolution as in ontogeny. If indeed ontogeny and phylogeny are closely related in this manner, then evolutionary theory could benefit exponentially from adopting epigenetic theories of ontogenetic development to theorize, model, and elucidate, wherever possible, aspects of the evolution of language in humans. In this commentary, therefore, I draw upon three principles of epigenetic theories of development, in particular *dynamic systems theory* (henceforth DST; Thelen & Smith 1994; 1998; cf. Lickliter, in press; Oyama et al. 2001), to evaluate and highlight some evolutionary phenomena elaborated upon by L&B. The primary purpose of this exercise is to integrate the principles underlying, and draw parallels between, changing systems of lifespan and species-specific development. After all, the forces that drive species to evolve can be explained only within a framework that makes explicit (a) the principles underlying the dynamics of complex biological systems, and (b) the multiple causes that drive dynamical systems to change over numerous time scales, within and beyond the lifespan.

According to DST (Thelen & Smith 1998; cf. Lickliter, in press; Oyama 2001), form is a product of process: *Changes in developing systems are not predetermined by a grand design*. To the contrary, they are shaped at the local level during the process of an organism's interaction with its immediate environment. Similarly, the evolution of language did not take place in a vacuum (Johansson 2005). Evolutionary changes culminating in language were the result of selectional pressures at the local level, always shaped by interactions between members of the species and their immediate environment. L&B provide rich examples of these local-level selectional pressures that resulted in key changes that, in turn, facilitated the onset of language in evolving humans. For example, extension of the period of brain volume increase into postnatal life, to ease the obstetric problem of cephalo-pelvic disproportion in human females (caused by bipedalism), likely caused increased dependency of infants on adults, requiring extensive postnatal care. Greater physical handling by human caregivers, in turn, resulted in greater social stimulation and infant-caregiver interaction, and greater neurological development, eventually facilitating language in humans.

The preceding example also highlights a second tenet of DST: *multiple causality in emerging systems*. According to this tenet, changes occurring in a system – neurological, physiological, or behavioral – are the complex product of interaction between many factors at multiple levels (Lickliter, in press). Therefore, attributing primary causal status to any one factor or level is inadequate. This tenet, also applicable to language evolution, is well represented in Oyama's idea that change occurs via interactive co-construction: "The idea of construction through interaction of many different factors is applicable to evolution as well as development, and it highlights striking similarities between the two processes" (Oyama 2001, p.6).

Third, according to DST (Thelen & Smith 1998), *stability or lack of variability is inimical to change*. Changes in an emerging system are driven by instability or perturbations (at the local level) during ongoing organism-environment interactions (Kelso 1997). Therefore, a few collective variables, if accurately identified, and the collective organism's ability to self-organize in response to the changes in these variables (or control parameters) can explain change at any given point in time. To identify these control parameters, evolutionary theory must turn to robust empirical findings from life-span development, as prescribed and practiced in the target article.

Finally, because much theorizing about how language evolved depends on post hoc evidence from ontogeny or life-history, as the authors suggest, predicting changes along extended time-scales might be possible by turning to the newly emerging field of *epigenetic robotics*. In this field, computational modeling of human development and its dynamics over multiple time scales is feasible. It involves the design and construction of artificial systems with adaptive, developmental algorithms, using key parameters that constitute specific behaviors of developing natural systems (Blank et al. 2005; see review by Prince et al. 2005). Future epigenetic models of language evolution would require architecture that is not fully specified. Fully specified systems are by nature predetermined by a grand design (e.g., see Hurford 2002; Kirby 1999b). These systems neither *develop* nor *evolve* by adapting to their local environment, and therefore are not accurate models of natural evolutionary processes. An alternative approach to modeling evolutionary changes in biological systems would require designing artificial systems to simulate self-organizing behavior and ongoing environmental interactions over extended time scales. These systems would adapt to perturbations at a local level (or levels).

In conclusion, future models of language evolution would need to include key parameters that do not fall strictly within the language domain. For example, consistent with developmental theory (e.g., Gogate et al. 2001; 2006), models of language evolution should find it useful to include the sensory and intersensory precursors to language development, to accurately model the

process of language evolution from basic perceptual processes (Dominey & Boucher [2005] model syntactic acquisition using auditory and visual inputs; Prince & Hollich [2005] model infant auditory-visual perception and word-mapping). This domain-general approach to modeling language evolution would complement the multi-domain perspective embraced by L&B in their life-history approach to language evolution.

Why don't chimps talk and humans sing like canaries?

Sverker Johansson,^a Jordan Zlatev,^b and Peter Gärdenfors^c

^aSchool of Education and Communication, University of Jönköping, Jönköping, SE-551 11, Sweden; ^bDepartment of Linguistics, Center for Language and Literature, Lund University, Box 201, Lund, SE-221 00, Sweden; ^cCognitive Science, Kungshuset, Lundagård, Lund University, Lund, SE-222 22, Sweden.

lsj@hik.hj.se <http://home.hj.se/~lsj> jordan.zlatev@ling.lu.se

<http://www.ling.lu.se/persons/JordanZlatev.html?language=English>

peter.gardenfors@lucs.lu.se

<http://www.fil.lu.se/lucs/staff/person.asp?id=42>

Abstract: We focus on two problems with the evolutionary scenario proposed: (1) It bypasses the question of the origins of the communicative and semiotic features that make language distinct from, say, pleasant but meaningless sounds. (2) It does little to explain the *absence* of language in, for example, chimpanzees: Most of the selection pressures invoked apply just as strongly to chimps. We suggest how these problems could possibly be amended.

We agree with Locke & Bogin (L&B) on the importance of considering ontogeny in evolutionary studies. The unusual human developmental pattern may indeed provide insights concerning language origins. The emphasis of L&B on functional and pragmatic aspects of language is likewise commendable. However, these need to be integrated within an account of the origins of the semantic and grammatical aspects that make language a unique semiotic system allowing the communication of *detached representations* (Gärdenfors 2003) and the construction of narrative (Donald 1991). Since this is not the case, there are at least two major problems with the specific selective scenarios proposed by L&B.

Why not just sing? A major feature of language distinguishing it from all animal vocalizations is its ability to express an endless number of *thoughts* in various complex *combinations*. A plausible scenario of language origins needs to explain this enormous expansion of semiotic functionality. But Bickerton's argument against Dunbar's (1993) verbal-grooming hypothesis, about which he writes "a similar result could have been achieved simply by using pleasant but meaningless noises" (Bickerton 2003, p. 79), applies to a considerable extent against L&B's scenario as well. Or as an informant of Folb (1980), quoted by L&B, puts it: "Don' hafta make whole buncha sense, long sounds pretty" (sect. 7 of the target article).

The first stage in L&B's two-stage scenario concerns parental-care elicitation during infancy and childhood. There are certainly strong selective pressures at work here, but, as noted by L&B, the interests of parents and offspring do not coincide. This would more likely drive the evolution of manipulative signals rather than cooperative interaction and communication, as it has, for example, among many birds.

The second stage concerns sexual selection among adolescents and young adults. The common theme in L&B's lengthy discussion of oral societies is the importance of form and presentation over content. One would reasonably expect this to drive the evolution of ever more elaborate form – but why would it drive the evolution of content? Isn't it more likely that a scenario driven by sexual selection and status competition would result in something more resembling birdsong than language? Invoking sex and

status as important factors in language origins is in itself not implausible. But in order to explain the distinguishing features of language, selection for content must be part of the scenario. The proposal of Miller (2000), discussed by L&B at the end of section 5, goes in the right direction: "Language put minds on public display, where sexual choice could see them clearly" (Miller 2000, p. 357, quoted in L&B). Related ideas are proposed by Dessalles (2000), in which status is gained through public speech containing *relevant information*, thus placing selective pressure squarely on the ability to provide content. L&B do refer to the work of Dessalles, but by focusing too much on form rather than content, they leave a gaping hole in their argumentation.

L&B do attempt to motivate the primacy of vocal abilities over grammar in their scenario, by arguing that it makes more sense for speech to evolve before syntax than vice versa. This is not self-evident, for several reasons. First, grammar is not just "syntax" but *patterned content*, which has been emphasized for decades by functional and cognitive linguists (e.g., Langacker 1987). But L&B don't even refer to this healthy tradition and mistakenly seem to equate "linguistics" with Chomskyan linguistics. From the cognitive perspective, it is completely possible that manual gestures and bodily mimesis provided the basis for propositional structure (Armstrong et al. 1995; Corballis 2002; Donald 1991; Zlatev et al. 2005), a possibility that L&B shunt aside in a footnote. And even if speech were the original modality, coevolution between speech capacity and grammar should not be discounted.

In brief, by separating vocal abilities from content and grammar, the scenario of L&B is hardly a scenario for *language* origins anymore. The aspects of language that are uniquely human remain unexplained.

And why not chimps? In the case of specifically human adaptations like language, it is not enough to present an evolutionary scenario showing how useful language would be for our apelike ancestors. The question that needs to be answered is not just why our ancestors evolved language, but also why chimps did not, even though we share a fairly recent common ancestor. It must be shown that language was useful and adaptive specifically for proto-humans *and not* for proto-chimpanzees. Many language-origin scenarios fail this test (Bickerton 2002; Gärdenfors 2004; Johansson 2005).

Using vocalizations strategically in the context of parental-care elicitation is hardly unique for humans – many birds and mammals, including primates, do so. Given that human childhood as defined by L&B is the result of earlier weaning, that is, a *decrease* in parental care allowing diverting resources from the current child to its future siblings, it is not clear how this can function as a selection pressure for human toddlers to be *better* at eliciting care than their chimp cousins, who still manage to get breast-fed at that age.

In the vocal competition among adolescents, impressiveness and attention-holding are important factors. As noted by L&B in the beginning of section 5, the same factors are important in establishing status also among nonhuman primates. Again, it is not at all obvious why this led to language among proto-humans but not proto-chimps, despite both being subject to similar selection pressures in similar contexts.

Similarly, at the end of section 9.1, L&B claim that for young hominids "even a small amount of vocal-verbal behavior would have facilitated warnings and instruction," but they do not explain why the same mechanisms would not apply to proto-chimps.

Still, we do believe that buried in L&B's account there is the germ that may save them from the "why not apes?" test. It is spelled out in section 13: "bipedalism is ... a key event ... for this ... produced, in time, pelvic narrowing. Remodeling of the birth canal caused a shift of skull and brain development into the postnatal period, increasing the degree and duration of infant helplessness" (target article, sect. 13, para. 2). This

together with the need of bipedal mothers to *carry* their young, would have led to the need for more *cooperation* rather than competition between mothers and infants, and to an increase in the quality of dyadic interactions in the form of mutual gaze, mutual imitation, and proto-conversations (Falk 2004). These are species-typical characteristics of human beings laid down in the first nine months of life, and serving as the basis for the development of joint attention and pointing in the second year (Hobson 2002; Tomasello et al. 2005), which are milestones of infancy bootstrapping into language – of which L&B say nothing.

Conclusion. L&B's basic proposal that there may be connections between these two uniquely human features, language and life history, is interesting and worth pursuing further. But more care should be taken in designing selection scenarios, so that the proposed selection pressures actually work in the right direction, towards the development of the "socially shared symbolic system" (Nelson & Shaw 2002) – that is, language – in the human lineage only.

The evolution of childhood as a by-product?

Peter Kappeler

Department of Sociobiology/Anthropology, University of Göttingen, 37073 Göttingen, Germany.

pkappel@gwdg.de <http://www.sozio.uni-goettingen.de/>

Abstract: The proposition that selective advantages of linguistic skills have contributed to shifts in ontogenetic landmarks of human life histories in early *Homo sapiens* is weakened by neglecting alternative mechanisms of life history evolution. Moreover, arguments about biological continuity through sweeping comparisons with nonhuman primates do not support various assumptions of this scenario.

The evolutionary scenario concerning the interaction between life history and language evolution developed by Locke & Bogin (L&B) suffers from two weaknesses. First, while L&B's focus on early stages of the life history cycle is new and laudable, they fail to recognize the possibility that shifts in the relative duration of early life history landmarks can also be brought about by selection on fitness-relevant traits or events later in life. Selection on a delay in the age of first reproduction is the best-studied example in this context (Promislow & Harvey 1990). It is therefore not necessarily the case that "Selection for vocal ability, and, ultimately, for language would thus have worked reciprocally to extend childhood" (sect. 2.4 of the target article). Developmental and evolutionary processes are not clearly separated in their life history model. It is therefore at least equally plausible that age of first reproduction has been delayed further in *Homo sapiens*, compared to *Pan*, *Australopithecus*, and other species of *Homo*, for adaptive reasons unrelated to language, and that the extra time that became available for juveniles was subsequently used to develop more refined linguistic skills. Alternatively, linguistic skills acquired early in life may have offset some of the costs of delayed maturity. The hypothesis that these skills were rewarded later in life through mate choice, as originally proposed by Miller (2000), is convincingly elaborated by the authors. However, these benefits accrue primarily to males, whereas life history evolution acts primarily on females (Stearns 1976) – a discrepancy also not addressed by the authors' life history model.

Second, when discussing various aspects of language development, the authors use several primate examples in an attempt to support their arguments. However, some of these examples consist of sweeping generalizations across species, sexes, and age classes that provide weak analogies, at best, to support claims about human uniqueness or biological continuity. The fact that a behavior pattern exists "in primates" does not logically imply that early humans behaved the same way. There is too much variability in behavior among the hundreds of species of

living primates for such generalizing claims, and we know very little about relevant behavioral attributes in extinct primates (Plavcan & van Schaik 1997). The parental selection hypothesis (sect. 3.2), for example, supposes that infant stress vocalizations invite neglect and abuse “in primates generally.” Whether the majority of the more than 300 living primate species will exhibit the same response remains to be studied, but in the few primate species where mother-infant interactions have been studied in any detail, this is not the case (Gouzoules & Gouzoules 2002). Generalizations in the opposite direction are equally unhelpful. For example, the assertion that “apes and monkeys do not vocalize as often as humans” (sect. 3) can be refuted with examples of dozens of primate species that permanently utter vocalizations. Humans are therefore not unique in this respect. Thus, although this article presents some interesting new approaches to the discussion of the origins of language, I doubt that it will be the final word on this topic.

Apes, humans, and M. C. Escher: Uniqueness and continuity in the evolution of language

Barbara J. King

Department of Anthropology, College of William and Mary, Williamsburg, VA 23187.

bjking@wm.edu

<http://www.councilhd.ca/announce/announce.htm>

Abstract: Ontogeny, specifically the role of language in the human family now and in prehistory, is central to Locke & Bogin’s (L&B’s) thesis in a compelling way. The unique life-history stages of childhood and adolescence, however, must be interpreted not only against an exceptionally “high quality” human infancy but also in light of the evolution of co-constructed, emotionally based communication in ape, hominid, and human infancy.

Locke & Bogin (L&B) bring together convincing data on primate life-history stages with informed speculation about the evolution of language. I limit my comments to the relationship between the evolution of language and the infancy life-stage.

Central to that part of L&B’s argument are the following assertions:

1. Few recent proposals about the evolution of language have given a primary role to matters of ontogeny.
2. In humans, the life-history stages of childhood and adolescence are added to the three stages – infancy, juvenility, and adulthood – found in other social mammals.
3. Compared to other primates, the quality of human infancy is enhanced by greater social stimulation of offspring by their parents. L&B’s parental selection hypothesis suggests that infants who were better at vocal engagement with their parents secured greater care and, in turn, learned more complex phonetic patterns. Then, with the advent of uniquely human childhood, and in the context of the family, new opportunities arose that drove the evolution of language via “negotiation of more structured and complex forms of vocalization” (sect. 9).

L&B’s emphasis on parent-infant engagement in the context of the family is a welcome addition to a swelling cache of theoretical formulations that – contra the first statement above – place ontogeny front and center when reconstructing the evolution of language from nonhuman primate communication. Humans communicate across the generations not as encoders and decoders of information using syntax and semantics but as emotionally attuned creatures who create meaning together as they go about their daily lives. An emphasis on the evolution of this emotional engagement (Greenspan & Shanker 2004; Mithen 2005) is crucial as scholars across the disciplines apply themselves with renewed excitement to experimental and theoretical work on the evolution of language (Fitch 2005). Crucially, it argues

against a current vogue to “fraction[ate] language into multiple interacting components” (Fitch 2005, p. 216). “Fractionating” means looking at speech, syntax, and semantics as discrete systems in order to trace their evolutionary roots separately. Some insights do emerge from this approach, but real progress requires that “mechanisms” of language be considered in the context of the ontogeny of meaning-making – that is, in a context that situates the origins of language in parent-child caregiver practices.

Some progress has been made already. Startlingly, L&B construct their parental selection hypothesis without reference to ontogeny-focused scenarios by Borchert and Zihlman (1990), Falk (2004), Parker (2000), or Savage-Rumbaugh (1994). Collectively these formulations support a view of *Homo* infants as supremely vulnerable, owing to the coupling of bipedalism and big brains. More importantly, they indicate that L&B’s claims for human uniqueness (statements two and three above) are best supported by a firm grasp of the continuity in development of meaning-making in apes and humans. This simultaneous embracing of human uniqueness, on the one hand, and of continuity with our closest living relatives, on the other, is no paradox. Rather, it is reminiscent of Escher’s famous drawing in which a hard look transforms fish-in-the-water to birds-in-the-sky. Look one way at the evolution of language and what comes into focus is human uniqueness; look another and you will see ape-human continuity.

For wild and captive apes, emotional engagement of infants with their mothers, siblings, and other social partners motivates, and even more so enables, the expression of certain (though not all) communicational skills. Writing together and separately (Fogel et al. 2006; Greenspan & Shanker 2004; King 2004; King, in press; Shanker & King 2002), Stuart Shanker and I have laid out a series of ideas about the evolution of affective meaning-making that are grounded in data from apes and children. We argue that the “vocal-verbal” advances highlighted by L&B (see, e.g., sect. 3.2) evolve from the multimodal communication of primates already highly skilled, from infancy onwards, at participating in mutually constructive meaning-making. Our understanding of meaning-making involves not the conduit-like transfer of information from sender to receiver in linear fashion, but rather the mutual transformation in the actions, and perhaps the thoughts and moods, of two partners in the contexts of ever-changing interactions (see also Reddy 1993). Posture, gesture, and facial expressions are central here, as well as vocal behavior.

To say that after the second birthday, “infants develop a suite of cognitive traits that will enable language to be used at a basal level of creativity and efficiency” (sect. 2.2) is, then, awkward shorthand at best. It is not cognitive traits alone that enable increasingly proficient language usage, but also the emotional engagement of infants with their caretakers; this back-and-forth communication, playful and loving in some cultures, serious and less explicitly affective in others, unlocks and indeed helps to create the infant’s abilities. What *Homo sapiens* parents and infants do together, they have evolved to do together; vocal-verbal behavior increases in importance while remaining part of a communication system that is multimodal.

The “greater handling required by the human infant” as a result of the shift from quadrupedalism to bipedalism does produce “more intense social stimulation during a period in which the brain grows at a compensatorily rapid rate” (sect. 2.1). Secondarily, altricial human babies are appreciably different than ape babies; brain-growth pattern are distinct in the *Homo* lineage. Yet the parental social stimulation of infants in hominids and *Homo sapiens* evolved from a strong foundation of emotional engagement present in our ape ancestors. The linguistic accomplishments in later life stages in *Homo sapiens* flow from the powerful dynamic foundation set in infancy, and, indeed, should vary with the emotional signature of that parent-infant interaction. Testable predictions at both the phylogenetic and

developmental levels follow logically – for example, greater contingency and emotional nuance in cross-generational communication should lead (whether phylogenetically or developmentally) to more advanced communication (for details, see Greenspan & Shanker 2004; King 2004). Future primatological research along these lines will surely contribute in serious ways to evolution-of-language theorizing.

Words are not costly displays: Shortcomings of a testosterone-fuelled model of language evolution

Chris Knight and Camilla Power

Department of Anthropology, School of Social Sciences, University of East London, London E16 2RD, United Kingdom.

chris.knight@uel.ac.uk c.c.power@uel.ac.uk

<http://homepages.uel.ac.uk/C.Knight/>

Abstract: Only by misconstruing the term *performative* are the authors able to argue that males surpass females in “performative applications” of language. Linguistic performatives are not costly displays of quality, and syntax cannot be explained as an outcome of behavioural competition between pubertal males. However, there is room for a model in which language co-evolves with the unique human life-history stage of adolescence.

This target article attempts an ambitious synthesis. It is high time that speculations about language evolution were grounded in an adequate understanding of the evolution of human life history. Where the article deals with human growth and development it appears authoritative; however, the specifically linguistic sections are less convincing.

Locke & Bogin (L&B) claim that “performative applications of language . . . consistently favor males” (sect. 5.1, para. 3, emphasis in original). In linguistics, the term *performative* is subject to precise definition. Austin (1975: 14) stipulates that “there must exist an accepted conventional procedure having a certain conventional effect, that procedure to include the uttering of certain words by certain persons in certain circumstances.” As a “conventional effect,” the performative force of an utterance is abstract and institutional – quite unlike the material impact which an animal signal is designed to produce. Hence, when a bride says “I do” during her wedding ceremony, her metamorphosis into a wife doesn’t depend on how she vocalises those sounds. Provided the circumstances are appropriate and her intention clear, the physical details of her performance – for example, whether she whispers or stridently declaims – are irrelevant. Speakers’ communicative intentions are accomplished by being socially recognised (Grice 1989); they are not judged by reference to physical qualities such as amplitude, stamina, or vigour.

L&B make their sexual selection case by claiming that “important aspects of language cannot appear until sexual maturity” (target article, Abstract). By this they mean that young children lack sufficient “real world knowledge” (sect. 10) – presumably regarding sexual behaviour – to be able to make pragmatic inferences about speakers’ intentions. But the presence or absence of adult content is irrelevant to the presence or absence of key features of language such as performative force, which is wholly within the capability of four-year-olds playing “let’s pretend.” L&B envisage a juvenile phase during which “teasing, joking, and gossip” serve “group-oriented goals” (sect. 9). This is uncontroversial, but how would such processes be reinforced through an adolescent phase of intrasexual, epigamic selection? Can the authors clarify the circumstances in which individualistic male sexual rivalry promotes “group-oriented goals”?

The authors’ evolutionary model gives pride of place to youths fighting with rap as chimpanzees pant-hoot or caribou bulls roar. Suggesting that “testosterone promotes verbal dueling” (sect. 6), the authors invoke shortages of this hormone to explain why female “performative applications” don’t measure up to those of males. However, they then let slip an observation that turns this extraordinary argument on its head. Adolescent females, they concede, gossip against rivals by enlisting “the support of peers, greatly surpassing males in this practice” (sect. 6). Only by systematically conflating linguistic performatives with bodily performances do the authors succeed in obfuscating the awkward truth: namely, that to enlist the support of peers in manipulating collective judgements is precisely to deploy “performative force.” Here, we encounter a gender bias in “performative applications” that contradicts their entire argument.

Gossiping teenage girls, then, compete by enlisting the support of peers in constructing and contesting perspectives on the world. In the case of male-on-male rap, the standards are different. As one informant puts it: “Don’t hafta make whole bunch sense, long sounds pretty” (see target article, sect. 7, para. 4). So, while, according to the authors, females compete with socially relevant information, males compete by making pretty sounds. Accepting this contrast for the sake of argument, whose strategies would have driven the evolution of syntactical and semantic complexity in speech? Gossiping is a distinctively linguistic skill (Dunbar 1996). Singing is not. Male-on-male vocal competition may help explain phonological complexity in the songs of birds, whales, and, arguably, hominin youths; it cannot explain the morphosyntactical or semantic complexities of gossip.

We readily agree that costly performances are valuable as hard-to-fake indices of individual quality. But how is this relevant to the evolution of language? The issue concerns more than narrowly vocal abilities. How and why did distinctively human verbal abilities become so decisive in social competition among our ancestors? Among nonhuman primates, attention paid to vocalisations may be symptomatic of dominance, but it is not causative. The reverse is true of humans. Among hunter-gatherers, social relations are best described in terms of “counterdominance” (Erdal & Whiten 1994). In such egalitarian contexts, physically unimpressive individuals may gain prestige and influence through their verbal fluency. Contrary to L&B, the pressure on speakers is not to show off with spectacular vocal displays. Typically, hunter-gatherers avoid signs of personal ambition or boastful aggression. Most valued are conversationalists skilful at managing conflicts and securing community-wide consensus. Often, older women have the last word. L&B convey the opposite impression by selecting examples of formal oratory typical of horticultural “Big Man” societies – as opposed to egalitarian hunter-gatherers who are more likely to be representative of early human societies.

Unlike animal vocal displays, which are evaluated on an analog scale, linguistic messages are digitally encoded. There is nothing intrinsically costly or reliable about a linguistic sign. The distinctively human language faculty – language in its “narrow” sense – lacks any counterpart in animal social communication (Hauser et al. 2002), where honesty is underwritten by investment reliably demonstrating signal quality (Zahavi & Zahavi 1997). L&B envisage linguistic evolution driven by direct behavioural competition between siblings or adolescent male sexual rivals. But such dynamics could only drive the evolution of signals that are honest because they are costly – exactly what linguistic signs are not.

In short, the authors show little awareness of the scale of challenge facing any theory of language evolution. To quote Chomsky, language is “based on an entirely different principle than any animal communication system” (Chomsky 1988, p. 183). As a milestone in the evolution of communication, “language is off the chart” (Chomsky 2002b, p. 146). Above all, what cries out to be explained is the abstract computational principle of digital infinity (Hauser et al. 2002). Instead of attempting

this difficult task, L&B focus on features of vocalization that show continuity with analog animal displays.

Linguistic topics aside, this article offers an important discussion of life history. Even here, however, a critical issue is neglected. Modern Darwinism takes account of costs as well as benefits. What about the costs to hominin mothers in producing larger-brained, larger-bodied offspring? The combination of reduced length of lactation plus extended childhood can bring reproductive advantage only to mothers who have reliable allo-care support. But according to these authors, young males are increasingly engaged in rap-style sexual display. By contrast with “show-off” hunting (Hawkes 1991), this offers no material support for mothers. Would hunter-gatherer females prefer reliable producers of meat – or clever rappers?

The idea of the coevolution of adolescence with language and symbolic culture is promising; the emergence of pubertal initiation rituals would be central to any such process (Knight 2002; Power & Aiello 1997). But the selective gender bias towards males needs to be corrected. Among African hunter-gatherers, it is not pubertal males but females who undergo the most elaborate and costly initiation rituals.

Knowledge of language and phrasal vocabulary acquisition

Koenraad Kuiper

Department of Linguistics, University of Canterbury, Private Bag 4800, Christchurch, New Zealand.

kon.kuiper@canterbury.ac.nz

Abstract: Locke & Bogin’s (L&B’s) main thesis can be extended to the acquisition of the phrasal vocabulary in that the acquisition of much phrasal vocabulary combines the acquisition of linguistic knowledge with pragmatics and performance and in that the apprenticeship system for such learning begins to flower in adolescence.

Knowledge of language must involve knowledge of a vocabulary, not just for the simple-minded reason that it would not be possible to say anything without some words to say it with, but also because significant aspects of the rest of the grammar of a language are driven from its vocabulary, as is now assumed by many models of grammar, for example Minimalism (Chomsky 1996).

Therefore, one of the central problems for language acquisition, as for explaining the evolution of language, is how contemporary members of the species *Homo sapiens* acquire vocabulary of the kind, in the quantity, and at the rate they do, often on the basis of apparently little exposure. The acquisition of a mature, adult vocabulary is a massive task given that in the case of a literate person a single-word vocabulary is reckoned to be between 60,000 (Fromkin 2000) and 150,000 items (Seashore & Eckerson 1940), and that the phrasal vocabulary is estimated to be equal to the single-word vocabulary (Jackendoff 1995) or to be an order of magnitude larger than this (Mel’čuk 1995, p. 169). Even using a conservative estimate of 120,000 total vocabulary items, this involves increasing the word power by at least sixteen items per day for every day of a twenty-year-old’s life; in Mel’čuk’s estimate that would require learning an average of approximately ninety items per day.

Locke & Bogin’s (L&B’s) hypotheses about human evolution might be extended as a partial explanation of the fact that humans are able to acquire vocabulary so rapidly, namely, that it lies in placing performance and pragmatics within the language faculty – that is, intimately connecting the use of language with the language itself. This is nowhere clearer than in the phrasal vocabulary. Kuiper and Tan (1989) have explored in some detail the pragmatic knowledge that must be known for appropriate usage of the expression *He’s old enough to be your father*, for example.

This vocabulary item, which is known by many native speakers of English, is highly constrained in its conditions of use. One learns it at the same time as one learns about the nature of sexual relationships. But one may only have heard it once or twice. The fact that it is embedded in social practice is the link between its acquisition and its utility. It is learned because it may come in handy. Formulae like this abound in a native vocabulary with items ranging from those taught to children as they go door-to-door on Halloween in North America (Berko-Gleason 1980) through to the arcane expressions used when crowning a British monarch.

Such expressions and their use are not confined to oral societies, although these are given, perhaps unnecessarily, preferential mention by L&B. Literate societies contain many subcultures that are oral societies. Auctioneers (Kuiper & Haggo 1984), supermarket checkout operators, and priests all learn a phrasal vocabulary which is as much part of an oral tradition as is that of illiterate bards (Lord 1960). It is learned in the same way, as part of being socialised, that is, as part of learning the script for a particular role (Goffman 1969). Following L&B, it would be expected that the acquisition of phrasal vocabulary must expand greatly during adolescence when adult social roles are being learned for the first time. It is therefore not surprising that many boys who select roles that involve rich adult oral traditions do so during this period and apprentice themselves to adult men to acquire the necessary vocabulary and later to practise its use. Reon Murtha, horse-race caller, began to practise race calling in his adolescence (Kuiper & Austin 1990). Many auctioneers such as champion tobacco auctioneer “Mac” Burnette are the sons of auctioneers (Kuiper & Tillis 1986). High school playgrounds are full of boys imitatively practicing repertoires such as those of sports commentators, news readers, and stand-up comedians. L&B are right to point out that this aspect of language acquisition does not rate in the normal classroom, or in classroom competency tests, but any high school teacher who is on playground duty can make these observations.

It is also not surprising that phrasal vocabulary acquisition, and the skills in employing it, are begun in apprenticeship mode in adolescence and mature only later in adulthood. As Lord (1960) points out, mastery of the formulaic lexicon in terms of both its acquisition and its employment takes years to develop. Adult males traditionally reach the peak of their social influence relatively late. Again this follows from the view that language acquisition and pragmatics and performance link throughout the human life span and not just during early life.

So what then of vocabulary acquisition and its place in evolution? The phrasal vocabulary normally combines strictly linguistic knowledge in terms of the phonology, syntax, and semantics of a lexicalised phrase, with knowledge of the conditions for its use – that is, its pragmatics and performance requirements. Such vocabulary is socially integrated in that its use is a function, both productively and perceptually, of social events which recur, such as the requirement under certain situations to apologise, thank someone, launch ships, and crown kings and queens. Those who can do these things in a socially sanctioned matter have social advantages. Those who cannot are social lepers. Such social advantages clearly provide evolutionary advantages in the way that L&B suggest.

If we think of small extended family groups living as hunter-gatherers in earlier times, many social events would have been recurring events (Malinowski 1922/1984). Mostly, therefore, a finite but extensive set of vocabulary items would have sufficed to accompany such events and in some measure to create them. That being so, the capacity to signal appropriately would have had evolutionary advantages for everyone, and superior ability – that is, having at one’s disposal a wide range of vocabulary – would have been of value. Wray (1998) suggests that, on the basis of such needs-based use, analytic decomposition of an increasing large communal vocabulary would have allowed for the evolution of grammar. On this analysis, vocabulary came

first and grammar bootstrapped off it. There is evidence that here ontogeny also may recapitulate phylogeny (Peters 1983; Wong Fillmore 1976).

In terms of mental storage and retrieval it is also clear that at least some of the phrasal lexicon and that part of the one-word lexicon which has associated conditions of use are right hemispherical, whereas analytic and synthetic linguistic capacities are generally left hemispherical (Van Lancker 1987; Wray 2002).

From crying to words: Unique or multilevel selective pressures?

Daniela Lenti Boero^a and Luciana Bottoni^b

^a*Corso di laurea in Scienze Psicologiche e delle Relazioni di Aiuto, Università de la Vallée d'Aoste, 11110 Aosta, Italy;* ^b*Dipartimento di Scienze dell'Ambiente e del Territorio, Università degli Studi Milano Bicocca, 20126 Milan, Italy*

d.lentiboero@univda.it luciana.bottoni@unimib.it
http://www.disat.unimib.it/bioacoustics

Abstract: In the first year of life, infants' utterances change from high-intensity crying to low-intensity acoustic sound strings, acoustically labelling the first word. This transition implies: (1) decoding of phonetic sounds, (2) encoding of phonetic sounds, and (3) a unique linking of an articulated sound to a specific object. Comparative, ontogenetic, and phylogenetic aspects are considered for multilevel selective pressures.

In the first year of life, a human infant's sound emission changes from crying, a high-intensity mammalian signal (Lenti Boero 1997), to low-intensity sound strings having a referential meaning (i.e., words). Semantics comes earlier in ontogeny than grammar and syntax, and constitutes the bricks on which subsequent language competence is built. Between the two extremes of high-intensity crying and low-intensity speech, we find early sound making: a pleasant, musical, rewarding signal for both infant and mother (de Boysson-Bardie 2001; Papoušek & Papoušek 1981; Ruzza et al. 2003). The transition from early crying to the first meaningful word implies the existence of the following competencies:

1. Decoding of phonetic sounds (perceptual)
2. Encoding of phonetic sounds (articulation and motor)
3. Linking univocally an articulated sound to a specific object (cognitive).

It is important to underscore that language includes both perceptual decoding and motor encoding components, as earliest clinical studies by Broca and Wernicke showed (Ellis & Young 1988).

Language ontogeny in the first year of life implies separate decoding and encoding competencies. In human communication artefacts (e.g., human communication engineered products, like telephones, where, in the same object, both encoding and decoding devices are designed at the same time by the human maker [who is not blind]) decoding and encoding features coevolve, but this might not be the same for language. (It is important to contrast human design and natural selection's design, and underscore the independence of decoding and encoding language features.) In fact, the above-mentioned three competencies might have different selective pressures.

Referential competence is defined as the ability to identify objects by means of an icon (acoustic or visual). Earlier studies on apes' language have shown that even the nearest apes cannot articulate human-like sounds because of the lack of articulation space and nervous motor control of the larynx (Lieberman et al. 1969; Ploog 1992); however, apes are very competent in referring objects to tokens or human gestures. Other mammals have been shown to utter species-specific sounds

related to predators (Cheney & Seyfarth 1990; Lenti Boero 1992), to understand human words relative to objects (Kaminski et al. 2004), and to discriminate phonetic sounds (Miller 1977; Morse & Snowdon 1975). Thus, from mammalian studies we deduce that competencies 1 and 3 are present (many more examples can be given), but competency 2 is lacking.

Studies on songbirds have proposed that they should be considered interesting models for human language because of their ability to articulate strings of sounds and to crystallize species-specific songs heard in the social environment, a process similar to the one that human infants undergo in the transition from crying, through early sound making, to correct articulation of the first word (Hultsch & Todt 2004).

Songbirds have competencies 1 and 2, but completely lack competency 3. Among birds, parrots (in particular, the Gray parrot) are a unique species in this respect, having, like humans, all three competencies (Pepperberg 1981; 1983). However, competency 3 is used only in animal-human interactions, analogously as among apes, suggesting that parrots and apes do not spontaneously generate socially shared referential systems – *apparently* a unique human competency (but see Savage-Rumbaugh et al. 1996). If all those competencies appear separately among vertebrates, they must have different selective pressures.

In the first month of life, the human infant shows competency 1 (Mehler et al. 1988), but does not show competency 2. (If proper experiments have not yet been done to explore competency 3, these will certainly come later on.) Did competency 1 undergo selective pressure, and, if so, from which agents? Perception and discrimination of phonetic sounds cannot be early selected by parents, being concealed to them, and can be disclosed only with proper experiments and selected for if and only if eventually related to further sounds and babbling emission.

The above-mentioned studies on song learning in songbirds suggest the existence in a vertebrate species of an inner motor learning module, expressing itself in future phases. In humans, the full expression of native language sounds might be postponed by the immaturity of the articulation and nervous motor control component. If perception and discrimination of phonetic sounds do not relate to later sound-making and babbling, we should think of selective pressures independent from parental selection. One possibility is that those competencies are a by-product of a more widespread and general cognitive module referring to analysis of acoustic scene performed in the natural environment. The fact that other mammalian and bird species are able to discriminate human phonetic sounds, and that Gray parrots are able to decode and discriminate musical notes from the temperate scale, might support this hypothesis (Bottoni et al. 2004). With regard to competency 2, it is important to underscore that humans are the only mammalian species endowed with an articulation apparatus allowing the emission of quasi-musical sounds that, as Locke & Bogin (L&B) correctly state, have been selected by parental pressures. This apparatus is the foundation of vowel emission (Titze 1994), and, together with an improved (in respect to apes) tongue and buccal control, it lies behind the ability to articulate early music-like sounds and more refined later phonetic sounds.

This articulation process is allowed by the descent of larynx in the neck, losing contact with the naso-pharynx (we are unique amongst mammalian species in this regard). In order to understand human language as we know it, a key point should be to question how and why this happened. Camperio Ciani and Chiarelli (1988), investigating the physiology of bone deposition and reallocation process in the cranium during ontogeny, suggest that larynx descent is a by-product of the systemic morphofunctional adjustments to include a large prefrontal cortex in the braincase. In the course of hominid phylogeny, larynx descent should have happened gradually; we might speculate of an hominid phase during which vocal communication was no longer built of fixed mammalian-like sounds but was not yet

phonetically as distinct as it is now. In synthesis there was a “quasi musical” melodic signalling, whose vocal signals were able to denote at least emotional internal state. This might explain: (1) the separation of music and language competence in contemporary human brain; (2) the role of vocal communication embedded in the verbal one, and the fact that vocal and verbal signals are separately processed in the human brain (Zatorre et al. 1992); and (3) the existence of independent selective pressure for early musical sounds and late phonetic sounds.

About juvenility, the features of feminine speech, and a big leap

Pierre Liénard

Department of Psychology, Washington University in St. Louis, St Louis, MO 63130.

p.lienard@qub.ac.uk

Abstract: In this commentary, I ask three specific questions: (1) Why would a juvenile stage be maintained in humans? (2) What could be a satisfactory evolutionary scenario explaining the features of feminine speech? And (3), what could be the contribution of sexual selection in the elicitation of higher informational contents in communicative signals?

Locke & Bogin (L&B) provide a brilliant account of how life-history theory can help explain the evolution of the human faculty of language. Although the analysis is quite convincing and the arguments are thoroughly developed, I still have some doubts about specific matters. Though these lingering problems are not central to L&B's core hypotheses, providing proper answers could clarify and lend support to the article's main argument that human language must be conceived as the outcome of natural selection operating at all stages of development and not only on development's end-products.

Why maintain a juvenile stage? Compared to other higher primates and extinct hominids, humans have a slow life history. Also, in some important aspects, *Homo sapiens'* developmental pattern has been deeply reorganized. The infancy and juvenile stages are shorter than their primate equivalents and two new phases appear in its developmental pattern. According to L&B, infancy and juvenility could be conceived as analogous in that, both are preparatory phases. The authors provide a convincing account for infancy's reframing in human developmental pattern. An accelerated brain growth that prolongs into early childhood palliates the shorter human infancy stage. Without touching upon the dimension of language, human infancy can be primarily conceived as a phase in which occurs part of the brain growth necessary for achieving some type of autonomy similar to that of other primate species' infants (cf. the obstetrical dilemma). So, in humans, a shorter infancy stage has acquired a species-specific function, somewhat different from its longer equivalent among other species. Contrary to what they have done for infancy, L&B have not provided much specification of the species-specific status of the human juvenile stage.

The initiation of juvenility coincides with the initiation of a sharp decline in growth and the tapering-off of brain growth at about age seven years. Why do we find this interruption? Why don't we find a continuous growth from childhood to adolescence? If a juvenile stage has been maintained, it is certainly because it has somehow enhanced fitness. Even if it is a survival from a previous evolutionary stage, human juvenility is only explained if a trade-off exists between a five years' delay of reproduction and a significant enhancement of future reproduction. Also, juvenility, with its definitional features (no significant brain growth, and an accelerated decrease in body development), should be explained by the advantage that childhood and adolescence don't provide. We know that human sociality is a lot more complex than the kinds of sociality found among primate species.

We also know that duration of juvenility in primates is longer than the duration of its human equivalent. Furthermore, a great deal of human middle childhood and adolescence is spent mastering social dimensions. So what can be the specificity of the juvenile phase? What is actually being learned, and what type of developmental process would be dependent upon the (relative) freezing of brain and body growth? Is the acquisition of social knowledge or skills compensating for some kind of freezing of physical development? An answer could be that juvenility is a phase during which cognition is subjected to a fast and massive energy-consuming reorganization/reconfiguration that would allow subsequent cognitive developments to occur. But do we find evidence of such a massive reorganization/reconfiguration?

How did the features of feminine speech come about? Sexual selection shaped human language through mate choice. L&B's development of the argument seems to be slightly asymmetrical. The account of how the features of the “masculine speech” might have come into being is impeccable. It is engaging and invites us all to further investigate the matter. However, as sometimes seems to be the case in some contemporaneous sexual selection hypotheses, the feminine counterpart is inadequately dealt with. And indeed, although L&B state important features of feminine speech, they don't provide us with much elaborate justifications of why it should have acquired those characteristics. They also make a strong and unusual claim opposing the well-established idea that women often have a linguistic advantage (and what of foreign languages!?). Stating it in a rather lapidary way, men would have a greater mastery of public use of language while women would master speech in other more intimate spheres. This is a very interesting claim that it shouldn't be too hard to investigate experimentally. Are women generally out-competed when placed in a situation of verbal dueling with men? Is the topic of the dueling of any relevance? One can think of many other relevant dimensions that would be worth investigating.

From grunts to symbolic language: What role might sexual selection play? L&B present various arguments insisting on the negative social reactions to vocal and verbal deficits. And surely, those linguistic disorders are easy-to-pick signals for appraising, for instance, a potential partner's fitness . . . but they are so for people endowed with a full-blown capacity for language who, early on in development, discover its importance. So people with vocal and verbal deficits might well encounter some difficulties in meeting a mate, in stabilizing themselves in a durable relation, and in starting a family. That does not tell us much about the previous evolutionary contexts when the faculty of language and speech were evolving towards their present forms. Voice, or its texture, might have indeed been an important parameter of mate choice. But what about the content? In the same line of inquiry, one might wonder if adolescence has played a role in eliciting the big leap (either incrementally or by successive “jumps”) between the uses of what could be termed indexical signs and signals with high informational content (actually linguistic, so to speak).

How the language capacity was naturally selected: Altriciality and long immaturity

D. Kimbrough Oller^a and Ulrike Griebel^b

^aSchool of Audiology and Speech-Language Pathology, The University of Memphis, Memphis, TN 38105; ^bDepartment of Biology, The University of Memphis, Memphis, TN 38152.

koller@memphis.edu ulrikegriebel@wnm.net

http://www.ausp.memphis.edu/people/kimoller.html

Abstract: Critical factors that appear to encourage vocal development in humans are altriciality and long immaturity. Hominid infants appear

to have evolved a specific tendency to use elaborate vocalization as a means of soliciting long-term investment from caregivers. The development of such vocal capacity provides necessary infrastructure for language development across human life history.

By highlighting the unique human life history, Locke & Bogin (L&B) bring into focus the need to address *development* in modeling the evolution of language. Although the emphasis in the target article is on stages spanning birth through adolescence, it also bears emphasizing that even in the first six months of human life, vocal development is remarkable, and appears to bring the infant to a point of functional and contextual flexibility in production and use of vocalization that is never achieved in any nonhuman primate (Oller & Griebel 2005). The foundations laid in the first six months appear to be critical to all subsequent development toward vocal language, because it would be impossible to learn even the simplest group-specific words or even to produce systematic imitation of novel syllable patterns in the absence of substantial functional and contextual flexibility of vocalization. Similarly, it is sensible to conclude that our hominid ancestors, as they broke away from the primate background, prior to possessing language must have developed command of vocal flexibility, because, without it, all further evolution in the direction of vocal language may well have been impossible.

This evolutionary process must have been the product of specific selection forces, just as there appear to have been special selection forces that have produced vocal variability and flexibility in other species with complex communication systems, especially some cetaceans and birds (Griebel & Oller, in press). Interestingly, there are more than 200 extant species of primates (Martin 1990) but only the human shows vast vocal flexibility, suggesting that primate life circumstances have overwhelmingly favored vocal systems serving specific, immediate functional needs such as aggression, distress, or alarm signaling, and to serving those needs with well-defined, unambiguous calls (Griebel & Oller, in press; Hauser 1996). One of the most fundamental questions of language evolution then is: What was unique about hominid life circumstances that yielded selection forces where hominids and only hominids came to possess vocal capacities that vastly exceeded the requirements of immediate functional needs?

The pattern of modern human development in the first six months of life suggests an answer. The human infant is more altricial and faces a longer immaturity than any other primate, as is emphasized in the target article. Consequently, the human infant has a need for long-term caregiver investment that dramatically exceeds that of any other primate. The unique topography and richness of human parent-infant face-to-face vocal interactions strongly suggests bonding is at stake (see, e.g., Stern 1974; Trevarthen 1979; Tronick 1982), and that elaborate, contextually flexible infant vocalization solicits parental investment (Oller 2000). Parents appear to distill fitness information from infant vocalization, and in many instances to elicit it in face-to-face interaction, presumably because it benefits parents to make wise decisions about investment of energies in infants facing a long immaturity (Locke, in press c; Oller 2004). Human caregivers also attend to a variety of infant vocalizations outside bonding interactions.

Vocalization in the human infant is then a fitness indicator, providing evidence to caregiving kin about infant well-being. Because the premium on long-term investment by caregivers is higher for the human infant than for any other primate, the selection pressure on infant fitness indicators is also higher than for any other primate. And since altriciality had already increased in hominids by the point of bipedalism, intense selection pressure on infant solicitation of parental investment must have been in place very early in hominid evolution. The pattern of vocal development in the human infant suggests, then, that the driving engine of evolution for hominid vocal capacity may

have been the unique constellation of life history circumstances (including altriciality and long immaturity) that encouraged immature hominids to seek caregiver investment, and the hominid parent (and other kin) to seek fitness indications from the infant in vocalization, in order to make better decisions regarding investment of caregiving energies across a long immaturity. This special constellation of forces encouraged parental selection (Locke, in press c) by vocalization assessment, a pattern that may have increasingly resembled sexual selection in its effects on evolution, as the priority on long-term parental investment became increasingly high. Runaway selection (rapidly producing salient new traits) has long been well-recognized as a product of sexual selection (Darwin 1871; see a review in Miller 2000), and it may well be that the elaborate human vocal capacity was spurred on by parental selection in early life of hominid infants. As noted in the target article, this vocal capacity, fostered in infancy through parental selection, could have been amplified in adolescence through sexual selection.

Of course, human parents use (and ancient hominid parents no doubt used) a variety of fitness indicators in making decisions about investment in their young. But vocalization has unique status as a communicative device among birds and mammals. Vocalization in many species communicates immediate survival needs and provides a primary fitness indicator in sexual selection (Hausberger 1997; Hauser 1996; Kroodsma 1999). In humans, vocalization appears to play a significant role in sexual selection (Miller 2000), but also a critical role in survival during the most altricial period of infancy. The importance of this early altricial period in fostering the creation of vocal capabilities that have a foundational character for language has been vastly underplayed in most prior portrayals of language evolution, where the focus has so often been on how syntax in language came about (see, e.g., Bickerton 1981; Pinker & Bloom 1990). Syntax, and many precursors to it, could never have occurred without fundamental communicative flexibility; and syntax is a feature of language that appears in the human infant only after many months of infrastructural development in flexibility of vocal communication. The target article is on the mark in highlighting the life history issue. The necessary refocusing on developmental issues in speculations about language evolution will inevitably bring us to the beginning of hominid evolution and thus to the beginning of vocal development in the first months of human life.

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Comparative, continuity, and computational evidence in evolutionary theory: Predictive evidence versus productive evidence

David M. W. Powers

School of Informatics and Engineering, Flinders University of South Australia, Adelaide, SA 5001, Australia.

David.Powers@flinders.edu.au

http://www.infoeng.flinders.edu.au/people/pages/powers_david

Abstract: Of three types of evidence available to evolution theorists – comparative, continuity, and computational – the first is largely productive rather than predictive. Although comparison between extant species or languages is possible and can be suggestive of evolutionary processes, leading to theory development, comparison with extinct species and languages seems necessary for validation. Continuity and computational evidence provide the best opportunities for supporting predictions.

Locke & Bogin (L&B) tell two kinds of story, the first seeking to demonstrate that *Homo sapiens* is unique in having a childhood and that this is critical to the nature of human language, the second seeking to explain how evolutionary pressures may have given rise to these phenomena. These stories are intimately intertwined in the target article, with many evolutionary hypotheses being stated badly as facts. Nonetheless, L&B are correct to emphasize the role of ontogeny and provide a useful review of developmental evidence. Computational models of self-organization show that significant visual, auditory, and linguistic features can self-organize with minimal input, whereas detailed ontogenesis without self-organization would seem to exceed the capacity of the genome, suggesting that a composite model is required (Willshaw & von der Malsburg 1979).

The perinatal and infancy period is certainly critical but L&B neglect the former. Since the 1980s we have known that infants, even in utero, can discriminate auditory information, can distinguish one language from another, can distinguish one speaker of a language from another, or even distinguish small phonemic changes in a single syllable (Mehler et al. 1988). Indeed, neonates as much as 10-weeks premature can distinguish low frequency tones and show auditory cortical event related potentials (Kurtzberg et al. 1984; 1986; 1988; Kushnerenko 2003).

L&B highlight an important phenomenon under the guise of “trickle-up phonetics.” There has been an implicit assumption in linguistics and psycholinguistics that children learn those aspects of their target language that are not innate. Although this seems to be self-evident, it is not true! The child’s idiolect is creatively constructed and negotiated in a complex social environment and is not identical to that of either parent – parental, sibling, and peer language is in general modified by the interaction with the child, and linguistic, cognitive, and social learning is part of a complex that is not conveniently modular. It is thus simplistic to assume there is a target language and that the child’s aim is identification in the limit (Gold 1967; Powers & Turk 1989). As L&B note, imitation of the infant is more common than imitation by the infant, and such parental imitation is associated with increased attention. The vocabulary of a family is changed by an infant, as child protowords are adopted, and the grammar and subject matter and complexity of child-directed speech are accommodated to the infant. This is most clearly evident in the process of creolization (Bickerton 1984; 1990; 1995).

An understanding of the language acquisition process that escapes from the naïve idea of a baby replicating his mother’s grammar is fundamental to a theory of language evolution and predicts that considerable language evolution is possible within the species. This puts the onus on a theory of macroevolution to make truly contrastive predictions with new innate mechanisms associated with new species. Although L&B do not clearly enunciate a model of language acquisition/ontogenesis, they do provide many details and hypotheses that could be useful in elaborating a testable theory of ontogenesis; though these details are far from a testable theory in relation to the evolution of innate cognitive and linguistic capabilities and distinctives.

An evolutionary theory may be tested in two main ways: (1) by making predictions that may be validated archeologically, genetically, or biochemically; or (2) by building computational models that demonstrate that proposed mechanisms produce the predicted effects. A developmental theory of language may be tested analogously by making predictions that may be validated neurologically, behaviourally, or linguistically; or again, by using computational modelling.

Existing fossil and comparative linguistics evidence is “productive” in inspiring theory *production* – “productive evidence” has its value in *producing* the theory but has no value, zero value, in establishing its validity. Validation requires making

and confirming theory *predictions* and requires new evidence that fits the “predictive” framework and either confirms or refutes the theory – “predictive evidence” must not have been utilized in formulating the theory and is the only kind of evidence that can provide support for the theory, although it can never prove it. The riskier the prediction, the more unexpected the evidence; and the greater the contrast with the predictions of competing theories, the better the theory is and the more support predictive evidence can bring (Popper 1963).

L&B make no explicit predictions and offer no confirmatory evidence. In particular, their Figure 3 is speculative and the proposed evolutionary sequence has been disconfirmed by genetic, biochemical, and other evidence. L&B themselves acknowledge that “the only reliable data are associated with *Pan* and *H. sapiens*” (sect. 9.1 of the target article). These are the endpoints in the proposed chain – the missing links are still missing and saltational theory has failed to hypothesize mechanisms that could explain the leaps.

We turn therefore to the third kind of evidence, that of computational modelling for both evolution of language (Steels 1998) and the development/ontogenesis of language (Powers & Turk 1989). The modelling of the evolution of language naturally divides into several aspects (Hauser et al. 2002; see target article, sect. 12): evolution of languages within the human species; evolution of communication capabilities independent of species; continuous macroevolution and adaptation of organic cognitive, communicative, and linguistic capacities across species; and saltational mechanisms that might explain the missing links and missing ancestors.

The use of the term “evolution” in relation to language as a medium rather than a faculty involves a metaphorical step: Darwinian, Lamarckian, and saltational evolution involve hypothesized mechanisms for genetic mutation, inheritance, and natural selection (ignoring the problem of the evolution of the genetic and proteomic mechanisms themselves); evolution of human language within *H. sapiens* depends only on social and ontogenetic processes. L&B espouse a theory of evolution that requires macroevolutionary steps; however, much of what they describe seems not to be evolutionary in the macro sense but rather concerns the emergence of language within the species. In either case, computational modelling is one of the most promising means for testing our theories.

To deal first with the question of computational models of macroevolution, it is necessary to define a starting substrate – species A with specific capabilities – and a condition for recognizing enhanced communicative capability (e.g., second signaling of facts not in evidence in the here and now). In computational terms, the distinction between evolutionary, self-organizing, and learning systems arises in relation to the program rather than the hardware. Evolutionary development involves different individuals having different programs, and normally includes both genetic variants (not true evolution) and mutation (not macroevolution of itself) and falls into the domains of artificial life, genetic programming, and evolutionary robotics. It may, for example, involve the evolution of different types of neural networks (Luerssen & Powers 2003) or it may be undertaken at a higher level of abstraction (Olsson & Powers 2003).

A developmental theory of the emergence of language in both the species and the individual has more of the character of self-organization and unsupervised learning (Powers & Turk 1989). Such processes involve the interaction of innately determined structures and capabilities, physical and environmental conditions, and boundary and interaction constraints, to produce detailed neural structure as well as define an individual’s idiolect and a society’s language. This has been demonstrated for various kinds of visual and auditory features as well as for phonological, morphological, and phrase-level structure (Powers 1992), and some multi-organism language creation (Steels 1998) also has something of this unsupervised character – although in a

composite system with multiple organisms, emergent supervised learning/teaching may be part of a larger self-organizational or evolutionary paradigm.

It should be emphasized that evolutionary and developmental theories of language both extend well beyond the usual domain of linguistics and linguists and are intrinsically multimodal. For, the sensory-motor and affective states of the individual and his peers and caregivers are all involved, not just in the emergence of language, but in the development of a physical and social world view – an ontology that encompasses our understanding of space and time, our learning to discriminate between superstitious and causal relationships, as well as our learning to affect and control our environment directly at a physical level and less directly through social and linguistic interaction. Only in the context of learning and evolutionary robotics are all these diverse aspects of evolutionary and developmental theory able to be modelled.

Language and life history: *Not* a new perspective

Sonia Ragir^a and Patricia J. Brooks^b

^a*Department of Sociology and Anthropology, College of Staten Island, City University of New York, and American Museum of Natural History, Staten Island, NY 10314;* ^b*Department of Psychology, College of Staten Island and Graduate Center, City University of New York, Staten Island, NY 10314.*

ragir@mail.csi.cuny.edu

<http://scholar.library.csi.cuny.edu/~ragir/webpage/htm>

pbrooks@mail.csi.cuny.edu

<http://www.library.csi.cuny.edu/~psy/brooks.htm>

Abstract: The uniqueness of human cognition and language has long been linked to systematic changes in developmental timing. Selection for postnatal skeletal ossification resulted in progressive prolongation of universal patterns of primate growth, lengthening infancy, childhood, and adolescence. Language emerged as communication increased in complexity within and between communities rather than from selection for some unique features of childhood or adolescence, or both.

From the middle of the twentieth century onward, a scholarly literature has linked evolutionary changes in the developmental profile of hominins to terrestrial bipedalism, the narrowing of the birth canal, encephalization, prolonged neocortical plasticity, behavioral flexibility, and profound changes in hominin social organization (e.g., de Beer 1930; 1951/1958; Easley 1946/1957; Gould 1977; Jerison 1973; Montague 1962). Comparative research has suggested that humans share the growth patterns typical of primates, but with a relatively greater prolongation of each developmental phase than any other mammal of comparable size (e.g., Finlay et al. 2001; Schultz 1960; Watts 1990). Prolonged cell division in one phase led to delayed closure of later phases. For example, a greater number of neurons required more time to divide, migrate to their final positions, establish dendritic connectivity, and become myelinated (McKinney 2000). With respect to brain development, the largest perturbation occurred in the latest developing regions in the neocortex, in particular, the prefrontal cortex (Deacon 1997; Finlay & Darlington 1995; Finlay et al. 2001). Greater numbers of cortical neurons resulted in data compacting and added levels of information processing that produced increasingly abstract representations of the compacted input (Calvin 1996; 1998; Kien 1991). Gould (1977) argued that these changes were systematic, and led to qualitative changes in the complexity and automaticity of human cognition and communication. Gould and Lewontin (1979) proposed that language emerged as a by-product of general increases in brain size, coincident with an increased need for communication within and between tightly organized primate social groups.

This well-documented view of language emergence contrasts markedly with Locke & Bogin's (L&B's) proposal of independent

selection for aspects of language during childhood and adolescence. What is most surprising about their proposal is the suggestion that childhood and adolescence are unique to humans, in the face of forty years of contrary evidence (e.g., Harvey et al. 1987; Hobson et al. 1981; Schultz 1969). Using skeletal and hormonal evidence from both monkeys and apes, Watts (1985; 1986; Watts & Gavan 1982) documented a distinct juvenile dependency comparable to human childhood and an adolescent growth spurt that preceded delayed sexual maturation in all higher primates. Extended human childhood and adolescence appear to be concomitant with the systematic changes in fetal and postnatal development (Gould 1977; Ragir 1985; 2001a; 2001b; Shea 1990). If anything, given the length of childhood and the life expectancy of humans, sexual maturation occurs relatively early as compared to other apes (Shea 1990). The observed non-uniqueness of these life history phases is indicative of the systematic patterns of primate growth and development described above. The purported uniqueness of human childhood and adolescence is seriously undermined by the similar patterns of monkey, ape, and human growth after infancy, and weak links between patterns of tooth eruption, facial morphology, weaning and changing social-sexual and cognitive competence (Watts 1990).

L&B's proposal offers an unconvincing combination of kin- and sexual-selection pressures that operate during different life history phases and select for seemingly dissociated competence and performance aspects of language. The kin-selection argument for language formation is seriously flawed; all nonhuman primates communicate with and successfully raise their infants without language. Language between parent and offspring would not necessarily improve the survival of juveniles, nor ensure "honest" communication. Studies of emergent Sign Languages and Creoles indicate greater complexity and systematicity in the negotiated exchange of information within and between groups composed of relative strangers as opposed to close kin (Kegl et al. 1999; Kendon 1980a; 1980b; 1980c; McWhorter 1997; Senghas et al. 2004; Washabaugh 1986).

We also strongly disagree with L&B's emphasis on sexual selection and the competitive aspects of language performance. Primates practice opportunistic mating in which females fail to show a general preference for alpha males, and males mate with any estrous female. Male displays of strength and cunning temporarily position them in a relatively unstable male dominance hierarchy that is likely to confer upon dominant males preferential access to estrous females for only a limited part of their mature reproductive life. In contrast, dominant females and their female kin show greater reproductive success over the entire period of reproductive maturity (Grant 2003; Lee & Bowman 1995; van Schaik & Hrdy 1991). On the other hand, adolescence is likely to be important in the formation of languages for other reasons; humans tend to disperse at adolescence to mate, carrying their local communicative practices to nearby groups. This dispersal would promote the exchange of skills and information, expand regional political affiliations, and create mutually intelligible language dialects.

Throughout the lifespan, speech performance is basic to human language, and adolescence is not special in this regard. Language use develops in tandem with lexicon and grammar, with all aspects of language increasing in complexity in ways that reflect and, perhaps, implement changes in cortical organization. Language acquisition is possible because infants are socially connected and sensitized to the dynamics of interpersonal communication from birth. Children acquire language by tuning in to the communicative intentions of others, through active social engagement and participation in conversation (Tomasello 1999). Young children's pragmatic sophistication manifests itself in the form of social routines such as peek-a-boo, vocal turn taking, pointing, use of prosody, and joint attention (e.g., Nimio & Snow 1996; Rochat et al. 1999). Children who are not segregated from adult activities readily imitate and incorporate aspects of mature speech acts into their repertoires. Their personal narratives, sense of self, and autobiographical memory are constructed through conversing and

reminiscing with others (Nelson & Fivush 2004). Word play and language games emerge fully in childhood (Goldman 1998), with mental simulation serving to decouple representation from the here and now, as children engage in non-literal language in their pretend play. The development of language use across the lifespan is a very important topic that will not be well understood if pragmatics is narrowly conceived as building on grammatical competence (Brooks 2004). Both the acquisition of language and its evolution require an appreciation of how both lexicon and grammar are rooted in participation in social life.

Life stages, put in words: Morning, four; noon, two; evening, three?

Wolfgang M. Schleidt

Robert-Hamerling-G.1/22, A-1150, Vienna, Austria.

wolfgang.schleidt@univie.ac.at <http://www.schleidt.org/wolfgang/>

Abstract: The social function of language, as exemplified by “tonic communication,” is certainly not restricted to our own species. An individual’s cognitive mastering of its environment, moreover, is equally essential for understanding the nature of any language. In the absence of comparative data, it is premature to claim that language skills at a particular developmental stage are uniquely human.

Morning, four; noon, two; evening, three? This is an amazingly concise statement of the ancient riddle the Sphinx posed to Oedipus. This riddle’s solution – “during infancy we crawl on all four, grown up we walk on two legs, and at old age a cane serves us as a third leg” – gives us a feel for the antiquity of human awareness of life’s stages, put in words (Schleidt 1992). There are additional discontinuities, of course, beyond the number of legs. During the bipedal stage we note several distinct changes: at school age, when the child is allowed to venture into society without constant maternal supervision; at puberty, certainly the most striking incision in the individual’s thread of bipedal life, and at menopause, for the female the beginning of grandmothering. Currently, the “eight stages of life” proposed by Erik H. Erikson (1950) are widely accepted, and connections between life history and social competence are beyond dispute (Schleidt 1992). The importance of oral language as an essential tool for the individual’s carving its niche within society, in pursuit of its biological fitness, is obvious. So, what is new in the life history approach taken by Locke & Bogin (L&B)?

Childhood and adolescence: Uniquely human? The new perspective on the development and evolution of human language, envisioned by L&B, rests on their claim that two developmental stages, childhood and adolescence, are relatively

new insertions into human development: a true childhood, as distinct phases preceding the juvenile stage (only since *Homo habilis*) and a true adolescence, as distinct phases following the juvenile stage (only since *Homo sapiens*). From my own experience with the development of various species of birds and mammals, I cannot follow the authors’ argumentation, since the vast majority of social animals, which rely on the use of a language to attain reproductive success, have similar sub-stages within their juvenile stage that justify a separate label. In mammals, for example, we can talk of childhood once nursing has stopped but the individual is still part of the family, and of adolescence when, prior to sexual maturity, new social bonds develop, usually among juveniles of the same gender.

The social function of language. L&B focus on differences in the oral language in each of the four pre-adult ontogenetic stages in human life history. This puts an unusually strong emphasis on the social function of language: talking as a form of communion among the communicants (phatic communion, Malinowski 1923; tonic communication, Schleidt 1973; gossip, Dunbar 1996; etc.). They strike a sympathetic chord with my own interests in bonding and communions, rooted in old concepts of psychoanalysis and ethology that are rarely recalled these days. In a nutshell, Erikson’s (1950) eight developmental stages, based on Sigmund Freud’s well-known oral, anal, phallic, latency, and genital phases, show a striking correspondence to the stages of bonding in birds, as described by Konrad Lorenz in his 1935 paper (translated as Lorenz 1970) on the various types of “companions” during a bird’s life (Schleidt 1992). Considering the recent recognition of grandmothering as a special form of child care (Hawkes et al. 1998), the grandchild can be added as another type of “companion,” a cognitive domain in its own right. Thus, I hypothesize that in each of the developmental stages a particular new kind of bond may evolve, a new type of “companion” can be added to the cast of conspecifics, expanding the social skills and cognitive competence (see Table 1).

Cognition without words. Finally I must confess that, while studying L&B’s proposal, I was reminded of two aspects of cognitive development that are intimately interrelated with our oral language, but remained strikingly absent in their deliberation: “first words” and “nonverbal thinking.” “First words” are only the tip of an iceberg, of course, since the nonverbal mapping of patterns in the environment into its memory is far ahead of the language skills of a growing infant. Thus, one may ask how much sense does it make to discuss language development without reference to the individual’s world? This caveat applies not only to infancy, but to all stages. “School age,” for example, is dominated by learning the names of many “things” the child is already quite familiar with from its own experience. The child’s ability to see “things” as cognitive entities is well illustrated in J. A. Comenius’s *Orbis sensualium*

Table 1 (Schleidt). Developmental stages

Age (year)	Generic term	Sigmund Freud	Erik H. Erikson	Konrad Lorenz
0–1	Infancy	Oral	Infancy	Parent
1–3	Childhood	Anal	Early childhood	Sibling
3–6	Childhood	Phallic	Childhood	Friend/foe
6–12	Childhood	Latency	School age	Friend/foe
12–18	Adolescence	Genital	Adolescences	Friend/foe
18–25	Adulthood (courtship phase)		Young adulthood	Mate
25–45	Adulthood (reproductive phase)		Adulthood	Child
45–?	Maturity		Maturity ^a	Grandchild

Based on Schleidt (1992), revised. Here I have replaced the German terms (“Elternkumpan,” etc.) with English translations of the chief companion of each stage (“parent,” etc.) and added the “grandchild” as another type of companion.

^aErik H. Erikson used the term “old age” for the age beyond retirement, years 60 to 70.

pictus (Comenius 1659/1968), the first “textbook” offering a keyhole look at the world, with each of its items labeled and named in the mother tongue and in Latin. And, throughout our adult life we are flooded with impressions of things we cannot name. We can handle such things, manipulate them in a creative, cognitive process without the need to name them. When we watch “higher” animals (e.g., a kitten, raven, chimpanzee) within their natural environment and analyze their behavior it becomes obvious that they can detect, classify, and recognize a multitude of “patterns” in their environment, or actually, discrete “things,” furnishings of their species-specific, individual world, their very own “*Orbis sensualium*.” As we can condense the behavior patterns of a species in an “ethogram” (Schleidt & Crawley 1980), we can represent the repertoire of patterns in the environment, of things as cognitive entities an individual can recognize, as an “ecogram” (Schleidt 1985). I feel we need to know a lot more about the cognitive development of birds and mammals before we can claim unique features in human life histories.

Is it language that makes humans intelligent?

Jo Van Herwegen and Annette Karmiloff-Smith

Neurocognitive Development Unit, Institute of Child Health, London, WC1N 1EH, United Kingdom.

j.vanherwegen@ich.ucl.ac.uk a.karmiloff-smith@ich.ucl.ac.uk

Abstract: The target article by Locke & Bogin (L&B) focuses on the evolution of language as a communicative tool. They neglect, however, that from infancy onwards humans have the ability to go beyond successful behaviour and to reflect upon language (and other domains of knowledge) as a problem space in its own right. This ability is not found in other species and may well be what makes humans unique.

The target article by Locke & Bogin (L&B) doesn't merely cover language evolution but also takes the whole of human ontogeny into account. However impressive the authors' life history model is, the question remains as to whether it is really language that makes humans intelligent. Throughout the article the authors focus on the development of language as a communicative tool which came into existence through selection, in order to secure the survival of the human species. However, there is no denying that many animals have complex communication systems, elaborate sensorimotor skills, as well as rich mental representations (Premack 2004). Something else, then, must make humans special. We argue that this is the ability in humans to re-represent their representations into an explicit format, transportable from one domain of knowledge to another one. Humans do not only master the basics of the language system for communication, they also reflect upon language as a domain of knowledge. Therefore, language is not merely a communicative tool, it is also a problem space in its own right, making young children behave like little linguists (Karmiloff-Smith 1992).

Even infants are sensitive to the subtleties of the linguistic sound system (Jusczyk & Aslin 1995). By as early as nine months, for instance, infants have begun to determine the phonotactic sequences of their native language that helps them to segment fluent speech into words (Jusczyk 1999). And, even when they become fluent speakers by about 3 to 4 years of age, children do not just learn the mapping between words and their corresponding referents, but also analyse the morphological system. An example comes from Karmiloff-Smith (1992) when she quotes a passage between a 4-year-old and her mother:

Child: “What's that?”

Mother: “A typewriter.”

Child: “No, you're the typewriter, that's a typewriter.”

(Karmiloff-Smith 1992, p. 31)

At the age of 4, the child is not merely focused on communication but on how the system works, that is, that the suffix “er” is agentive and that it is used after verb stems to refer to

human agents. This and numerous similar examples show how humans, even young children, consider language as a form of knowledge beyond its use as a communicative tool.

Such explicit consideration of knowledge by children is not only found in the domain of language. Physics is another domain that becomes a problem space in its own right for children. For instance, 5-year-old children are successful at balancing blocks where weight is both evenly and unevenly distributed. However, 7-year-olds fail to succeed in balancing the unevenly distributed weight blocks. A finer analysis shows that this failure can be explained by their going beyond successful behaviour and creating the geometric-centre theory, believing that all blocks balance at their centre. They ignore counterexamples to their theory, while consolidating it (Karmiloff-Smith & Inhelder 1975). Only by age 9 years do they accomplish the task at hand when they understand the law of torque. So unlike other species, children do not merely aim for successful behaviour.

If language is not just a communicative tool but also a problem space in its own right, then we can expect to find populations in which linguistic communication is not impaired, but language as a domain of knowledge is, and that having fluent language is not sufficient to ensure peer acceptance. The neurodevelopmental disorder, Williams syndrome, is such an example. Despite IQs in the 50- to 60-point range, individuals with Williams syndrome (WS) have surprisingly proficient language skills (Donnai & Karmiloff-Smith 2000). Yet, their fluent language does not suffice to get them accepted by peers. In contrast to other adolescents with neurodevelopmental disorders, their peer interaction problems are not caused by reluctance to join in social conversations. So, fluent language and a desire for interaction do not suffice to get a WS adolescent accepted by peers. Outside the field of language, children with WS also do not organize or make their knowledge more explicit. For example, adolescents and adults with WS can learn a vast list of facts; however, they fail to organise these facts into core and peripheral knowledge – a reorganisation process found in normal 9- to 10-year-olds (Johnson & Carey 1998).

Another population in which the ability to re-represent knowledge is likely to be impaired is Down syndrome, a developmental disorder which, in contrast to WS, involves poor language skills. A longitudinal case study of block balancing involving a Down syndrome child showed that, in contrast to typical developing children, there was no sign over time (from age 9 to age 11 years) of his developing geometric centre theory. Instead, for 19 months the child remained on the level of repeated successful behaviour of the typical 5-year-old. This points to an impairment in the reorganization of knowledge (Karmiloff-Smith 2006).

So even though human language is an impressive communicative tool, humans may be the only species that can re-represent their acquired knowledge through representational redescription. This constitutes an endogenous way of gaining new knowledge, leading to the achievement of creativity and flexible control in humans, in contrast to other species (Karmiloff-Smith 1992). L&B argue that verbal creativity may have played an important role in the evolution of language, but they don't raise the question as to what makes this verbal creativity possible. We believe that the ability of re-representation, both within and across different domains of knowledge, may turn out to be a possible answer to this question.

Uniqueness of human childhood and adolescence?

Glenn E. Weisfeld

Department of Psychology, Wayne State University, Detroit, MI 48202.

weisfeld@sun.science.wayne.edu

sun.science.wayne.edu/~psych/people/facultypages/weisfeld.htm

Abstract: Locke & Bogin (L&B) propose that humans are unique in possessing stages of childhood and adolescence. Arguments to the contrary include evidence for a similar and adaptive juvenile period in

simians of slow growth, intense play and learning, and provisioning with solid food by adults. Likewise, simians as well as humans undergo a compensatory growth spurt during puberty.

I question two of the basic assumptions of this article: namely, the supposed uniqueness of human childhood and of human adolescence.

In section 2.3 of the target article, Locke & Bogin (L&B) define the stage of childhood as comprising a “slow and steady rate of body growth and relatively small body size; large, fast-growing brain; higher resting metabolic rate than any other mammalian species; immature dentition; dependence on older people for care and feeding; and motor and cognitive advances” (numbered list in original).

These traits also seem to characterize young simians after infancy. A large, fast-growing brain relative to body weight occurs in primates generally (Jones et al. 1992). As for humans having a higher resting metabolic rate than any other mammal, according to Kleiber’s equation,¹ metabolic rates for mammals and birds when plotted against body mass on logarithmic coordinates tend to fall along a straight line. Smaller animals have higher basal metabolic rates (BMR) per unit body weight than do larger animals. Humans indeed exceed this formula slightly, but the peak of exceeding it comes at around 10 kg body weight, or before two years of age – that is, in infancy, not childhood (Jones et al. 1992). Moreover, the high BMR in infancy seems merely to compensate for a low rate at birth. Macaques and chimpanzees fall right on the Kleiber line. Thus, the BMR of humans and other primates is not remarkable. However, simians may have a high overall (not resting) metabolic rate, given the energy required for climbing and play. Primates, including but not restricted to children, use high-energy play to advance motorically and cognitively – to learn – during the juvenile stage.

Humans doubtless exceed all other simians in the extent of provisioning for offspring during the juvenile stage. The authors note that the first permanent molar erupts significantly later in humans than in the great apes – at age 6 years versus about age 3 years – suggesting that juvenile hominids began to forage independently at a relatively old age. However, food sharing with immatures occurs in other primates, for example: golden marmosets (Brown & Mack 1978), male tamarins (Goldizen 1987), male titi monkeys (Starin 1978), and chimpanzee mothers (Goodall 1968; McGrew 1975; Silk 1978; 1979). Although these may be mainly or exclusively cases of food sharing with infants rather than juveniles, they do constitute food sharing with the young. Extensive and prolonged food sharing occurs in canids such as jackals and the African hunting dog. In the wolf, pups begin receiving regurgitated meat during their fourth week, shortly before weaning; the deciduous teeth begin to be replaced much later, at 16 weeks (Mech 1970). So the main basis for claiming a unique stage of childhood in humans compared with other primates (but not canids) would seem to be the extent, not the existence, of provisioning. In their section 2.3, L&B quote Lancaster and Lancaster (1983) as asserting that no other primate is so actively involved in childcare and feeding, implying that other primates also exhibit these behaviors. Worthman (1993) went further, stating that “Uniquely, humans provision juveniles” (p. 340). Yet, none of these primatologists has seen fit to conclude that humans uniquely possess a stage of “childhood.”

The assertion that only humans possess a stage of adolescence is more puzzling still. The authors claim that, in humans, “uniquely, there is a distinct skeletal growth spurt in both sexes and in almost all skeletal elements of the body after several years of gently decreasing juvenile growth. The onset of this spurt ... marks the onset of adolescence” (sect. 2.7). “Nonhuman primates lack childhood, but they also lack a post-juvenile period of dramatic growth of the sort that defines human adolescence” (sect. 9.2). But an adolescent growth spurt has been documented in primates generally. Tanner (quoted in Jones et al. 1992) wrote: “The characteristic form of the human growth curves is shared by

apes and monkeys. It is apparently distinctive to higher primates; neither rodents nor cattle have curves that resemble it” (p. 100). Accompanying graphs show spurts of weight gain in adolescent rhesus macaques, chimpanzees, and humans of both sexes. The growth curves for male chimpanzees and rhesus macaques appear to be even more pronounced than that for boys; the curves for females are similar in magnitude for the three species. Likewise, Deaner et al. (2003) state that for the primate species with sufficient data on the point (humans, macaques, mangabeys, and chimpanzees) a growth spurt follows the end of brain growth. Worthman (1993, p. 342) acknowledges that the possible uniqueness of the human adolescent growth spurt has been debated, partly because many of the simian data refer to weight, not length. However, she cites a report showing a distinct skeletal growth spurt in puberty for female rhesus, with a sequence of skeletal changes that is the same as for humans (Tanner et al. 1990). It would be surprising if a spurt in weight were not accompanied by an allometric increase in length.

The adolescent growth spurt has been explained adaptively in general primate terms – not just in human terms. L&B refer to Janson and van Schaik’s (1993) explanation: that the pubertal growth spurt compensates for the slow growth of the preceding juvenile period. L&B note that this slow period of development allows time for brain growth and learning in “various species of social mammals” (sect. 2.5). Carnivores, elephants, and primates are mentioned specifically. In effect, the slower growing, altricial systems of the body defer to the precocial nervous system. Slow growth also reduces feeding competition and lowers caloric requirements (e.g., Janson & van Schaik 1993). Other adaptive advantages accrue not just to a few primates. Small juvenile size broadens the opportunity for locomotion in trees: a smaller body can be supported by thinner branches. Small size reduces conservation of bodily heat, but most primates live in warm climates; furthermore, juveniles sometimes sleep with and are warmed by their mothers (Altmann 1986). Also, young primates in some species are protected from predators by arboreality and, especially in terrestrial species, by adult troop members, further reducing the need for large juvenile size. Last and perhaps most important, the extensive vigorous arboreal play and large brains of simians are energy intensive, so slow growth frees up energy for this activity and the learning that it entails.

As primates undergo puberty, many of these factors no longer operate as strongly. Caloric energy is shifted from play to growth. Juvenile primates play more than adolescents undergoing a growth spurt (Pereira & Altmann 1985). As large size is attained, adolescents can forage further afield with less danger, and can fight for rank or against predators more effectively. Female primates benefit from large body size in that their infants are born larger. The benefits of slow juvenile growth and the learning that it enhances may be greatest in humans, but this seems to be another quantitative distinction. Simians as well as humans need an adolescent growth spurt to compensate for slow juvenile growth.

Primatologists have long recognized a stage of adolescence in monkeys and apes. This consists of the period of the growth spurt and other observable pubertal changes – the same criterion by which all tribal societies recognize human adolescence (Schlegel & Barry 1991). There seems no reason to abandon this convention. What would we otherwise call the period of puberty in simians?

Many unique characteristics of humans have been proposed over the years, only to be discredited in light of subsequent research. Given the great genetic similarity of humans and simians, it seems prudent to assume similarity in basic characteristics, such as life stages, in the absence of overwhelming evidence to the contrary.

NOTE

1. Basal metabolic rate = $kW_B^{0.75}$, where k is a constant and W_B is body weight.

Melody as a primordial legacy from early roots of language

Kathleen Wermke^a and Werner Mende^b

^aCenter for Pre-Speech-Development and Developmental Disorders, Julius-Maximilians-University, Würzburg, Würzburg, 97070, Germany; ^bBerlin-Brandenburg Academy of Science, Berlin, 10117, Germany.

wermke_k@klinik.uni-wuerzburg.de mende@bbaw.de

Abstract: The stormy development of vocal production during the first postnatal weeks is generally underestimated. Our longitudinal studies revealed an amazingly fast unfolding and combinatorial complexification of pre-speech melodies. We argue that relying on “melody” could provide for the immature brain a kind of filter to extract life-relevant information from the complex speech stream.

Locke & Bogin (L&B) emphasize that the “development of language requires the whole of modern human ontogeny” (target article, Abstract) and point out that the human brain grows at a very fast pace during infancy. Furthermore, they stress a disparity of brain growth after birth in comparison to other primates. We strongly support and complement L&B’s life history based perspective on language development by new data from the earliest period of infancy.

Our investigations are focused on the time function of the fundamental frequency (melody) of infants’ utterances. Melody in vocal communication is a legacy from the early roots of oral language; it can be traced along the entire ontogeny and it is an essential constituent of prosody. In ontogeny, its primacy is reflected in the amazing perceptive capacities of newborns and young infants for melody recognition (e.g., Fernald 1989; Nazzi et al. 1998; Ramus et al. 2000; Sansavini et al. 1997) and in the astonishing melody-related performances of their vocal production (Wermke 2002).

Longitudinal twin studies have revealed a unidirectional development from simple to complex cries during the first weeks of life (Wermke 2002; Wermke & Friederici 2004; Wermke et al. 1996). In a subsequent study we applied a mathematical model in order to quantitatively compare melody properties of different vocalizations such as soft cries, cooing, and babbling. A continuous unfolding of melody structures during infancy and a high structural similarity between melodies of different pre-speech phases was demonstrated (Wermke et al., in preparation). Furthermore, a unidirectional decrease of melody-arc duration and FM-amplitude was observed on the developmental path from early crying to speech-like babbling. These parameters converge during early infancy toward the range of intonation components in later language. Although melody is a key parameter for characterizing infants’ utterances during the first months, other parameters, describing the voluntary control of the vocal tract, become increasingly important. Beginning at about age three months, an increasing articulatory activity was identified, connected with coupling phenomena between melody (phonation) and resonance properties (articulation; Wermke et al. 2002; Wermke et al. 2005). These processes represent amazingly systematic preparation phases exercising the fast transitions of resonance frequencies (formants) necessary for speech. The establishment of intentional interaction between melody and formants and a mastering of fast formant transitions seem to require such a training period before being available for intentional use in vocal production.

So, we could prove a continuous development of melodies during early infancy as well as an engagement of melody in learning to articulate. This development starts immediately after birth, and all this happens long before the one-word stage of language acquisition (stressed by Jackendoff [2002]) is reached by the infant. The development of melody skills in ontogeny precedes by far any symbolic word use and rule-based grammar constructions.

Human infants acquire a repertoire of complex melodies with remarkable speed, which corresponds to the fast brain growth at this early age. There is a general underestimation of the stormy preparation phases concerning vocal production during the first

weeks, and the target article opens a stage for a general recognition of the much broader range of presuppositions for the faculty of language as generally accepted. The huge metabolic and growth rates in the brain associated with these stormy developments provide a life historic substantiation for the significance of language-related pre-speech development, including melody development of soft, mitigated crying.¹ Long-term consequences of a disturbance in cry melody development were demonstrated by comparing infants with a normal language outcome and those with a delayed one (SLI or specific-language-impaired-infants) at age two years (Wermke et al., submitted).

In the phylogenetic perspective, mother-infant communication and social talking in Locke’s sense (Locke 1995b; 1997) might have ignited behavioural changes to bundle preexisting competences into a new communication system: symbolic language. In its primordial function, melodies express feelings and emotions, which are tightly connected with social relations (Dunbar 1996). An increasing decoupling from affective states is only a relatively recent achievement of modern languages. This emancipation was necessary when language became a symbolic tool. Language evolution represents a long uninterrupted “chain” or better web: The coevolution of brain, speech interface, language, and socio-cultural environment (well treated in Deacon 1997) has a subtle coupling with co-developments in ontogeny, including a critical mother–infant communication in infancy and an adequate social stimulation.

From our perspective on language evolution, we offer a complementary argument to L&B’s argumentation for not being in danger of seeing postnatal helplessness and immaturity of the brain as a design flaw (cf. target article, sect. 2.1): We argue that melody could provide for the immature brain of the young infant a kind of filter to extract life-relevant information out of the complex parental speech stream. Recall that melody is the most salient component among all acoustic components that contribute to infants’ preferences for “motherese” speech. The infants’ melody skills may be much more than a capability; they are probably a social imperative. Infants from all cultures pass through the same stages of melody development at the same life historical phase. The perspective of L&B implies that spoken language is tested and shaped by all the infants’ brains of a language community, and vice versa. Language acquisition by the immature brain is the critical bottleneck (a language “pelvis”) through which all evolving language has to pass, generation by generation. This points to long-term selection pressures out of small, seemingly inconspicuous phenomena like social sound-making. This perspective imposes seemingly insurmountable constraints on language as an evolving system with respect to its learnability by the immature brain of the infant. But these constraints could eventually enable the only possible way to incrementally acquire a rich symbolic language. The passage through the immature brains of the babies has probably minimized the abyss between an object and its symbolic reference in the past at the cradle of symbolic language, and does continuously repeat this coding process in each infant acquiring language today. At this critical moment of life history there is not yet a deep gap between meaning and symbol: In young infants, the coding of needs and emotional states is not arbitrary, but it is closely coupled to real physiological processes and expressed by vocal production. However, these earliest traces of coding seem to precede later complex hierarchical coding and symbolic constructions. This life historic perspective eventually might resolve linguistic coding problems.

NOTE

1. Only soft crying and whining uttered in a context of low distress and mitigated in its intensity was recorded.

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“Language impairment gene” does not necessarily equate to “language gene”

Lance Workman

Department of Psychology, School of Social Sciences, Bath Spa University,
Bath BA2 9BN, United Kingdom.

l.workman@bathspa.ac.uk

Abstract: The finding of the same language deficit in half the members of the KE family is taken as suggesting that a specific allele (FOXP2) is normally involved in the development of language. Recent studies, however, question the exclusivity of FOXP2, and it is argued that the finding of a gene that disrupts language should not be taken as strong evidence for the existence of genes that underlie it.

Locke & Bogin’s (L&B’s) argument that life history theory provides a fruitful way of re-examining the relationship between evolution and language development is, for the most part, a compelling if somewhat speculative argument. Both the unique life history pattern and the uniqueness of language in our species require explanation. I agree that such patterns should be examined in the light of selective advantages. L&B provide evidence of selective advantages for a wide range of aspects of language development. Where I would urge caution, however, lies in the use of studies of language deficits in the “KE” family to imply that these provide evidence of the existence of genes directly related to the neurological substrate supporting language production and grammar.

In the early 1990s the KE family caused a stir among linguists when it was discovered that more than half of the 31 members of three generations of the family had impaired language abilities (sometimes referred to as specific language impairment, or SLI). It was found that individuals with SLI have a number of problems, including a deficit in the ability to use inflection (e.g., producing the past tense of a verb) and problems of articulation, comprehension, and orofacial dyspraxia (i.e., putting together orofacial movements; Bishop 2002; Gopnik 1990; 1997; Pinker & Jackendoff 2005).

The finding of the same language problem in such a high proportion of family members has been taken by a number of researchers as suggestive of a specific underlying genetic problem. If a specific allele leads to such problems then it has been argued that an alternative allele might normally be involved in the development of appropriate neural hardware to support language (Gopnik 1990; Jackendoff 1994; Pinker 1999). L&B are clearly sympathetic to such an argument.

In support of L&B’s stance there is now strong evidence of a defective dominant allele of a single gene that is found on the long arm of chromosome 7 in the impaired members of the family – FOXP2 (Lai et al. 2000; 2001). Moreover, as L&B point out, scanning techniques have demonstrated associated neurological anomalies of structure and function in sufferers, such as a bilateral deficit in activation of Broca’s area (Liégeois et al. 2003) and abnormal activation of the caudate nucleus (Vargha-Khadem et al. 1998). Although L&B do not explicitly label FOXP2 as a “grammar gene,” their use of the KE family to back up their argument that “selection acted on [language] performance” (sect. 11 of the target article) implies that this is an allele directly related to language and hence has arisen via selection pressures for that purpose.

It is entirely possible that the KE family’s SLI does provide evidence of an allele related to the development of language, but currently there are at least two problems with the argument as presented by L&B. First, the evidence is presented as if there is general consensus that an exclusive language-related problem is found in the KE family and that this provides support for the existence of a specific defective gene related to language production. In fact, Gopnik (1997) herself has documented how controversial this conclusion is, with some experts suggesting that the language impairments uncovered might be part of a more general cognitive deficit, which might include non-linguistic problems (Leonard 1994; Vargha-Khadem et al. 1995). It is certainly

possible that the problem is a part of a more general cognitive deficit since afflicted members of the family have IQ scores 18 to 19 points lower than those of unimpaired members (including nonverbal aspects of IQ; Vargha-Khadem et al. 1995; 1998).

Second, even if an allele has been discovered that disrupts language production via the development of neurological abnormalities, this is not strong evidence that an alternate allele exists that is directly involved in the development of neural circuitry underlying language and speech (Karanth 2005). As Lai and colleagues caution with regard to the FOXP2 allele, the biological deficit may well be in the form of a trigger that disrupts a key stage of embryogenesis rather than the replacement of an allele coding for normal language development (Lai et al. 2001; Karanth 2005). Removing an air-filter from an internal combustion engine will stop a car from running but that does not mean that the air-filter is responsible for running the car (Workman & Reader 2004). Finally, Newbury et al. (2002), through association and mutation screening analysis, have thrown doubt on the argument that variants in FOXP2 underlie such forms of language impairment.

None of these misgivings constitutes a deathblow to L&B’s argument; they may well be correct that language development and production are directly related to specific alleles. But, currently, the evidence from families that show language deficits such as the KE is equivocal and needs to be examined with a degree of caution. L&B have done a service to our understanding of the relationship between evolution and language by weaving together a number of sources of evidence using the framework of life history theory. They should be careful not to leave any loose threads.

Authors’ Response

Life history and language: Selection in development

John L. Locke^a and Barry Bogin^b

^aDepartment of Speech–Language–Hearing Sciences, Lehman College, City University of New York, Bronx, NY 10468; ^bDepartment of Behavioral Sciences, University of Michigan–Dearborn, Dearborn, MI 48128.

john.locke@lehman.cuny.edu bbogin@umd.umich.edu

<http://casl.umd.umich.edu/faculty/bbogin/>

Abstract: Language, like other human traits, could only have evolved during one or more stages of development. We enlist the theoretical framework of human life history to account for certain aspects of linguistic evolution, with special reference to initial phases in the process. It is hypothesized that selection operated at several developmental stages, the earlier ones producing new behaviors that were reinforced by additional, and possibly more powerful, forms of selection during later stages, especially adolescence and early adulthood. Peer commentaries have provided opportunities to explain human life history more comprehensively, and to add details to our account of spoken language. We made no attempt to explain syntax in the target article, but we propose here that selection for “vocal plumage” may have increased our species’ capacity for utterance complexity, a development that would have benefited all levels of language.

It is a rare pleasure to have comments on our target article from so many thoughtful colleagues, representing such a wide range of academic disciplines and cultures. We will begin our response by addressing comments that relate

particularly to our treatment of life history, and then turn our attention to replies that pertain more specifically to language.

R1. Life history

Any theory of human biology and culture needs to explain how *Homo sapiens* successfully combines delayed reproduction, helpless newborns, a short duration of breastfeeding, a vastly extended period of offspring dependency, an adolescent growth spurt in both sexes, and female menopause a decade or more before death. No other primate species shares all of these traits. Theory also is needed to explain the extraordinary size of the human brain, in relation to overall body size, and the extraordinary cognitive-behavioral abilities of the brain, including symbolic language, theory of mind, kinship, marriage, religion, and even nihilistic philosophy. In our target article, we apply life history theory in an attempt to better understand human nature regarding growth, development, and language.

One commentator, **Weisfeld**, denies that human beings have a unique or unusual life history; in fact he does not use the phrase “life history” at all in his commentary. If Weisfeld’s critique is correct, then the whole of our argument falls. But, his citations regarding human life history and nonhuman primate growth are both selective and somewhat old. The most recent citation is from 1993, well before some of the most salient work on primate life history was published. We cite that more recent research in our target article, and we provide additional references in this response (see below). Moreover, Weisfeld’s interpretations are idiosyncratic, do not reflect the broad consensus of primate life history researchers, or are incorrect. The studies he cites (also cited by **Ragir & Brooks**) alleging that all primates have a skeletal, or even a body weight, growth spurt at the time of puberty

originated in the 1950s (Gavan 1953). Gavan’s original paper concludes that chimpanzees (a sample of 9 males and 7 females) do not have a pubertal growth spurt. Watts and Gavan (1982) reanalyzed the 1953 chimpanzee data, along with new data for the rhesus monkey, and reported that a “very small” positive deviation in bone growth could be detected at the time of puberty. “Very small” means less than a 3.0-mm deviation, which occurs during one year, and the detection scheme required polynomial regression fitted to the bone growth data.

We have criticized the methods and statistics needed to show these “spurts” (Bogin 1999a; 1999b). The human adolescent growth spurt is measured in centimeters – with a mean peak velocity of about 7.5 cm per year for girls and 9.0 cm per year for boys. The human spurt takes about eight years to complete. Leigh (1996; 2001) shows that, among 61 primate species, weight growth spurts vary greatly in magnitude and even in their existence – only one species of New World monkey may have a weight spurt; gibbons do not, and only males of the common chimpanzee do. Leigh could not confirm that any nonhuman primate species has a skeletal growth spurt. Hamada and Udono (2002) published the first statistically sound and methodologically rigorous longitudinal study of chimpanzee skeletal growth. They found that chimpanzees reared within semi-natural social conditions at a zoological park in Japan show no increase in long bone growth velocity at the time of puberty (Fig. R1).

In contrast, chimpanzees used in medical research, who were taken out of their social groups prior to puberty, stopped or greatly slowed growth during the time of experimentation. When returned to their social group after experimentation these chimpanzees experienced rapid growth, imitating a growth spurt. But this is not at all similar to the human adolescent growth spurt. Rather, Hamada and Udono (2002) explain that it is a type of “catch-up” growth following the stress of social separation and medical experimentation. Human beings show this

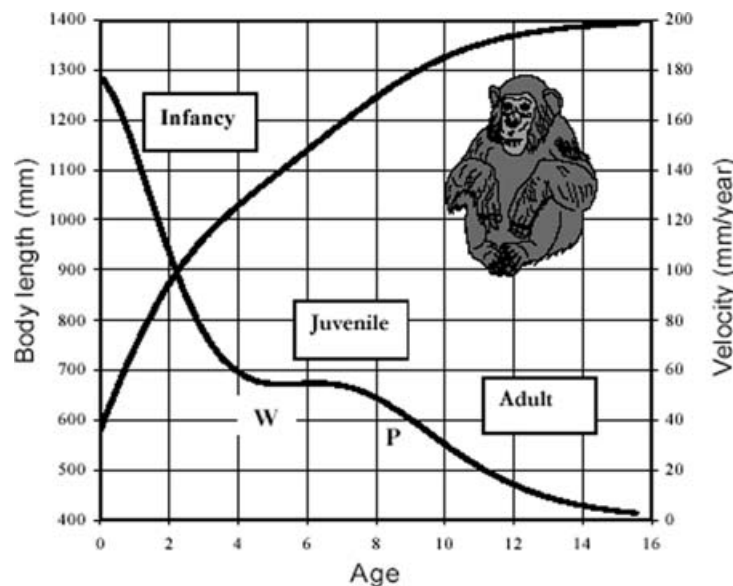


Figure R1. Model of distance (left) and velocity (right) curves for chimpanzee growth in body length by years of age. Data for the figure come from the longitudinal study of captive chimpanzee growth conducted by Hamada and Udono (2002). The infancy, juvenile, and mature adult life stages are labeled. In the wild, weaning (W) usually takes place between 48–60 months of age (Pusey 1983). In captivity, female puberty (P), assessed by age at first maximal perineal swelling, takes place at a mean age of 7.95 years (Littleton 2005).

type of “catch-up” growth following chronic illness, nutritional deprivation, or severe emotional distress (Bogin 1999b; Prader et al. 1963).

Finally, **Weisfeld** writes that we should not abandon the convention of using the term “adolescence” to apply to simians. He states, “What would we otherwise call the period of puberty in simians?” How about “puberty”? Indeed, primate puberty is a neuroendocrine event of relative short duration, taking place in the brain (Plant & Barker-Gibb 2004). Human adolescence follows this event, lasts for eight years, and involves ritual behaviors that instruct the youth in economic, sexual, and political behavior, and eventually transform the youth into a socially acceptable adult ready for marriage and parenthood. No other species comes close to this biological, behavioral, and cultural stage of life history.

Eckhardt’s comments remind us that the hominin lineage split off from other primates at least 6 million years ago. There is no evidence that chimpanzees, as we know them today, even existed at that time (McBrearty & Jablonski 2005). That chimpanzees knuckle-walk and humans have childhood and adolescence merely reflects their independent evolution and adaptation to different ecologies. Despite this separation in time, **King** makes a very good point about continuities between primate species in many aspects of communication and social interaction. The discontinuity, we believe, is the human capacity for emotional engagement between multiple caretakers and dependent young that is clearly different.

A few of the commentaries on our article seem to have a different notion of life history and life history theory than we do (e.g., **Bickerton; Dickins; Ragir & Brooks**). Others, including **Gogate, Kappeler,** and **Oller & Griebel,** have expressed legitimate differences of opinion with our model of human life history. Let us address their comments with a clear definition of our terms. Life history may be defined as the strategy an organism uses to allocate its energy toward growth, maintenance, reproduction, raising offspring to independence, and avoiding death. For a mammal, it is the strategy of when to be born, when to be weaned, how many and what type of pre-reproductive stages of development to pass through, when to reproduce, and when to die (Bogin & Smith 1996). Life history, in this definition, encompasses the major growth, development, and reproductive events that occur between the conception and death of an organism.

Living things on earth have greatly different life history strategies and life history stages – consider those insects with more than a dozen stages from conception to reproductive adult. The differences in life history characteristics can have profound effects in several biological domains, including growth dynamics, ecology, demography, behavior, and evolution of populations. Life history theory, which is the scientific study of life-cycle strategies and their evolution, provides a way to unify systematic research in the many separate domains, each studied by different groups of specialists. One of the best introductions to current life history theory is provided by Stearns (1992).

Part of the focus of our article links the way in which people grow and develop with human reproductive success, which is greater than that of any other mammal. The social mammals, such as wolves, lions, and elephants, rear about 12–18% of their live-born offspring to

adulthood. Our closest living relative, the chimpanzee, rears about 36% of its live-born offspring to maturity. But human hunter-gatherers and horticulturalists, living in traditional societies without the benefits of modern medical care, rear about 60% of their infants to adulthood. Industrial societies of North America and Western Europe successfully rear at least 95% of live-born infants to maturity (Bogin 2001). Some of the reasons for this amazing human reproductive success are short birth intervals due to early weaning, the evolution of the childhood stage of development, and human capital-building during the juvenile stage and the uniquely human adolescent stage of development (Kaplan et al. 2000). Despite the delay in first reproduction produced by the insertion of adolescence, primiparous human mothers are physically, socially, and emotionally better prepared than other primate females. This may be seen in the mortality rates for infants, which are lower for humans than any other mammalian species (Bogin 1999b).

Perhaps the most important attribute leading to reproductive success is human cooperative breeding. By this we mean the cooperative childcare and feeding by non-maternal kin and non-kin that is essential to ensure the survival of a weaned child. Cooperative breeding has evolved independently in several species of mammals, birds, and insects. In those species, and in many but not all human groups, the helpers are close genetic relatives of the mother (Clutton-Brock 2002). By assisting the mother to care for her offspring, the helpers increase their own inclusive fitness, meaning that they increase the chances that their genetic kin will survive to reproductive age (Hawkes et al. 1998; Paine & Hawkes 2006). Unlike other species, human societies define kinship relations on the basis of social as well as genetic ties. In traditional human societies, kinship is the central organizing principle for economic production, social organization, and ideology. Human cooperative breeding, therefore, enhances the social, economic, political, religious, and cultural “fitness” of the group as much or more than it contributes to genetic fitness.

We agree with **Gogate’s** reference to Dynamic Systems Theory (DST), according to which causality should not be viewed as a linear sequence since the emergence of new systems is usually the result of interactions of many factors at multiple levels. Gogate makes two other points about DST, life history, and language – namely, that change is not predetermined, and that change is driven by instabilities within the system. We think that these aspects of DST and evolution help explain discontinuities in the biology and behavior of closely related species such as chimpanzees and people.

The concept and stark reality of biological costs and trade-offs are also part of life history theory. **Knight & Power** state that we do not consider biological costs in our article, but we do use the word “cost” or “costly” four times in both a biological and a social sense (also see sect. R9 of this Response). For some reason, we failed to use the term “trade-off” and that is a serious omission in any article on life history evolution. A trade-off may be thought of as the competition between two biological or behavioral traits. Stearns says that “trade-offs occur when two traits compete for materials and energy within a single organism” or, “when selection for one trait decreases the value of a second trait” (1992, p. 223). An example of the

first type of trade-off is competition between organs or tissues of the body during growth. For example, should energy and materials be devoted to growing a large set of muscles or a larger brain? An example of the second type of trade-off is the choice of producing one large offspring (k-selection) or many, smaller offspring (r-selection; cf. Wilson 1980). All living things face these trade-off decisions. Some occur on a day-to-day basis, others occur over longer periods of time. Those that have reproductive consequences and occur over generations are subject to natural selection, and the effected traits may evolve over time.

Had we discussed trade-offs, we might have forestalled the comment of **Johansson, Zlatev, & Gärdenfors (Johansson et al.)** that our model does not “explain the absence of language in, for example, chimpanzees” (emphasis in original; also see sect. R9). Chimpanzees have taken one path in life history trade-offs, and it includes a long period of nursing of infants to ensure survival versus more rapid reproduction, in the hope that some offspring survive (also see the final paragraph of sect. 2.7 in the target article). Human ancestors evolved cooperative breeding to have both more offspring and more survival, but with a trade-off cost in terms of social interaction. That cost entails getting individuals with selfish interests to cooperate. Our model proposes that human ancestors intensified the use of honest signaling, the use of communicative displays such as smiles, and eventually language as a means to reduce social conflict and foster cooperation.

Bjorklund & Grotuss pick up the theme of evolutionary trade-offs in their commentary. They refer to developmental plasticity, another important concept and mechanism that we do not mention in our target article but have discussed at some length elsewhere (Bogin 1999b; Locke 1997). Bjorklund & Grotuss’s proposition that language is a product of childhood plasticity in “sociocognitive abilities” is entirely consistent with the message of our article. We thank them for providing another important way to look at the question of the evolution of language.

The commentaries of **Brighton, Mata, & Wilke (Brighton et al.)** and of **Powers** point to another omission in our article, namely, the importance of mathematical modeling. Much of life history theory is predicated on mathematical models (e.g., Bogin 1988; Charnov 1993; Gage 1998; Gurven & Walker 2006; Kaplan et al. 2000; Stearns 1992;). Modeling adds clarity of conceptualization, delineates the variables and parameters to be considered, and offers one type of scientific testability. Modeling is akin to inductive reasoning, whereas the approach we take in our article combines deductive and inductive reasoning. We neither disagree with our critics nor do we grant their approach primacy.

Kaplan et al. (2000) and Gurven and Walker (2006) are two excellent examples of modeling human life history, not mentioned by any of the commentators. Kaplan and colleagues show that human life history differs from the life history of the chimpanzee in several key dimensions. Based on empirical research with living human foraging societies, they show mathematically that adults must provision human offspring for about 15 years. Until that age the young cannot produce enough food to meet their own energetic demands. The need for such lengthy

provisioning requires the type of close, cooperative, honest, and, at times, deceptive social contact that is both a human defining trait and facilitated by symbolic language and human cultural behavior (Gurven et al. 2000). We also note that the provisioning of young and their language development takes nearly all of human ontogeny prior to reproductive age. This is not likely to be a coincidence.

Gurven and Walker (2006) build on Bogin’s life history model. They use computer simulations inductively to show that slow childhood and juvenile growth allows for the type of food provisioning that defines human cooperative breeding. Moreover, Gurven and Walker’s modeling shows that slow “growth followed by a rapid adolescent growth spurt may have facilitated rising human fertility rates and greater investments in neural capital.”

A fundamental distinction in approaches taken in life history research is clarified by the work of mathematical modelers such as Gould (1977) and McKinney (2000), cited in some commentaries, as well as Charnov (1993) and Gage (1998), who were not cited by any of our respondents. Gould and McKinney employ models based on heterochrony, which is an evolutionary process that alters the timing of existing life history stages. The heterochrony model for human evolution holds that the existing life stages of human primate ancestors were lengthened to derive the human condition (McKinney & McNamara 1991). This is, essentially, the basis for the continuity model for primate biology presented in the commentaries already discussed. Heterochrony does have its place in life history evolution, but we have found it lacking for human evolution. We have reviewed the literature both for and against heterochrony and offered new empirical evidence – using our inductive approach – against heterochrony (Bogin 1997; 1999a; 1999b). Instead, we found evidence supporting the insertion of the novel life history stages of childhood and adolescence into human development. The insertion of childhood shortened the infancy stage and the juvenile stage of other primate species. The insertion of adolescence did lengthen the time to adulthood, but not by lengthening any pre-existing life history stage. The inductive model theorists Charnov and Gage support our view. Charnov finds that the life histories of most species of fish, insects, and mammals studied can be modeled with his invariant life history symmetries. The glaring exception is the species of Order Primates, especially *Homo sapiens*. Gage used both mathematical modeling and empirical data to contrast chimpanzee and human life history with regard to demography. He finds that these two most genetically similar primates are quite divergent. Chimpanzees have a longer reproductive life span than humans, due to both the later onset of fertility and menopause of human women (chimpanzee do not have menopause; see Littleton 2005). Chimpanzees suffer greater infant mortality than humans. Indeed, chimpanzee mortality is greater at all ages prior to sexual maturation. Human demography is unstable, meaning there is more variability in both mortality and fertility among humans than among chimpanzees. Humans are an unusual primate species for having “baby booms.” Gage suggests that these fertility booms may have played an important role in the evolution of human culture. Finally, the life history pattern of the human species depends on low pre-reproductive mortality. This novel

demographic condition evolved after the pongid-hominin split, perhaps after the evolution of the genus *Homo*. Gage's inductive modeling supports the essential features of our deductive empirical associations. The evolution of human childhood greatly increased the fertility of women by decreasing both birth spacing and mortality. Cooperative breeding to support weaned but still-dependent children was the key to lowering mortality. Human culture, including language, evolved as part of the "package" that enhanced both cooperative breeding and individual reproductive success.

Powers advises us to consider models based on genetic programming, evolutionary robotics, and artificial life. We are forced to leave such work to others as this lies outside our expertise. Of course, we would be pleased to work with experts in those areas. Powers says that our Figure 3 in the target article is "disconfirmed," but does not offer any reference citation to support that rather strong statement. We do not know of any disconfirming evidence for Figure 3, which is based on stages or grades of hominin evolution and not specific species of hominins. Several of our hominin paleontology colleagues have reprinted this figure in their own work, including textbooks (e.g., MacDonald & Hershberger 2005; Relethford 2006; Stanford et al. 2006).

R2. Language

In the target article, we noted that theorizing in the area of linguistic evolution is incomplete in two major ways. The first is that most theories presuppose the existence of the word, relieving them of any perceived need to explain articulatory or symbolic capabilities. As words lie far beyond the reach of other primate groups, no theory of language can be complete without an account of speech. We proposed several evolutionary processes, and fitness benefits, that may have increased control over a range of speech sounds – something that language universally requires – and offered a brief remark about sound-meaning relations in the context of parental care.

The second characteristic that we noted also relates to an omission. Evolution is a two-stage process (West-Eberhard 2003). In the first stage, a plastic phenotype responds to environmental variation, producing novel forms that vary genetically. In the second stage, selection acts on the variants. From the late nineteenth century to the present it has been argued that the first stage, the origin of novel characters, can only occur in development. It is therefore strange, we asserted, that theories of linguistic evolution have been largely devoid of any developmental considerations. Few theorists say anything about the contributions of infancy, childhood, and juvenility, or even, specifically, adolescence. The relevant behaviors merely appear in adulthood.

One of the commentaries points out that we ourselves omitted something. **Bickerton** wonders why, in our attempt to explain certain aspects of the evolution of spoken language, we devoted so little attention to "the language faculty" that ultimately evolved – the capacity for a lexicon and especially the grammatical codes of modern languages – and so much attention to "the use to which it is put." No one, he suggests, would confuse objects such as cars and forks with the associated actions

of driving and eating. Bickerton thus welcomes discussion around the possibility that language is an object. Its current use, he also claims, is primarily cognitive and private. These views of language surely present interesting implications, if not complications, for discussions of its evolution.

What is wrong with viewing language as an object? Surely it is not that language has *no* inventory of forms and rules, because it does. Indeed, if we are to achieve a comprehensive theory of linguistic evolution, we must explain how our species came to possess the capacity to learn and use linguistic codes. But in the context of evolutionary theory, language-as-code can have serious consequences if it distracts us from the *behavioral processes that led to language*. For the things that code excludes – the emotions, intentions, and interactions of living beings – are, or should be, the stuff of reproductive fitness accounts. Cues to personal identity, developmental stage, dominance, aggressiveness, health, and fecundity may be gleaned from the voices of humans and other primates (Cheney & Seyfarth 2005a; 2005b; Krauss et al. 2002), and a great deal of additional information, from honesty and character to personality and temperament, is to be found in speech. In many societies, speech also carries information about important cultural matters, such as social class, education, and region of birth.

If language can be so socially informative, and so animated, how did it come to be thought of as a static object? The culprit, to some extent, may be literacy. Since print is inanimate and stationary, one can examine and endlessly re-examine language that is expressed in this form. When words and sentences are written down, wrote Lakoff and Johnson (1980, p. 204), they "can be readily looked upon as objects." When literate individuals think about language, according to Linell (2005, p. 4), what they think about is "an inventory of forms, and rules for generating forms."

Is language-as-thought – either as a phenomenon or a proposal – also fostered by literacy? Goody and Watt (1968) suggested that "writing, by objectifying words, and by making them and their meaning available for much more prolonged and intensive scrutiny than is possible orally, *encourages private thought*" (p. 62, emphasis added). Comparative researchers have also expressed doubt about the naturalness or primacy of linguistic thought. Some point out that thought without language is already present in nonhuman primates (Seyfarth et al. 2005). Others fail to see how the linguistic thought hypothesis accounts for vocal learning or the meaning-to-sound mapping that occurs in language, or how one could appreciate the intellectual benefit of a private language "without a rich culturally-conveyed set of words, socially accreted over generations in the lexicon" (Fitch 2005, p. 211). But the problem with language-as-thought is not that it is incorrect; it is that this application, if it occurs with significant frequency, is likely to have originated fairly recently in evolutionary history.

Bickerton embraces Chomsky (1980) but neglects a more recent work, Chomsky (2002a), that seems to explain the latter's statements regarding language and thought. In this later work, Chomsky associates himself with a conclusion by Hauser (1996) to the effect that language fails to qualify as communication because it has different properties than the signaling systems of bees,

wolves, birds, squirrels, frogs, apes, monkeys, and other nonlinguistic species that are addressed in *The Evolution of Communication*. What, then, is language? Chomsky responds that it is “a system for expressing thought” (Chomsky 2002a, p. 76). This, he says, makes language “quite different” from the signaling systems of animals. Fair enough, but the expression of thought is what people have in mind when they say that language is used to communicate. It is virtually the dictionary definition.

In the target article, we discussed Hauser et al.’s (2002) distinction between broad and narrow conceptions of the faculty of language. **Bickerton** suggests that we misinterpret this distinction “as licensing the subsuming of structural and pragmatic elements under a single umbrella” while evincing no awareness of the arguments that we actually made for the “single umbrella.” In the target article, we sampled evidence from development, evolution, and genetics. The messages from these fields converge upon a single conclusion: the capacity for *speech* is intimately related to other levels of language. Developmentally, it is evident that infants who have difficulty with word learning are likely to have problems later on with grammar or pragmatics, even if their lexical difficulties abate. Evolutionarily, it is evident, on logical grounds, that grammar and other areas of language *must be* related. For if some observable behavior increased fitness at sexual maturity, then developmental precursors would have been incidentally reinforced – development being continuous – by virtue of facilitative relationships of the sort that have been documented in contemporary humans. In behavioral and molecular genetics, analyses of individuals with problems at multiple levels of language have revealed stronger or more consistent effects in the areas of phonetics and phonology, effects that imply a vocal influence in the development of all areas of language.

The commentary by **Bickerton** was not the only one to raise connections between language and thought. One other, that of **Van Herwegen & Karmiloff-Smith**, points out that we do not say whether it is language that makes humans intelligent. These commentators claim that the uniqueness of humans depends on the ability “to re-represent their representations into an explicit format, transportable from one domain of knowledge to another one.” This may be true, but it has nothing to do with our stated objective, or with any claims that we have made.

Johansson et al. suggest that by failing to deal with “patterned content” (something that also concerned **Brighton et al.**, **Gogate**, and **Powers**) we do not actually explain language. What we did do was identify life history changes that would have provided critical opportunities for increased plasticity, flexibility, and innovation of relevant behaviors. We also presented arguments for the reproductive advantages of vocal, articulate, and referential behaviors during different stages of life history, from infancy to adolescence. We made no attempt to explain grammar, though a life history approach such as ours could well converge, at some point, with ongoing work on phonetic and phonological patterns (Locke 2000a; MacNeilage & Davis 2000; Ohala 2005; Studdert-Kennedy 1998; 2005). It could also produce an account of vocal complexity that interfaces with syntax (see sect. R5).

R3. Developmental contributions to the evolution of language

It was gratifying to receive comments on the role of development in evolution by several scholars who have inspired our own thoughts in this area. **Gardner** congratulates us for adopting a biological framework, and for achieving an account that is more credible and relevant than strictly linguistic formulations. **Bjorklund & Grotuss** commend us for focusing on the role of childhood in evolution. Our own valuation of the young emphasized their creativity, in the contexts of parental care and play. These commentators call attention to a possible extrafamilial contribution of the young: play groups in which words are combined in novel ways to form new words and rudimentary syntax. They also point to the unusual plasticity of the developing brain, suggesting that this might have endowed the young with a responsiveness to environmental change surpassing that of mature individuals. We see merit in both ideas, and also in their suggestion that language, and its antecedents, may have altered the contexts in which the young found themselves, exposing them to novel selection pressures.

One change of context may have involved increases in the size of working groups. In hominins, the ability to speak may have facilitated new levels of organization, enabling increases in group size. This would have increased cooperation in some areas, such as predator defense, while increasing within-group competition for physical resources (Locke 2005), though a reverse-order effect has been argued in which larger groups encouraged a transition from manual to vocal grooming and speech (Dunbar 1993). Larger groups would also have increased sociosexual competition, as we suggested earlier, which may have affected males and females, and their uses of vocal and verbal behavior, differently (see sect. R4).

When **Kuiper** refers to “analytic decomposition” of an enlarging “phrasal” vocabulary, he is proposing that such an act promoted the evolution of grammatical mechanisms. We agree, having argued in the past that in *development*, too, grammatical mechanisms are pressured into action by a burgeoning store of prosodic forms. In the second year of life, about half of infants’ distinct utterances may be of this sort (Lieven et al. 1992; Locke 1997). Many persist in prosodic form, seemingly immune to segmental decomposition. We have proposed elsewhere that when this sort of material begins to overflow its memorial banks, typically in the third year, it triggers activation of a system that analyses entries into elements corresponding to linguistic units (Locke 1993; 1997). This leads to more efficient storage and permits grammatical computation. Hence, it may be said that words and phrasal words not only precede grammar, but provide its justification.

Johansson et al. say that we fail to show why chimpanzees did not evolve language, but that “buried” in our account “is the germ that may save” us. Fortunately, they were not forced to dig too deeply to find it. The germs – bipedalism, pelvic narrowing, and helplessness – were key components of our argument. We, like Johansson et al., proposed increases in proximity, attention, and care as key ingredients in the evolution of language as well as its development (Locke 1993).

King and Cowley wish we had placed more emphasis on interaction. We agree with Cowley that language, which is typically manifested as speech, is more often

produced *with* others than *to* them, a pattern initially manifested in infancy. King sees antecedents in the actions of other primates, ones that result in “mutually constructive meaning-making.” We would like to know more about the actions King has in mind. King welcomes our emphasis on parent-infant engagement, suggesting that message-making activity, and especially the emotional energy that drives it, represents a powerful force in the evolution of linguistic structure. We agree. Several years ago, we wrote that infants acquire language “merely by dancing with mature humans,” the dance following on from “previous success in the area of emotional development and attachment” (Locke 2002, p. 633).

Spoken language owes its existence, and a great deal of its flexibility and utility, to a “comparably complex, flexible phonological system” (Fitch 2005, p. 200), something not present in the Last Common Ancestor shared with apes. One of the more important goals of evolutionary research is to achieve an account of how vocal tract activity was submitted to cortical control. **Oller & Griebel** take this on, asking how our hominin ancestors achieved the capacity to disconnect vocal or, more precisely, articulatory activity from its previous environmental and emotional moorings. In their own research, taking a recapitulatory stance, they ask how this now occurs in developing infants. Oller & Griebel offer an interesting theoretical and analytic framework, one that deserves to be adopted by other researchers. They fully understand the possibility that vocalization may be associated with requests for care, just as it affects parental decisions regarding the quality or quantity of care to provide. Nearly two thousand years ago, a medical doctor, Soranus of Ephesus (96–138 A.D., translated by Temkin in 1956), claimed that certain newborns were “not worth rearing.” The newborns he had in mind, significantly, included those who cried atypically and failed to respond appropriately to external stimulation.

Oller & Griebel stress developments in the first six months of life. Cooing, perhaps the first nonstress vocalization, appears at about three months. This is an interesting age. It is also when crying declines, along with infanticide (Locke, in press c), and it is generally assumed that this age is when instrumental crying (and smiling) begin. When the infant is finally freed from internal discomforts that block optional and playful forms of vocal behavior, it may begin to “read” others to see how they are affected by his vocalizations. Doing so will make it easier to use syllables strategically to attract and engage others.

It is of course possible for articulatory control to emerge in association with endogenous variables, such as the development of arm and hand activities, as may have occurred in response to environmental changes that freed the limbs from their earlier role in ambulation (cf. Locke, in press a). But there may also have been pressures to signal that added to the benefits of articulated phonation by itself.

Sharing **Oller & Griebel’s** concern with the emergence of vocal-motor control, **Lenti Boero & Bottoni** see value in comparative studies of vocal development, especially in songbirds and parrots, and of various communicative practices in nonhuman primates and vocal behavior in human infants. **Schleidt** also emphasizes comparative studies of development. For him, the chief contribution of different ontogenetic stages relates to social factors, primarily the formation of close ties to new types of companions.

Powers chides us for not saying more about fetal learning. At one time, we could have been accused of saying *too much* about it (Locke 1993; 1994a; 1994b; 1994c; 1997; 1999; Locke & Snow 1997), but we repeat here: linguistically relevant stimulation appears to begin at some point in the final trimester of gestation, possibly with the onset of audition.

R4. Oral societies: Verbal performance

In the target article, we devoted some space to oral societies in which orators – and in segments of industrial societies, “street orators” – exercise a number of impressive vocal and verbal skills to attract audiences and persuade them to their point of view. No formal training is needed to do these things, as the work on “Brazilian bards” confirms (Roazzi et al. 1993; 1994). **Kuiper**, in commenting that literate societies “contain many subcultures which are oral societies,” stresses that orality is a hardy disposition that endures in spite of literate pressures. Even in the highly literate corridors of academia, oral story-telling reigns supreme (Wickham 1998).

“Some people have a way with words,” comedian Steve Martin once joked, “other people . . . not have way.” **Kuiper** points out that in many societies, those who “not have way” cannot handle phrasal vocabulary (colloquialisms and other forms of formulaic material) with some degree of skill and may become “social lepers.” In various cultures, people who do not speak well are disrespected or even censured (Edwards & Sienkewicz 1990; Peek 1981). In the target article, we pointed out that African Americans who lack the knowledge and skill needed for verbal duels are derided as “lames” (Abrahams 1989; Labov 1972; 1973), and if they fail with women, their raps are ridiculed as “tissue paper” (Anderson 1990, p. 115).

Clearly, various sorts of verbal gamesmanship are beneficial in adolescence and early adulthood. This is also true in the preceding stages of juvenility and childhood, when riddling and formulaic jokes become popular in a variety of cultures around the world. McDowell (1979) encountered four different genres of verbal performance in “chicano” and “anglo” children and juveniles in Texas: stories, rhymes and songs, taunts, and riddles. The riddles were used in a competitive or agonistic arena. The taunts expressed aggression in verbal form, thereby preventing physically injurious activity. These genres also help increasingly autonomous individuals to make decisions about which others to include as friends and future collaborators, and to decide which groups to join. In adolescence, they may be used as a means of judging intelligence and suitability for long-term relationships (see sect. R5).

Several peers, including **Benga**, have commented on our treatment of verbal performance. **Knight & Power** indicate that we use the term “performative” differently from Austin (1975), who cast about for alternatives before he settled on this term, and who clearly felt a need to justify his final choice (Austin 1975, pp. 6–7). However, our use is completely consistent with the relevant literatures. “Performer” and “performance” frequently appear in the accounts of oral societies (e.g., Abrahams 1968; Bauman 1975; Gossen 1974; Ong 1982),

as does “performative” (e.g., Edwards & Sienkewicz 1990; Finnegan 1969; Linell 1982). This is unsurprising since the phenomena in question involve verbal artistry and an audience. Still, to ensure that readers would not confuse our meaning with Austin’s, we referred to pragmatics *and* performance five times. In section 2.8 of the target article, we pointed out that a number of verbal functions that belong to the performative function (e.g., joking, mollifying) fall outside the area of pragmatics as usually defined, and in section 10 (title “Pragmatics and performance”), we further discuss these categories.

Knight & Power imply that we erred in claiming that “performative applications of language, in the form of speech and voice, consistently favor males.” Evidence from the (heavily Western) anthropological literature indicates that males are, in fact, more likely to engage in public displays of vocal and verbal prowess than females. There are cultures where both men and women speak in public, but we have yet to find a culture where the male dominance pattern is reversed, and would expect to find few in which females outperform males in agonistic displays.

Knight & Power suggest that any evolutionary accounts based on male dominance in the public display of vocal and verbal behavior are necessarily limited, since these would only take place in hierarchical or stratified societies. If this were true, it would be difficult to square with anthropological accounts. Consider, for example, the song duels of the Hindi-speaking Fiji Indians, an “unstratified” society in Bhatgaon. In these duels, sung by men in groups of three to six, the “singers usually attack, insult, and slander the religion, relatives, and persons of their opponents,” attempting “to lower the prestige of their opponents and their opponents’ religion” (Brenneis & Padarath 1975, p. 283). “Despite an apparent *lack of stratification*,” the authors conclude, “the nature of one’s standing relative to other men is a recurring concern for villagers” (p. 284, emphasis added).

In the target article, we claimed that “important aspects of language cannot appear until sexual maturity.” **Knight & Power** chose to conflate this claim with an equally uncontroversial statement in section 10, that “the ability to infer intentions presupposes real-world knowledge,” (sect. 10, para. 2) and then drew the conclusion that the knowledge we had in mind had something to do with sexual behavior. It does not. What we stated is that pragmatics is the last area of language to develop, and must be, because it depends on knowledge that could not be present until the individual had witnessed, and engaged in, behaviors that typically emerge in the run up to adulthood. The knowledge we had in mind concerned the social, economic, political, and physical world as it can only be known to those who interact with it outside of the familial context, with some degree of autonomy.

Knight & Power again merge separate statements from section 6. There, we pointed out that the verbal dueling of males may be supported by testosterone, which is related to dominance and aggression (Puts et al. 2005), and that it may be adaptive for them to use verbal sport and humor in place of physical combat. Knight & Power take this to mean that *in females*, lower levels of testosterone are somehow responsible for the documented gossip preference associated with that sex; they then interpret gossip, as a means of disseminating socially relevant information,

to be syntactically more complex than the elaborate verbal performances of males.

There are at least two things to say here. The first is that in males, testosterone contributes to aggression, which is frequently exercised physically (Dabbs 2000). To avoid physically harming each other, some other behavior must be substituted. Marsh (1978) has described the “aggro” of young British men, a ceremonial display of physical posturing and verbal taunting that expresses aggravation in a fairly harmless manner. Aggro, he writes, “is an all-male affair . . . females are irrelevant – they form no part of the ceremony and, more importantly, they are not legitimate objects of attack. There is no conflict here except with other males” (Marsh 1978, p. 28). It is widely recognized that male adolescents and young men need ways to avoid physically injuring each other. Although this can be accomplished with nonverbal as well as verbal displays (Kochman 1969; 1983; Marsh 1978), in practice, the two work together. Street gangs that are physically violent have a high rate of verbal duels (Short & Strodtbeck 1965).

Although aggrieved members of both sexes swear at, scold, scorn, and chastise others, the second thing to note is the strong tendency of females to engage in gossip – a private verbal behavior used primarily or exclusively with other females – to lower the status of perceived opponents, and to do so during the same life history stages, juvenility and adolescence, in which males engage in verbal duels – public verbal behavior used primarily or exclusively with other males – in an effort to compete for status and other resources. However, in our reference to gossip (sect. 6), we pointed out that the stronger female disposition to gossip “may have to do with the fact that gossip serves an *affiliative* function,” and that females, in times of stress, “tend to *come together*,” turning to each other “for *mutual aid*” (sect. 6, para. 2, emphasis added). It was in this context that we discussed sexually dimorphic applications of speech.

In searching for the biological bases of such differences there are plenty of places to look. Consider the birth process. In the other primates, there appears to be a tendency to give birth alone. Women, on the other hand, seek each other out at the time of childbirth (Trevathan 1999; Walrath 2003). Even in the case of apparent contradictions to this pattern, the woman typically does not leave the group for her first child, or go too far to summon help if needed (Biesele 1997).

If women gossip more than men, **Knight & Power** say, this should give them an advantage in the area of syntax, but this takes several things for granted. First, it assumes that gossip is syntactically complex. We accept that it may be. Second, it assumes that the more public displays of verbal prowess by male speakers are syntactically deficient. To our knowledge, no such evidence exists. Indeed, the reports indicate that the more powerful individuals in traditional societies are unusually expert in manipulating sentential material.

Studies of baboons indicate that here, too, females are less aggressive than their male counterparts. Seyfarth (1976) has reported that the ratio of approach-retreat interactions to bouts of overt aggression is less than 2:1 in males, but 20:1 in females. The affiliative function that is fulfilled by human gossip may also have antecedents in nonhuman primates. Elsewhere, we have reviewed

research indicating that social grooming is carried out predominately by females (cf. Locke 2000b; in press b). When grooming, monkeys characteristically emit lipsmacks and girneys – low amplitude oral and vocal activity that, to some ears, bears faint resemblance to speech (Richman 1980; 1987) and also is displayed in the context of appeasement. In a study of captive Japanese macaques, 90% of all the girneys were produced by females (Blount 1985).

There is evidence in our own species that girls are less competitive and domineering than boys (Benenson et al. 2001; Miller et al. 1986; also see review in Campbell 1999). A factor in this pattern may be the size of social groups. Left to their own devices, females prefer dyadic interaction. Males, by contrast, prefer larger groups (Belle 1989). The significance of this is that larger groups foster competition. In Benenson et al. (2001), 6- and 7-year-old boys, but not girls, made a higher proportion of competitive moves in tetrads than in dyads.

Liénard asks if there is evidence that women are verbally dominated by men, and there is evidence – at least when it comes to interruption and volubility. Investigators typically find that females are more inclined to speak than males when interacting with a same-sex conversational partner of their own choosing, and in this context they also tend to be more talkative in juvenility, childhood, and infancy (see Locke & Hauser 1999 for references).

We welcome **Wermke & Mende's** emphasis on melody. They argue that melody may provide the immature infant brain with “a kind of filter to extract life-relevant information out of the complex parental speech stream” (last para.). They remind us that, to infants, the most salient of all acoustic components in speech is prosody, a feature that parents exaggerate when addressing their infant. It is also a feature that figures into the identification of prepackaged phrasal material, as **Kuiper** understands.

Johansson et al. ask why protohumans need to have spoken when they could have achieved similar benefits by singing. Our mission, of course, was broader than vocal control; we also took up reference, within the context of interactions between parents and their young, as did Fitch (2004; 2005). Still, there are at least three reasons to study speech in conjunction with song. First, there is, as we have pointed out, a logical connection between the use and control of the voice in singing and speech – an excellent reason for collaboration between speech researchers such as **Oller & Griebel** and those who study music and song (e.g., Merker 2000; Mithen 2005). Second, verbal duels and vocal contests appear to serve similar social functions in several different societies. Finally, competitive pressures in both modalities may have increased our species' capacity for vocal complexity. We discuss these functions and pressures in the section that follows.

R5. Verbal plumage: Folk IQ?

Functional connections between speech and song are implied by research revealing a male bias and an agonistic tone in vocal as well as verbal dueling. Herndon and McLeod (1980) observed that in Malta, the most frequently performed style of folk music, the song duel, or *spirtu pront*, “is an improvised poetic duel, sung by two

men, which develops a subject by means of complex metaphorical insult.” The *spirtu pront* is completely *improvised*, except for the melody. “Due to the complexity of this sung poetry,” according to Herndon and McLeod, “those who attempt it *must be extremely intelligent*” (p. 147, emphasis added).

Several years ago, we suggested that modern men attract and impress listeners “with verbal *plumage* – fluent mastery of a broad range of words and phrases, many of them outside the more limited repertoire of their audience” (Locke 1998c, p. 92, emphasis in the original). In the target article (Note 6), we pointed to evidence in industrialized societies that the use of rare, long, abstract, diverse, or unusual words is correlated with formal measures of intelligence. Here we speculate that in evolution, verbal ornamentation was created *so that* performers' cognitive abilities could be displayed and, thus, evaluated by others. If so, verbal plumage is something on the order of a folk IQ test.

It is evident that precisely this purpose – intelligence assessment – is now served by the Maltese song duels mentioned above, and that riddles permit similar judgments in the wide range of cultures in which they are used. In 1783, Chrisfrid Ganander described an ancestral Finnish tradition in which riddles were used to test “the acuity, *intelligence* and skills” of suitors. When a young man sought romantic commitment, “three or more riddles were posed to him, to *test his mind* with them,” wrote Ganander, “and if he could answer and interpret them, he received the girl, otherwise not, but was classified as stupid and good for nothing” (quoted by Maranda 1976, p. 127, emphasis added; also see Burns 1976).

Associations between verbal ability and intelligence have been described in members of African and African-American cultures. In a review, Peek (1981) points out that among the Igbo of southeastern Nigeria, oratorical ability “is directly equated with *intelligence* and success,” and that the Barundi people of central Africa associate verbal ability with “successful *cleverness*” (Peek 1981, p. 22). In Sierra Leone, “it is noticeable how strongly the Limba connect *intelligence* and speaking” (Finnegan 1969, p. 75, emphasis added). In African American communities too, “rap” and “the dozens” permit evaluations of an individual's ability to compete and adapt. “Black culture,” Kochman (1971) has noted, “promotes the development and demonstration of those skills which reflect on an individual's underlying *intelligence*, verbal ability, speed, strength, agility and endurance” (p. 19, emphasis added).

But the association between speech and intelligence is not limited to individuals of African descent. Among the Chamula Indians of southern Mexico, the ability to perform well in “truly frivolous talk,” a verbal duel fought exclusively by young men, “serves as a fairly dependable index of a man's social maturity, linguistic competence, *intelligence*, and political potential” (Gossen 1974, p. 106, emphasis added).

Since each developmental stage contributes to language, we should not be surprised to encounter nascent forms of verbal performances and duels long before adolescence. In his fieldwork with the Chamula Indians, Gossen (1976b) heard attempts by 2- or 3-year-old boys to verbally duel with their older brothers, with increases in phonological proficiency at ages 5 and 6 years. In a rare report, verbal

performances of 3- to 5-year-old African American boys were captured on audiotape and transcribed. In one case, a spontaneous rap, a boy expressed his feelings toward one of the female research assistants on whom he had developed a crush. In the other case, three boys engaged in “the dozens” (Wyatt 1995; 1999). These boys were playing, but a decade later they would be expected to enlist their verbal abilities as adaptive strategies, ones that would help them to attract females, avoid violence, and compete for status with same-sex peers.

To this point, we have exposed few connections between linguistic function and form, but if there was a reproductive advantage of vocal and verbal complexity, runaway selection – which, as Harvey and Arnold (1982) point out, would certainly have applied to vocalization – may have produced a huge increase in the complexity of speech and, therefore, the possibility of complexity *at other levels of language*, and possibly in other modalities. If speech were kept simple, observers would have to find other ways to make the necessary inferences.

If a performance is rhythmic or euphonious, and the material novel or complex, then it is possible that form and function interact. Are there relationships between the quality of the dance and the ornamentation of the dancer? There are multiple cues to attractiveness in other species, and these interact in extremely complex ways to produce their effect (Badyaev & Hill 2003; Candolin 2003; van Doorn & Weissing 2004). They even complement each other (Badyaev et al. 2002; Coleman et al. 2004; Johnson 1999). In our own species, too, speakers are evaluated along with their messages. It is possible that in display mode, the evaluations of others are based both on structural complexity and behavioral finesse.

R6. Genetic support of verbal performance

We have proposed that vocal and verbal skills enable adolescents and young adults to engage and compete with others, and to perform in public arenas – the relevant abilities increasing their fitness. Now it could be said that these verbal dimorphisms were merely brought to the surface and made observable by underlying sex differences in the tendency to compete and aggress (Fitch 2005, p. 212). But, for behavioral traits, as opposed to physical ones that are readily perceptible, such as size, the individual must be motivated to act in the first place, and the source of the motivation may be an internal change. In fact, if anything was selected directly, it was vocal and verbal ability. The indirect effects were the supporting physiological variables. Thus, males’ greater disposition to compete – secondary to increases in testosterone – may have increased the functionality of their vocal and verbal ability while also making it public, raising the probability that these skills would be selected, and tightening the links between speech and testosterone. If so, one might expect a genetic legacy: genes that code specifically for verbal expressivity and dominance in modern humans. Recently we came across several reports indicating that monozygotic twins, but not dizygotic twins, are highly concordant on measures of social potency and expressive control, tests that tap the ability to act or perform in social situations, even where the twins have been reared apart (Gangestad & Simpson 1993; Lykken 1982).

Significantly, individuals who were unusually social and expressive reported that they had engaged in sex with more partners, and with more partners on just one occasion, than their less social and expressive peers (Snyder 1987).

With such high concordance rates, one might expect to see differences in sociality and expressiveness appearing early in life history. It is interesting, in this connection, that investigators in other fields have documented the existence of unusually social and expressive individuals in infancy (cf. Nelson 1973; 1981), termed “dramatists” by Wolf and Gardner (1979) since they appear to learn at an early age that different individuals can exchange roles in identical social situations. Dramatists also like to tell dramatic stories and display elaborate forms of imitation. On the basis of content validity, Gangestad and Snyder (1986) speculated that such expressive differences in infancy and adulthood are manifestations of the same latent factor.

This section on the genetics of verbal performance is a convenient place to acknowledge the kind remarks of **Workman**, who does, however, misinterpret our discussion of FOXP2, thinking that we see in this gene a basis for linguistic grammar. In fact, we referred to the behavioral research leading to the identification of this gene because it related to the role in language that is played by “production factors.” We pointed out that problems experienced by the KE family “included a severe *oral and verbal dyspraxia*, accompanied by deficits at other levels of language” (emphasis added), and quoted from several theorists who suggest that speech might have a certain primacy that has been neglected in the past. This supported our argument that verbal performance was selected.

R7. Performance as adaptation

What supported the use of vocal and speech-like activity before there was speech? **Knight & Power** doubt our account of reproductive advantages because, they say, linguistic signs represent no “cost” or investment. They fail to recognize several things. First, the resting metabolic rate (RMR) of the human brain exacts a continuously high energetic cost from infancy, as mentioned in the target article and in section R1. Were this not so, many complex human activities, including language, would be impossible. Second, articulated phonation carries a great deal of information *about the individual*, whether or not it is consciously transmitted. Apes rely on this information and so do we. Third, potentially informative components of the voice are supported by physiological activity that is energetically expensive (e.g., pulmonary pressure; cf. Fitch & Hauser 2002). Fourth, traits will be selected if females prefer them, and not everything females prefer is costly (Johnson 1999). Finally, the mere uttering of certain words (or other constructions), especially rare ones, may reflect a great deal of prior learning – learning that presupposes the efficient action of relevant mechanisms. Merely to use a behavior that was learned, or requires an unusual mode of articulation, can mean that the individual has an intact nervous system, has the ability to attend, perceive, store, retrieve, and reproduce complex patterns of behavior, and can do so meaningfully

in an appropriate social context. The energetic requirements of the motoric act, and the veracity of any statements, are not the only relevant factors.

Dickins sees a need to identify proximate mechanisms for the actions that we propose, and **Powers** would like us to have made more explicit predictions. Perhaps we underplayed our effort to construct an adaptive account of vocalization in relation to social dominance and courtship. In section 8, we suggested that women who are attracted to men with a commanding way of speaking may get a mate for themselves, and a father for their children, who has high levels of testosterone and status, and unusual access to valued resources. Specifically, we evaluated research that reveals connections between properties of male voices, as measured acoustically and appraised perceptually, and both virility and social dominance. In light of other research, we would predict that women prefer the voices of men who are high in testosterone, especially when heard during ovulation (Fisher 2004; Puts 2005).

In the target article we reviewed research indicating that the speech of courting men contains unusually wide frequency and intensity swings, and that young women, when asked to evaluate utterances extracted from children's conversations, expressed a preference for selections that were classified as excitable, loud, and uncontrolled, among related variables. Taken together, these behaviors could suggest the operation of a sensory trap (after the pattern described in insects and other animals) in which sexually mature males mimic the vocal qualities that appear to excite females (Christy 1995; Enquist & Arak 1993; Macias Garcia & Ramirez 2005). Surely there is raw material here for testable hypotheses on the fitness benefits not just of speech, but of particular aspects of prosody, and investigations could easily be extended into lexical and other areas of spoken language. To implement such an agenda in the context of linguistic evolution, it will of course be necessary to investigate the perceptual preferences of sexually mature females and the use of male vocalization and speech in social competition and courtship, and this is exactly the kind of research that we propose. In line with a standard approach in biology, it would then be possible to look at which vocal variables were most strongly linked to perceptions and proximate variables that index fitness. By carrying out a research agenda of this sort, one does not show how language evolved, of course, but one may be able to argue for the plausibility of a particular proposal on the basis of empirical data.

Dickins is not sure that we adequately supported our claim that the components of language are related, but it can only be so if, as we argued in the target article and repeated earlier in this response (sect. R3), they were stitched together by sequential patterns of selection. Behaviors that were selected at sexual maturity, such as verbal persuasiveness, could not have appeared without some level of pragmatic development, and without linguistic skills that rest on previous accomplishments in the area of lexical, phonological, morphological, and syntactic development. We noted in this context, additionally, the well-attested observation that development is continuous, behaviors not usually emerging *de novo* in later ontogenetic stages without an appearance, in some form, in one or more of the preceding ones. We also cited evidence suggesting that individuals having problems in one area of language tend to have problems in other areas.

Johansson et al. say that we failed to show “that language was useful and adaptive specifically for proto-humans *and not* for proto-chimpanzees.” **Ragir & Brooks** seem to think, in parallel, that if language benefits humans, it should have benefited the other primates equally. If it did, they say, the behavior would have followed. But these comments miss the point. The question is not who language could have assisted, but rather, in whom it could have evolved. In section R1, we point out that hominins took a different path, one that led to cooperative breeding and protolanguage, and therefore evolved a completely different life history.

Ragir & Brooks comment that performance is beneficial at every stage of language development, not just in adolescence. That we also believe this is why we devoted so much attention to proposals regarding infant behavior, including parental selection and trickle-up phonetics. In the target article, we argued that skillful vocal performances by adolescent and adult *male hominins* would have facilitated their quest for rank and reproduction. Ragir & Brooks express doubt about a portion of this argument since, they say, *female apes* fail to show a preference for alpha males. The relevance of this is unclear, since our claim is that there were changes in *hominins* that occurred *following* their divergence from shared lineage. As indicated in the target article, we trace these changes to pre-adult stages when control over new and more variegated vocal behaviors emerged under environmental pressures that remodeled *human* infancy and contributed to the evolution of childhood.

R8. Pluralism

We noted at the beginning of section R2 that in the first stage of evolution, environmental variation produces novel forms that vary genetically, and that in the second stage of evolution, selection acts on the variants. According to our account, infancy and childhood produced new abilities to effect and manipulate vocal forms, with selection occurring in those stages and perhaps more powerfully at sexual maturity. To us, the development and evolution of language – and ultimately its nature – are interrelated. Work in one area potentially affects progress in the other. Theorists must integrate findings in psychology, biology, animal behavior, anthropology, archaeology, genetics, and linguistics if these benefits are to be appreciated. In our own attempt to explain the evolution and modification of life history stages, we needed to integrate findings from archaeology with findings on the development of brains, teeth, endocrine systems, and other characteristics of modern humans. We think that such efforts will eventually produce a small step toward the unification of a broad base of language-relevant knowledge, emanating from a wide range of disciplines. Theorists also need to explain developments across the various stages of linguistic evolution, not merely those pertaining to language as it is, or as it appears, now. We have claimed that insertion of new ontogenetic stages into human life history, and the remodeling of others, produced new developmental processes that fashioned novel communicative behaviors and increased fitness. If so, reciprocal action by evolutionary and developmental mechanisms – working in an “evo-devo-evo” sequence – may have played a major role in the evolution of language.

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Letters “a” and “r” appearing before authors’ initials refer to target article and response, respectively.

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