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

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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

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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

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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.

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