

12

Language evolution

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12.1 Introduction

In the wake of the success of Darwin's ideas, speculative papers on the evolution of language became such a rage that they were officially banned by the Société de Linguistique de Paris in 1866, and unofficially by the new Linguistic Society of America in 1924 (its journal *Language* did not publish a paper on the subject till 2000; see Newmeyer 2003). The rationale for exclusion was that there was no possible evidence that could bear on the problem: Language does not fossilize, and we cannot bring comparative biological evidence to bear because our closest primate cousins exhibit nothing like language.

In the 1990s, this extraordinary self-censorship was broken by a diverse group of pioneering scholars, who advanced a range of largely speculative but interesting ideas, nicely summarized in the collection by Christiansen and Kirby (2003). Perhaps language evolved to replace primate grooming in groups too large to do the physical thing (Dunbar 2003); perhaps it began as a gestural system (Corballis 2003), aided by the pre-adaptation of the neural mechanisms for action recognition (Arbib 2003). Whatever the beginnings, perhaps it involved a chance mutation that allowed advanced syntax (Bickerton 2003, Chomsky 2010), or perhaps the latter evolved in response to the preceding evolution of the capacity for vocal learning and production (Lieberman 2003). And what is the essential development, the essence of language as it were, that made all the rest possible? Is it the basic notion of semiosis (Deacon 2003), perhaps viewed as a triangle between speaker, hearer, and referent (Tomasello 2003)? Or is recursive syntax the crucial advance (as Hauser *et al.* 2002 have argued)? Can one spell out all the pre-adaptations and steps through which the ascent to language passed (Hurford 2003)? These are the kinds of questions that preoccupied the first decade of the renaissance of studies in language evolution.

However, in the last decade, the subject of language evolution has experienced a boom in international conferences (see, e.g., www.evo-lang.org/), monographs, textbooks, and learned papers – in fact, far too much has happened to be adequately reviewed here. Crucially, in that time, the subject has been transformed from a speculative enterprise to one where critical new data and new methods have completely overturned the apple cart. The new data include archaeo-DNA, large typological databases of existing languages, the discovery of contemporary emerging languages, the discovery of the relevance of animal models, and a range of new fossils. New methods include ways of extracting ancient DNA without contamination, its insertion into mice to see the effects on brain and behavior, the application of bioinformatics to typological data, laboratory simulations of evolutionary processes, the MRI scanning of the internal structure of fossils, and much more besides. These developments, missing from anthropological linguistic textbooks, are likely to rapidly accelerate, transforming the subject into a core part of the curriculum. Linguistic anthropology can surely no longer ignore these developments: Language is the key factor in making us a cultural species, and how that happened is a saga that should be told in every introductory course.

This review covers two subjects that many would consider essentially unrelated: the evolution of the underlying biology that makes language possible on the one hand, and the processes underlying language change and diversification on the other. But the two need to be considered hand in hand for a number of reasons. First, biological and cultural evolution is an interlocked process. A new model for conceptualizing this is *niche construction* (Odling-Smee *et al.* 2003). Many animals alter their ecology so fundamentally that the selecting environment has now been constructed by the species. Consider for example the beaver, whose dams make watery fastnesses which then select for specialized aquatic and woodworking skills. In these cases, along with the genetic mode of inheritance, the environment becomes a second inheritance channel, with the two in mutual interaction (better teeth, more felled trees, more water. . .). For humans, this second channel has been exploited on a unique scale, for culture is this second channel: a new human enters a world that is highly structured by the cultural environment. That includes the material culture, the habitat, and of course the language(s) a child must learn, which pervades the acoustic environment. The cultural ecology has a direct impact on genes, e.g., through the vectors of disease: wet-rice agriculture breeds malaria, which selects for resistance. In this perspective, culture is as much part of biology as the genome.

A second reason for seeing cultural and biological evolution as a single process is that there are clear feedback relations to observe. Consider the human hand, with its extreme motor control and opposing thumb: this clearly evolved hand in hand (to pun) with human tool use, which now seems (on indirect evidence) to date to over 3.5 mya (and 2.5 mya on direct

evidence). That motor control was likely inherited by the cortical strip that happens to lie next to hand in the motor cortex: the tongue. The vocal apparatus is an impressive retrofit to the basic primate system: the supralaryngeal tract is bent at right angles, the larynx lowered at the risk of choking, cortical (rather than midbrain) control allows voluntary breath control, the tongue, the palate, and the velum are reconfigured to allow a wide range of filters that give us our speech sounds (Fitch 2010). This retrofit was driven by the increasing cultural exploitation of the speech channel – presumably for language. It largely took place somewhere between 1.5 mya and 0.5 mya, but the interaction between language and vocal tract continues to this day (see §12.4). Finally, there are model systems – micro-speech communities – where this kind of ongoing interaction between genes and biology on the one hand and culture and language on the other can be directly observed today.

This review is therefore structured as follows. We first consider (§12.2) the range of new data that gives insights into the time course of the biological evolution of language capacities. We then turn (§12.3) to cultural evolution and introduce the new methods that are revolutionizing this area. Finally, we consider the evidence for ongoing relations between biological and cultural evolution, and point to many avenues where future research is likely to rapidly expand our horizons.

12.2 Biological evolution and the antiquity of language

Until ten years ago, there had been a majority of linguists, paleontologists, and archaeologists who subscribed to a very recent origin of language, with mention of dates between 70 kya (kilo years ago) and as low as 50 kya. The reasoning was based largely on the archaeological and paleontological record in Western Europe, where the Upper Paleolithic (from *c.* 40 kya) ushered in a huge burst of technological and symbolic creativity which suggested some qualitative change in human cognition associated with modern humans arriving in this rich ecology about that time. In addition, the paleontologists viewed the Neanderthal forebears, who had inhabited the same area for some hundreds of thousands of years, as premodern in anatomy and primitive in technology and resource exploitation. There was an influential theory too that Neanderthals lacked a fully modern vocal tract, and as a result would not have had the vowel contrasts typical of modern languages. Chomsky (2010, Berwick *et al.* 2013) influentially continues to hold this model, arguing that some freak mutation suddenly made available the recursive syntax that typifies modern languages.

But in fact this position is now undercut on almost every front. We now know that Neanderthals were not a separate species and interbred with modern humans (Green *et al.* 2010), that anatomically modern humans had lived with Neanderthal-level technology for 150,000 years in Africa

(McBrearty and Brooks 2000), that Neanderthal technology has been underrated, and Neanderthals seem to have all (or virtually all) of the genetic and anatomic preconditions for modern speech (Dediu and Levinson 2013). Modern humans up to the modern era have occasionally exhibited (e.g., in Tierra del Fuego, or Tasmania) simpler technologies and less traces of symbolic activity than Neanderthals (Henrich 2004). In short, the European Upper Paleolithic now looks like just one of those epochal leaps in cultural complexity that we associate with such periods as the Greek city states, the Renaissance, the Industrial Revolution, or Mayan civilization.

This section therefore sketches the modern synthesis of information from different contributory sciences (see Dediu and Levinson 2013 for a full review). Let us start with paleontology. The discovery of a Neanderthal hyoid bone, structured within the modern range, undermined the idea that the larynx had a different structure with higher position (Arensburg *et al.* 1989). A low location for the larynx is essential for the structure and function of the modern vocal tract: the larynx is the vibratory source at the base of the vocal tract, allowing the flexibility of the upper tract to provide a variable filter to encode speech sounds (Fitch 2010).

If modern humans and Neanderthals had the same vocal tract, this can be attributed to their common ancestor, *Homo heidelbergensis*, who flourished roughly half a million years ago. Recently a huge cache of fossils of this species was found in Spain, and it has yielded invaluable information about anatomy. Especially interesting has been the preservation of the middle ear, which allows the reconstruction of audiograms, reflecting the sensitivities to specific wave-lengths. It turns out that the hearing of *H. heidelbergensis* seems to be within the range for modern humans, and distinctly different from the sensitivities of chimpanzees (Martinez *et al.* 2004). The range is ideally suited for sensing the formant structure of vowels. For almost all species the hearing range matches the broadcast range for vocal communication, and this allows us to be reasonably confident that *H. Heidelbergensis* was making sounds similar to modern speech. Other features are in line with this assumption, like the hypoglossal canal that serves the tongue.

Bones, especially from cold locations, can preserve ancient DNA, and we now have fully reconstructed genomes for Neanderthals and a sister race, the Denisovans (who diverged perhaps 600 kya, Meyer *et al.* 2012). These genomes present protein-coding differences from modern humans in only a handful of locations, mostly to do with skin and bone structure. The gene that (at the time of writing) seems most intimately connected with language is FOXP2, which seems involved in fine motor control (see Dediu, this volume, Chapter 28). Neanderthals and Denisovans had exactly the same variant as modern humans, which is unique to the *Homo* genus. Breaking news suggests that one way in which most (but not all) modern humans differ, however, may be a gene that binds to FOXP2, and which

may therefore effect its quantitative expression. Although caution is in order, as the recovery and interpretation of archaeo-DNA is a rapidly developing field, the implication seems to be that humans of various lineages half a million years ago seem to have differed at most quantitatively in their genetic foundations for language.

There is one other crucial piece of evidence. Chimpanzees have little if any voluntary control of vocalization, which is produced both on the in- and out-breath. For human speech, very fine voluntary control of breathing is required: this involves a separate control pathway to the involuntary system controlled by the medulla or mid-brain which is triggered chemically by oxygen levels. This breath control allows a sharp in-breath in proportion to the length of an utterance, and controlled release of air that allows sufficient more or less constant pressure to power the source (larynx) and filters (vocal tract) that encode speech. The cortical pathway necessary for this passes directly down the vertical column to the intercostal muscles, requiring an enlarged vertebral canal which can be picked up in the fossil record (MacLarnon and Hewitt 1999). Once again it turns out that Neanderthals had the modern system, and thus the common ancestor at c. 500 kya. This vertebral evidence also puts a top limit on the modern speech system, since it is not found in *Homo erectus* at about 1.4 mya (at least in the one intact column found so far).

All the evidence thus tends to point modern speech capacities by half a million years ago. Various commentators have pointed out that speech – the capacity to produce something like modern speech sounds – does not necessarily imply language, interpreted say as words combined syntactically. Fitch (2010), for example, argues that various deer species have permanently lowered larynxes, and corresponding formant-structured vocalizations, without exhibiting anything like language; the motivation in this case, he argues, is to extend the perceived size of the animal, a mating adaptation specialized in males. There is nothing exclusive to humans in the production and comprehension system for speech, Fitch argues. This helps to motivate the Chomskyan view that it is something else that is the magic bullet for language, namely recursive syntax (Hauser *et al.* 2002). But this and other such arguments miss the point: the structure of the vocal tract is an elaborate adaptation for speech, involving a highly flexible and relatively small tongue, domed palate, voluntary control of the velum for nasal sounds, and above all the fine motor control that may be empowered by the human variant of FOXP2. And although size-exaggeration may well have been a pre-adaptation for speech, the complex system as a whole is clearly adapted to language – that is, complex and rapid human communication. It is worth bearing in mind that it is peripheral motor and sensory systems that drive neural development: the structure of the brain adapts to the available input and output systems (so that, e.g., in the blind, language is served by the visual areas of the brain). That is why the evidence for the full system for modern speech at half a million

years ago should be interpreted as an adaptation for language, carrying with it much re-wiring of the brain which unfolds during infant development.

The other evidence for early language is much more indirect, but nevertheless compelling. It is the complexity of cultural traditions, passed on across many generations. Apes may pass on rudimentary gestural and grooming habits, even some kinds of tool using (e.g., sticks for “fishing” in termite mounds), but this is controversial since chimpanzee groups also differ ecologically and genetically. Nothing like the systematic traditions of human tools exist in any primate species. To take an example: Neanderthal stone-tool technology involved the elaborate preparation of a large flint core, trimmed around the edges to make a 90-degree percussion angle; from this large flakes could be struck, and then trimmed to fit the job, as awls, scrapers or points. It will take an average archaeology student at least a month of practice to achieve this (even without having to learn where to procure the raw material), and then only under constant verbal instruction. Skeletally modern humans used the identical technology up to c. 40 kya. Neanderthals systematically controlled fire, something that some modern human groups may actually have lost from time to time (for example the Tasmanians). Most of the stone tools seem to have been machine-tools as it were: they were used largely on wood, and fine aerodynamic javelins have been recovered from 400 kya in Europe. Add to this that Neanderthals lived in sub-Arctic conditions (presumably with clothing and footwear), hunting large game like mammoths, and it seems overwhelmingly likely that all of this cultural elaboration was empowered by an advanced communication system based on speech.

Combining these lines of evidence argues for something close to the modern capacity for language in our premodern forebears at half a million years ago. But why does the antiquity of language matter? For the same reason that Charles Lyell’s (1830–33) demonstration of the antiquity of the earth opened up the way for Darwin’s theory of evolution – the time-depth radically changes how we should think about language. If language really evolved in the last 100,000 years there would be hardly time for any significant biological reorganization. Consider for example the case of bat echolocation: a substantive re-tooling of basic mammalian vocalization for the purposes of spatial cognition. It has an antiquity of around 50 million years. Even half a million years for the antiquity of language makes it a biologically recent and rapid adaptation, which would have occurred mostly in the preceding one million years or so (using the vertebral evidence from *Homo erectus* as a terminus post quem). This relatively recent development suggests that language capacity has been cobbled together from pre-existing aspects of human biology and cognition. Moreover, it suggests that much of what we think about as the complexity of language is actually carried in the cultural channel, a point to which we now turn.

12.3 Cultural evolution of language over deep time

As Darwin (1871) observed, there is a strange parallel between the biological evolution of species and the historical development of languages. In both cases, species and languages split over time, evolving in distinct lines, so generating family trees. There are roughly as many languages as mammals, and they are phylogenetically related in similar ways, except that we have extreme difficulties connecting together the great language families, at the apex of the language tree. How many such families are there, of unproven relationship to one another? The answer depends on whether you are a “lumper” (like Joseph Greenberg) or a “splitter” like most historical linguists – splitters might estimate 300+ independent stocks, including many isolate languages (Nichols 1997). Historical linguistics, which has studied the processes involved in language change and diversification, is the oldest and perhaps the most scientific branch of linguistics, and played a role in inspiring Darwin’s ideas. The “comparative method” – the gold standard in historical linguistics – involves finding cognates (words or morphemes with similar sounds and meanings) across languages and reconstructing the mother forms from which the descendant forms are derived by systematic sound changes (Durie and Ross 1996).

The parallel between biological and linguistic, and more broadly cultural, diversification has been explored from different perspectives. Efforts have been made to find detailed parallels between the particulate “genes” as it were, the origins of variation and the selective forces that work upon them, but there is no consensus on how best to view this exactly (see, e.g., Croft 2008, and Enfield, this volume, Chapter 13). Nor does that seem to hamper research. The fact is languages change generally slowly at their core, while peripheral words and structures change faster. The differential rate of change allows one to see both the common ancestry of languages and the ways in which they have diversified, and thus to trace out the family tree of related languages. Most of this work has been done on core vocabulary, using for example Swadesh’s wordlist of conservative vocabulary, or on grammatical morphemes. It relies on the fact that detailed form–meaning pairings are unlikely to be due to chance. This kind of research presupposes a family-tree model of diversification, but it has been recognized for well over a century that languages change also through contact and diffusion from neighboring languages that may not be related at all phylogenetically. And words diffuse more often and more rapidly than structure (Thomason and Kaufman 1988). In rare cases, such diffusion can obscure whether two languages are actually related by descent or not (as in the case of Quiche and Aymaran), but mostly the two processes can be readily distinguished. In an earlier phase of anthropological theory, very similar processes of both descent and diffusion were noted in technology, ornament, and ritual, suggesting that linguistic evolution and cultural evolution in general follow similar principles.

In the last decade there has been a methodological revolution in the study of linguistic and cultural evolution (McMahon and McMahon 2005, Holden and Mace 2005, Levinson and Gray 2012). Methods developed in biology to trace the genetic similarities between species or the hybridization of plant or microbial lineages have been fruitfully applied to linguistic and cultural material. If a set of languages are known to be related, the tree-like nature of that relation can be extracted computationally, by searching for the most likely tree that underlies the present pattern of features in the descendants. All that is required is a large number of features for each language, some resistant to change and some less so. The favored technology at the time of writing is Bayesian phylogenetics, which involves making basic assumptions of, e.g., rates and directionalities of change, and seeing whether the most likely trees under those assumptions predict back the observed distribution of features across languages. If not, the assumptions are minimally changed, the computations repeated, and so on for thousands of iterations until no improvements are found. If some dates are known (e.g., for ancient Hittite or Linear B), then these methods allow the dates to be factored in, and rates of change varied across the tree in proportion to the number of feature changes in each branch. Using these methods, for example, the age of Indo-European as a language family seems robustly established as about 9,000 years (much older than many philologists had thought; Gray and Atkinson 2003).

Many linguists have assumed that these bioinformatics methods are undercut by the facts of language contact or diffusion. But this is not so. Methods exist for estimating the degree to which the data for a language family exhibit tree-like structure, and network models for analyzing hybridization have developed in parallel to computational phylogenetics. Work on bacterial evolution, where hybridization is a constant force, has provided bioinformatic models that may prove more appropriate for language. Recently, using the same techniques used to trace the source and diffusion of influenza types, it has been shown that Indo-European arose in Anatolia and not much later in the northern Kurgan steppes as many philologists had argued (Bouckaert *et al.* 2012). The success and generality of these methods have transformed the study of cultural evolution generally; there are intriguing studies of the development of Turkic carpet patterns, kinship systems, stone-tool traditions, and so forth. But in the case of language at least, a limiting factor has been a ceiling on the time-depth that we seem to be able reach back to, due to the erosion of word forms and meanings over time. The ceiling for the comparative method has been put at 10,000 years (close to the estimate of the age of Indo-European by the new methods mentioned above).

An alternative resource is to look not at the vocabulary of languages but at their abstract structure – their word order, their grammatical categories, their phoneme inventories, and so forth. There are limitations here:

there are limited numbers of word-orders (for transitive sentences, subjects, objects, and verbs can be in one of six orders for example), so having the same word order is much more likely than having the same or similar sounds meaning “water,” for example. However, the chances of having the same or similar word orders, specific phonemes, and specific grammatical categories entirely by chance are quite remote: the combination of features can carry the signal of phylogenetic relatedness very well (Dunn *et al.* 2008, Levinson *et al.* 2011). One interesting thing that has come out of this work is the timescale for the cultural evolution of language. For vocabulary, the stability of word forms varies widely, and is closely related to their frequency. Using this as a yardstick, one can estimate the age of word forms, and it may be that some date right back to the Paleolithic (Pagel 2009). For the structural features of language, one can examine the pattern of diversification through the largest extant language families (like Austronesian, Indo-European, or Bantu). Once a split has occurred, e.g., Italic vs. Gothic, all further changes in both lines are independent. If one adds up all the independent lineages in Indo-European one arrives at something like 200,000 years of language evolution. One can then ask how many and which structural changes have occurred per unit time. The answer is that structural changes are actually very slow, varying from say one change per 10,000 years to none at all in 200,000 years. This contrasts of course with other aspects of cultural evolution like technology, and for principled reasons: change in language is stabilized by the parity problem (what I say must be understandable to you, unlike my fishing techniques which don’t depend on yours). If these computations are correct, they suggest that language typology – the overall structure of languages – is on the whole very stable over deep time, offering the possibility that the 300-odd language families of the world may be provably related to one another using structural features. It may be possible to rank the structural features of language according to their stability, just as one can rank vocabulary according to its conservatism (Dediu and Cysouw 2013). It is also possible to discern that specific language families have a tell-tale “stability profile” – being especially conservative about specific features. Using these profiles it is possible to suggest very ancient connections between language families, e.g., between those in Siberia and North America (Dediu and Levinson 2012).

Another interesting payoff from this work is that once one has established the most probable family trees, it is possible to look at the interconnections between structural features – their systemic properties. For example, Greenberg suggested that languages tend to “harmonize” their features, so that, for example, if they have SOV (subject object verb) basic order, they will have postpositions rather than prepositions, thus harmonizing with head elements of phrases at the end (see Bickel, this volume, Chapter 5). Greenberg tested this by looking cross-linguistically (see the online WALS atlas for a modern update), but if there is some causal

mechanism at play then it should also channel language change. This can now be tested, and initial tests show that the causal effect is in fact very weak if present at all (see Levinson and Gray 2012).

12.4 Language emergence

Languages are changing all the time, and sociolinguists have shown how to catch these changes in the process (although this work is confined to Western languages). But a more intriguing question is: What would a language soon after its birth look like? Bickerton (2003) believes that creole languages provide such insight, allowing us a glimpse of a stripped down innate language system. But creole languages are amalgams of other languages, and emerge in multilingual situations where everyone is already a speaker of some language. It is possible, however, to see the birth of languages absolutely or nearly from scratch, by observing deaf children, either isolated in hearing communities, or where there are other deaf individuals with whom to construct a sign language. The emergence of language-like properties in the signing of isolated deaf individuals has been studied in the US, China, and Turkey, in particular, under the rubric of “home sign” (Goldin-Meadow 2003, and this volume, Chapter 4). In these cases, one observes the rather rapid emergence of a structured signing system distinct from gesture, e.g., with a systematic word or phrase order. In industrial societies deaf children are rather rapidly institutionalized, where the chances occur for more systematic transformation of the signing system into a full-blown language. In the case of Nicaragua, there has been recent institutionalization of this kind with the provision of centralized deaf schools; here the transformation of individual home-signers into sharers of a common, jointly constructed system can be observed (Senghas *et al.* 2004). This work shows that these first-generation signers of a common language remain somewhat handicapped, for the simple reason that it takes time (generations indeed) for a fully expressive language to emerge; they may thus fail to communicate fully satisfactorily even about spatial locations, and find it difficult to express and even reason about other minds (Pyers *et al.* 2010).

In more rural circumstances, a local community where there is a strand of hereditary deafness may develop its own sign language. Such systems, known as village sign languages, are known from, e.g., Ghana, Israel, Mexico, Thailand, and Bali, where the languages may be five to seven generations old (Zeshan and de Vos 2012). This gives us the nearest glimpse into early-stage languages that we are ever likely to get – the urban systems like that in Nicaragua are rapidly creolized with developed sign languages through the importation of teachers and professionals.

The properties of these village sign languages are thus of very great scientific interest (see Meir *et al.* 2010; Zeshan and de Vos 2012, and

Sandler *et al.* this volume, Chapter 10). One of the surprising findings is that they may lack many of the features that linguists have judged to be essential characteristics of language, while still performing as fully adequate, sole languages for many individuals. They often seem to lack “duality of patterning,” i.e., the construction of words out of recombinable segments or features. They may or may not have developed a fixed word order that allows “who did what to whom” in a transitive sentence to be disambiguated. They may lack proper names for places, making do with pointing instead. And they may lack features that scholars had presumed to be universal for sign languages, like the so-called classifier constructions, the use of arbitrary loci for anaphoric reference, or grammatical agreement on verbs. From this it is clear much of the grammatical machinery that we take for granted in languages takes many (perhaps a dozen or more) generations to evolve. These reports therefore qualify the findings from Nicaragua, where second generation signers in institutional settings already showed rapid development of the linguistic system. In both emerging urban and emerging rural sign languages there are special conditions: in the urban case, the building of a deaf culture in opposition to a hearing one, together with the hot-house conditions of institutionalized schooling and imported language structures; in the rural case, if the deaf population is of any size, the whole community participates in the sign language, although to varying degrees. Thus in the Balinese sign language studied by de Vos (2012) and others, some sixty congenitally deaf members of the village are complemented by over a thousand signers, whose second-language skills in sign may hold back the fast development of complex grammatical machinery.

Insights into the emergence of grammar can also come from simulating these processes, either by getting individuals to learn simple constructed languages and pass them on, or by computer simulations that can mimic thousands of repeated transmissions of this sort. Both paradigms involved iterated learning – transmission of a simplified language to another agent, who then passes it on to a third (Kirby and Hurford 2002). Under these conditions, unexpected simplifications and regularizations occur: regularization, double articulation, and recursive compositionality, for example, can be emergent properties in both computational simulations and experimental outcomes of iterated learning (Kirby *et al.* 2008).

12.5 Genes and culture in interaction

A common assumption is that the evolution of the language capacity and the cultural evolution of language have nothing to do with one another: at some distant point in the past we evolved the language capacity and then, on this platform, cultural evolution took off. In fact, of course, the

two processes are interconnected: language is a kind of bio-cultural hybrid, with the cultural part evolved to exploit the biological part, and vice versa (Richerson and Boyd 2005). This tandem evolution is how we have been able, in some half a million years, to evolve such a complex system of communication, unparalleled in the animal world since the mammals evolved some 100 mya. The process can perhaps be understood best in terms of “niche construction,” the way in which animals often construct the environments that then select for biological features: the environment becomes another track of inherited material, with the genetic and environmental tracks in constant interaction. In this way, we don’t invent our languages (except in the rare cases involving sign languages mentioned above), we inherit them from our social environments. We know of a number of cases where these interactions between culturally constructed environments and our biology are attested. For example, dairying peoples have evolved greater adult lactose tolerance, or cultural processes for modifying lactose (e.g., through bacterial processing as in yoghurt), or both.

In the case of village sign languages, the feedback relations between biology and culture are rather visible. A strand of hereditary deafness creates the need for cultural innovation: as an expressive sign language emerges, and the speaking population also masters it, deaf people become fully competent central players in the community, intermarrying, and producing more offspring with genes conducive to deafness in the general population. That spread of the genes generates the further generations who can further elaborate the sign language. Both the biology and the culture depend on one another (see Levinson and Dediu, *in press*).

Ongoing interactions between genes and spoken languages are less visible, but almost certainly in play. It has been shown that even slight biological or cognitive biases can become amplified through cultural transmission, so that cultural evolution can be channeled by slight differences in population genetics. Take the case of contrastive tone in languages. This inversely correlates with the distribution of certain rather recent variants of genes involved in brain development: populations without these relatively recent alleles or variants seem more likely to have developed tone languages (Dediu and Ladd 2007). We don’t know the mechanisms involved, but in the case of the more recent alleles they may involve slight changes in auditory cortex, which might make tone marginally harder to process. Additional arguments of this kind have been advanced for different shapes and sizes of the vocal tract which may make the production of some sounds easier or harder to produce. In all cases, the presumption is that the biological biases are weak, and represented only as slight differences in frequency distributions in the populations. Any child can master a tone language, but perhaps not every child finds it equally easy.

12.6 Conclusion

Both fields of language evolution – the evolution of the biological capacity for language and the cultural elaboration of languages – are vibrant fields of current study. It is a matter for regret that linguistic anthropology has played such a small role in either the first decade of speculative work, or the last decade of more empirical work in both subjects. Linguistic anthropologists are uniquely placed to contribute to these debates, since they have empirical information about what language is actually primarily used for in small-scale societies, how it is transmitted, the effects of divisions of labor, varying demographics and social organizations. It is to be hoped that their voice will be heard in the next decade.

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