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Epilogue

This book has focused on a specific aspect of the evolution of our species, which are the neurobiological innovations that took place to allow us to communicate through a syntactically and semantically structured language that uses speech as its main communicative channel. Our brain is special for several reasons, most of them related to our capacity for speech and language, like its large size housing a great number of neurons, and the lateralization of its functions that puts stringent demands on interhemispheric connectivity. Our memory capacity, particularly in the form of working memory (especially auditory), is also unique among primates. This led me some years ago to think that the expansion of working memory capacity, particularly through the development of the phonological loop and its neuronal underpinnings, was a particularly relevant acquisition for the evolution of speech. Recognizing that the evolution of speech must have been an extremely complex process, my proposal has focused on identifying specific inflection points that may have significantly changed or accelerated the evolutionary trajectory of our species. In my view, this is a useful and recommended strategy to unveil the different variables involved in complex phenomena. In this direction, I have aimed to specify circumscribed neural

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circuits that may be necessary for speech development and may have been critical in its evolution. Furthermore, I have looked for possible homologous circuits in non-human primates (possibly serving a quite different function), in order to establish an evolutionary continuity with our recent ancestors.

Throughout this book, I have discussed alternative perspectives for the origin of speech, like the gestural origin of language and the mirror neuron hypothesis, with which I partly agree, in the sense that human communication is an opportunistic, multimodal behavior that uses any means possible to transmit information, be it gestural, vocal, or otherwise. Nonetheless, none of these perspectives has really addressed the key issue of how speech became the dominant communication modality, and what were the neural and biological processes involved in this transformation. Furthermore, in my opinion, the idea that there was a primitive gesture-dominant stage that served as scaffolding for subsequent speech origins is speculative and backed by little evidence. On the other hand, I have reviewed comparative evidence from birds and mammals, including primates, to illustrate that vocal learning capacity – a critical requisite for speech evolution – occurs in several animal species. Primates may not be particularly good at vocal learning, as they have little voluntary control over the vocal folds, but their voluntary control of the upper vocal tract, particularly the lips, is related to social behavior and its motor coordination is not unlike that in humans.

The book's central argument is that at a more central level, the acquisition of the phonological loop was a key element in the acquisition of speech, as a circuit connecting the ventral motor cortex with auditory areas via the arcuate fasciculus (supported by inferior parietal and anterior temporal projections to the emerging Broca's region), and with brainstem nuclei controlling phonation. It is very likely that at least part of the circuitry involved in the phonological loop, including a rudimentary arcuate fasciculus, was already present in the common ancestor with the chimpanzee, but did not necessarily participate in vocal behavior. At some unknown point in evolution (perhaps in Australopithecines), this temporoparietal circuit was co-opted to participate in learned vocal behavior, slowly giving rise to a

primitive proto-speech-like stage, marked by song-like sequences and "proto-lexical" items signaling objects or events. This resulted in behavioral changes associated with a gradual increase in brain size in early *Homo*. But the full functional expansion of this incipient phonological loop is probably a more recent event, concomitant with the development of semantics, syntax, and the development of a theory of mind, which are essential events in the cultural and genetic revolution that started with archaic *Homo sapiens* and exploded some 50,000 years ago. The acquisition of modern language, largely mediated by speech, had vast consequences for human behavior, engaging us in a large-scale evolutionary process that includes not only us but also many other species. This is perhaps one of the most radical events we have seen in the history of the Earth and is not without consequences, as we are probably on the verge of causing the sixth mass extinction of the planet. Eloquently, Brian Cox asserts, "The idea that a civilization may destroy itself is both ludicrous and likely. We are pathetically inadequate at long term planning, idiotically primitive in our destructive urges and pathologically incapable of simply getting along" (Cox 2014 p 45). But speech has also endowed us with the power to establish conversations and listen to others, and with a powerful ability to foresee outcomes that are distant in time. It therefore depends on our capacity to converse again to secure the fate of our species and our world.

Reference

Cox B (2014) Human Universe. William Collins, London