Language & Communication 54 (2017) 9–20

Contents lists available at ScienceDirect

Language & Communication

journal homepage: www.elsevier.com/locate/langcom

Language is not isolated from its wider environment: Vocal tract influences on the evolution of speech and language

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ARTICLE INFO

Article history:
Available online 3 December 2016

Keywords:
Biases
Language change
Linguistic diversity
Vocal tract
Language evolution

ABSTRACT

Language is not a purely cultural phenomenon somehow isolated from its wider environment, and we may only understand its origins and evolution by seriously considering its embedding in this environment as well as its multimodal nature. By environment here we understand other aspects of culture (such as communication technology, attitudes towards language contact, etc.), of the physical environment (ultraviolet light incidence, air humidity, etc.), and of the biological infrastructure for language and speech. We are specifically concerned in this paper with the latter, in the form of the biases, constraints and affordances that the anatomy and physiology of the vocal tract create on speech and language. In a nutshell, our argument is that (a) there is an under-appreciated amount of inter-individual variation in vocal tract (VT) anatomy and physiology, (b) variation that is non-randomly distributed across populations, and that (c) results in systematic differences in phonetics and phonology between languages. Relevant differences in VT anatomy include the overall shape of the hard palate, the shape of the alveolar ridge, the relationship between the lower and upper jaw, to mention just a few, and our data offer a new way to systematically explore such differences and their potential impact on speech. These differences generate very small biases that nevertheless can be amplified by the repeated use and transmission of language, affecting language diachrony and resulting in cross-linguistic synchronic differences. Moreover, the same type of biases and processes might have played an essential role in the emergence and evolution of language, and might allow us a glimpse into the speech and language of extinct humans by, for example, reconstructing the anatomy of parts of their vocal tract from the fossil record and extrapolating the biases we find in present-day humans.

1. Introduction

[1]There is no doubt that language is a cultural phenomenon continuously evolving[2] (Dediu et al., 2013), a complex process influenced by a multitude of factors, most internal to language itself (for example, morpho-syntactic changes driven by reinterpretation (Bybee, 2001), phonetic by-products becoming important due to the erosion of other sounds, etc.; Campbell,

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[1] Abbreviations: VT = vocal tract.

[2] There is an intriguing ambiguity in "language evolution" – is it cultural? is it biological? or is it both? – to which we return in Section 4.

http://dx.doi.org/10.1016/j.langcom.2016.10.002
0271-5309/

2004), but some having to do with the *wider context* of language use. While the first category is extensively studied and numerous general principles and fascinating particular cases have been discovered (Campbell, 2004; Hopper and Traugott, 2003), the latter is much broader and much less studied, but promises more articulated causal explanations better integrated with other scientific disciplines. In this paper we will briefly review some of the proposals currently available, with a particular focus on the anatomy and physiology of the vocal tract and their influence on phonetics and phonology, concluding with some suggestions about the origins and evolution of language in the auditory-vocal modality.

2. Language in its wider context

More and more, language is seen as a complex entity that has cultural, social and biological components in intimate interactions (Dediu et al., 2013), leading to a fascinating interplay between cultural and biological evolution. Also, the increasing realization that language is intrinsically multimodal (see, for example, the theme issue "Language as a multimodal phenomenon" of Phil. Trans Royal. Soc. B from 14 September, 2014, vol. 369, issue 1651; Wacewicz et al., 2016), involving simultaneously multiple channels (voice, face, hands), plays a major role in the proper understanding of language and its evolution.

There are several well-known examples of *gene-culture co-evolution* (Richerson et al., 2010) and *(cultural) niche construction* (Laland et al., 2010) concerning non-linguistic phenomena, such as the co-evolution of lactose tolerance and farming (Gerbault et al., 2011).[3] However, when it comes to language probably the most convincing cases of such a full co-evolutionary cycle are sign languages and possibly the descent of the larynx (Lieberman, 2012; Fitch, 2010). In this section we will briefly review some recent proposals linking language to its wider environment, starting with congenital hearing loss, moving to the way the physical and social environments experienced by the speakers affect their language(s), and ending with the possible influence of neuro-cognitive, perceptual and even genetic characteristics of the speakers themselves.

2.1. The cultural evolution of language

Culture is a full-blown evolutionary system in its own (Richerson and Christiansen, 2013) and language in particular is increasingly viewed from such a perspective (Tamariz and Kirby, 2016; Dediu et al., 2013; Pagel, 2009; Atkinson and Gray, 2005; Croft, 2000). Thus, many of the properties of language, including its universal tendencies and its amazing diversity (Evans and Levinson, 2009), ultimately emerge from its repeated use, learning and processing (within and across generations) in a range of social contexts, but of particular importance here is the capacity of cultural evolution to *amplify very weak biases*. At face value, it is easy to believe that such defining properties as the duality of patterning and compositionality must certainly reflect strong innate biases, but several lines of ongoing research, ranging from computer simulations (Kirby et al., 2007; Dediu, 2008; Smith and Kirby, 2008; Thompson et al., 2016), to animal models (Fehr et al., 2009) and human participants (Kirby et al., 2008; Caldwell and Smith, 2012; Smith and Wonnacott, 2010) clearly show that this is not the case.

The repeated use and transmission of culture (and, in particular, language) in a population of agents that have only very weak biases can result, under the right circumstances, in the amplification of these biases out of proportion, creating a strong emergent patterning of the resulting communicating system. A striking consequence of this is that the nature and strength of the biases cannot be directly inferred from the observed properties of the emergent communicative system (Kirby et al., 2008): a strong "universal" property of language does not immediately imply a strong universal bias in humans. A second important consequence concerns the locus and nature of these biases: while they might be part of the biological infrastructure of language (but even this apparently simple statement hides incredible complexities; Fisher and Vernes, 2015; Fisher, 2006; Dediu, 2015), this is not necessarily the case and they may result from properties of the wider environment in which language is used, and, in the following sections, we will encounter different types of such biases. Third, if the bias is universally present it might play a role in explaining the "design features" and universal tendencies of language, but if different human populations show different such biases (due to the different environments they inhabit or due to genetic differences), or with a different strength and/or direction, then this might help explain, through cultural evolution, patterns of cross-linguistic diversity (Dediu, 2011).

2.2. Sign languages and their co-evolution with genes

There are several communities around the world where the high incidence of recessive mutations resulting in congenital non-syndromic deafness coupled with inclusive attitudes towards the deaf members of the community have resulted in the *de novo* emergence of sign languages (famous examples are *Kata Kolok* on the island of Bali, Indonesia; De Vos, 2012 and *Al-Sayyid Bedouin Sign Language*, or ABSL, in Israel; Sandler et al., 2005; see also Meir et al., 2010). While the particular genetic mutations and socio-cultural practices involved are different, there seem to be certain commonalities (Dediu, 2015; Gialluisi et al., 2013) including the recessiveness of the mutation (making it very hard to predict which parents will have deaf children), its localized and early effects (hearing loss only present at birth), the (more or less complete) social acceptance of the deaf persons within the community, and social arrangements that increase the frequency of the mutation in the community (tendency to marry close relatives or people from within the village). When such conditions are maintained for several generations, the initially simple spontaneous *homesigns* of the first generation(s) of deaf children become gradually more

[3] For more examples see Dediu (2015, chapter 9) and Jobling et al. (2013).