Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Psychology

The cultural evolution of language

Monica Tamariz and Simon Kirby

Human language has unusual structural properties that enable open-ended communication. In recent years, researchers have begun to appeal to cultural evolution to explain the emergence of these structural properties. A particularly fruitful approach to this kind of explanation has been the use of laboratory experiments. These typically involve participants learning and interacting using artificially constructed communication systems. By observing the evolution of these systems in the lab, researchers have been able to build a bridge between individual cognition and population-wide emergent structure. We review these advances, and show how cultural evolution has been used to explain the origins of structure in linguistic signals, and in the mapping between signals and meanings.

Address
School of Philosophy, Psychology & Language Sciences, University of Edinburgh, 3 Charles St, Edinburgh, UK

Corresponding author: Kirby, Simon (simon@ling.ed.ac.uk)

Current Opinion in Psychology 2016, **8**:37–43

This review comes from a themed issue on **Culture**

Edited by **Michele J Gelfand** and **Yoshihisa Kashima**

For a complete overview see the Issue and the Editorial

Available online 14th September 2015

http://dx.doi.org/10.1016/j.copsyc.2015.09.003

Introduction

Language is arguably the defining characteristic of our species, and the evolution of language is an area of intense interdisciplinary interest [1–6]. The term 'language evolution', however, has three common interpretations: biological evolution, language change, and the cultural emergence of linguistic structure (Figure 1). This review will focus on the third interpretation. We will examine research looking at whether the way language is transmitted and used can explain the origins and evolution of key design features of language. These are the features which mark language out as special when compared to the vast number of communication systems in the natural world, and enable us to communicate about an open-ended range of meanings.

Transmission to new learners, communicative use, interactions among speakers in a community, and the structure of the world, all leave their imprint on the structure of languages (see Figure 2 for a description of two structural design features of language that have been claimed to be adaptations arising from cultural evolution: combinatoriality and compositionality). The headline conclusion so far is that language evolves to maximise expressivity under pressures for communication whilst minimising complexity under pressure to be learnable. Evidence in support of this conclusion comes from experiments [11••], computational and mathematical models [12] and data from a wide range of languages [13].

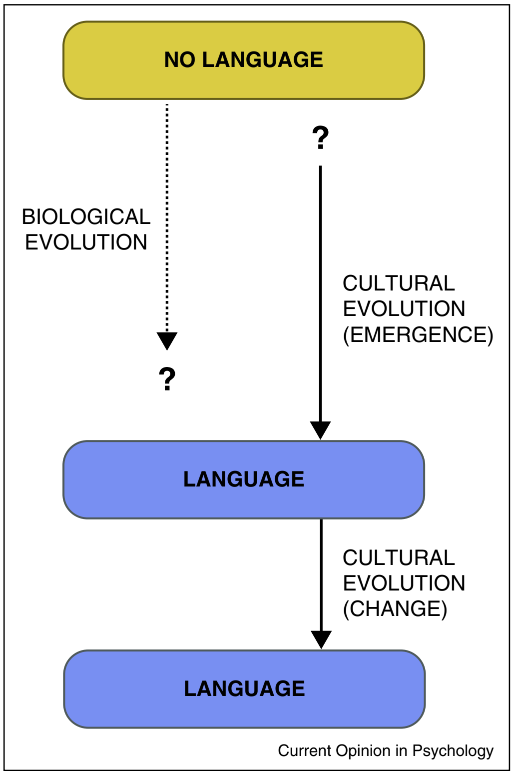
We will focus in this review on experimental approaches to cultural evolution as they have been applied to language (Table 1). There is a long history of using transmission chain experiments to look at how behaviour evolves culturally [14–18], see also Whiten *et al*., this volume. Kirby *et al*. [19••] emphasise the applicability of this method to language, which they argue undergoes a process they call *iterated learning* [20–23], emphasising the way in which individuals learn from other learners during transmission and usage. Figure 3 gives various different ways in which iterated learning of language has been explored experimentally.

Signals

Why is human language combinatorial (Figure 2)? One answer might be that it arises in response to the need for a large vocabulary. Hockett [24] argues that once a system has too many meanings to be efficiently encoded by distinct non-combinatorial forms, a combinatorial system becomes advantageous. More recently, an alternative hypothesis has been proposed [25] that combinatoriality emerges through cultural transmission under biases favouring simplicity. In Verhoef's [25,26••] cultural transmission experiments inspired by earlier simulation work (e.g. [27–31]), participants had to learn and reproduce a set of twelve distinct, independent slide-whistle sounds. Their produced sounds became the set the next participant had to reproduce, creating a transmission chain (Figure 3). At the end of ten generations, the whistle sounds had become easier to reproduce. They had ceased to be independent; many of them shared discrete internal elements, despite the continuous nature of the slide-whistle medium. In other words, they had developed combinatorial structure.

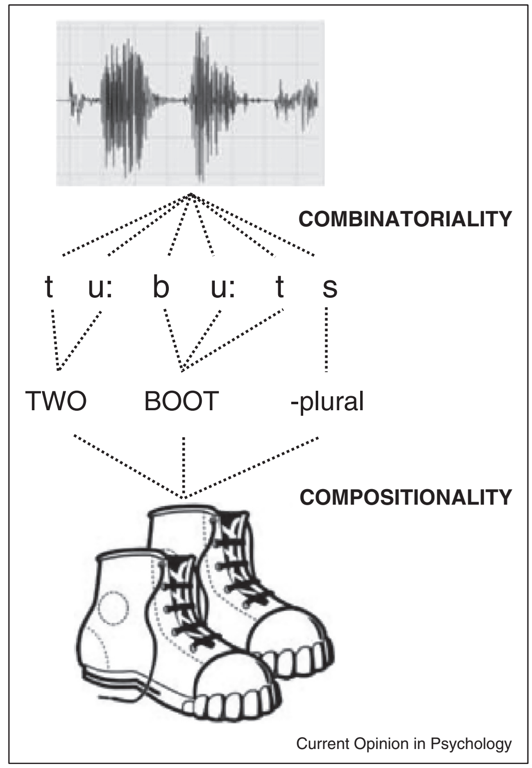
In related work, Cornish *et al*.'s [32] transmission chain experiment explored the extent to which cultural evolution can explain the origins of systematic structure in sequences of discrete rather than continuous signals. Their participants had to observe and then recall a large number of sequences of flashing lights. Over ten generations, the sequences became increasingly accurately

Figure 1



The mechanisms of language evolution. Both biological (dotted arrow) and cultural evolution (solid arrow) are implicated in the origins and evolution of language. The term 'language evolution' could refer, first, to the biological evolution of the cognitive capacity for language (dotted arrow). Second, to ongoing historical language change — a cultural process [7–10] (solid arrow, bottom). Third, to a more qualitative change whereby language emerges from non-language through cultural evolution (solid arrow, top). It is this third interpretation we focus on in this paper. This diagram also includes a possible role for gene–culture coevolution in the explanation of the origins of language (when both cultural and biological evolution overlap).

Figure 2



Two key structural design features of language. In relating sound (or manual gesture) and meaning, we make extensive reuse of subparts of utterances at two levels of description. Below the level of the word (or, more accurately morpheme), we reuse and recombine atomic elements of signals. This *combinatoriality* gives us a huge range of possible meaningful signals from a small set of parts. In addition, we are able to string together these meaning-bearing morphemes in structured ways to create utterances whose meanings are composed of the meanings of their sub-parts. This structural feature is called *compositionality*.

reproduced, and the set of sequences began to show systematic structure (see Figure 4). Subsequences came to be reused and recombined across different items in the set, and incipient hierarchical structure emerged towards the end of the chains.

These examples illustrate the evolution of *compressibility* of the behaviours of the participants over generations. In both studies, the sets of behaviours have lower entropy at the end of the chains than they did at the start. Entropy is a measure of the amount of information in a sequence; low entropy sequences can in principle be compressed because they contain inherent redundancies. Redundancies allow us to construct short descriptions of behaviour. For example, grammars are concise descriptions of linguistic behaviour that can be constructed precisely because language contains systematic, compressible regularities. This emergence of compressibility in behaviours has been argued to be a characteristic outcome of iterated learning [11••]. The generality of this outcome has also been demonstrated experimentally in non-linguistic tasks [33,34].

Mappings between signals and meanings

Linguistic signals fulfil their communicative function because they have conventionally associated meanings which are shared by a community of speakers. A number of experiments have explored how signal-meaning mappings come to be shared (however, see [6] for the limitations of treating languages as mappings). Fay *et al.* [35••] used a graphical communication design in which a micro-society of participants (Figure 3) played naming games based on a 'pictionary' task: a participant had to draw a signal to communicate a meaning to his or her partner. Initially, individuals had different variant drawings for the