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Editorial

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# Introduction to the special issue on the emergence of sound systems

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## Abstract

How did human sound systems get to be the way they are? Collecting contributions implementing a wealth of methods to address this question, this special issue treats language and speech as being the result of a complex adaptive system. The work throughout provides evidence and theory at the levels of phylogeny, glossogeny, and ontogeny. In taking a multi-disciplinary approach that considers interactions within and between these levels of selection, the papers collectively provide a valuable, integrated contribution to existing work on the evolution of speech and sound systems.

**Key words**: sound systems; speech; phonetics; phonology; evolution.

## 1. Introduction

Research into the evolution of language and speech has exploded in recent years. As Dediu and de Boer (2016) note, this is the result of an accumulation of factors making the topic more 'amenable to empirical investigation'. New techniques have emerged including experimental paradigms, computational and statistical modelling and analysis, brain and vocal tract imaging, genetic analysis and comparative methods. The Journal of Language Evolution prides itself on being a venue that allows for a discourse between all of these sources of evidence. In this vein, this special issue aims to bring together work from across disciplines specifically on the topic of the emergence of sound systems: how did human sound systems get to be the way they are?

This special issue originated in its conception at a workshop at the 18th International Congress of Phonetic Sciences in Glasgow in 2015 on the evolution of phonetic capabilities. The workshop had its primary focus on 'how the physical aspects of a linguistic modality might shape our language, and how our phonetic capabilities at the speech level may influence our phonology at the language level' (Little 2015). The workshop aimed to bridge a gap that exists between work on the evolution of speech, primarily concerned with the biological evolution of the vocal apparatus, and the evolution of linguistic structure, primarily concerned with the effects of cognition, learning and communication. In other words: what can the articulatory constraints of the spoken modality tell us about why sound systems are structured the way they are? And how can we separate those affects from cognitive or neural mechanisms?

Beyond the focus of the original workshop, this special issue considers how processes interact within and between different evolutionary timescales. Research on the evolution of language has been revolutionised in the past 20 years by viewing language and its emergence as the result of a complex adaptive system (Steels 2000; Kirby 2002). This system is composed of three interacting timescales; phylogeny (biological evolution), glossogeny (cultural evolution) and ontogeny (linguistic development). There are contributions here that consider selection at all

of these levels and how they might interact with each other. In considering such interdisciplinary contributions through the scope of these interacting timescales of the linguistic selection, this special issue provides an integrated approach to answering the difficult questions of why human sound systems are structured in the way that they are.

## 2. Contributions

### 2.1 Tutorial

The first manuscript does not aim to provide its own evidence, but to give others the tools to do empirical research themselves. Ravignani and Norton provide a tutorial for quantifying and comparing temporal structure in speech and animal vocalisations. The tutorial includes guides for what software and analysis to use given different hypotheses, and how to interpret results. An amalgamation of such methods is an invaluable contribution to the current literature. It is an especially valuable tool for work on the evolution of speech and sound systems because it facilitates comparisons between the vocalisations of different species including human speech.

### 2.2 Research articles

The research articles have loosely been arranged around the different timescales explained in the introduction: phylogeny, glossogeny, and ontogeny. However, some contributions are relevant to more than one level, or explicitly discuss interactions between these levels. The contributions come from researchers in biology, anthropology, linguistics, and computer science and cover evidence from animal studies, bio-mechanical modelling, large scale typological data, and statistical and computational modelling.

#### 2.2.1 *Phylogeny and physiological constraints*

The first research article uses comparative methods to investigate the similarities and differences between human speech to that of non-human primates: geladas and chacma baboons. Gustison and Bergman's contribution measures and compares the formant profiles and other features of the calls of these species. Comparative work, such as this contribution, is important in order to answer questions of what aspects of human vocal behaviour are unique or likely present in our ancestors. Gustison and Bergman use their measurements to argue that geladas are anatomically capable of producing speech-like modulated signals. This finding indicates that the gap between the vocal capabilities of humans and other primates may be smaller than previously thought, and likely the result of neural capacity and control, rather than the result of the physical capacity to produce complex speech sounds.

Next, Moisik and Dediu's contribution links our anatomical capabilities to typological trends. They use bio-mechanical modelling to argue that alveolar ridge size affects the articulatory effort needed to produce clicks. They link this to the observation that palates belonging to peoples who speak click languages, specifically the Khoisan people, have smaller alveolar ridges. This sets up a possible link between an anatomical bias that may be amplified in its effect as the result of glossogeny.

#### 2.2.2 *Glossogeny and phoneme inventories*

Focusing more intensively on processes of cultural evolution (but still relating somewhat to articulatory constraints), the next contribution from Fleming presents a theoretical argument for why African languages have larger phoneme inventories than languages outside of Africa. This contribution argues that languages from Sub-Saharan Africa, where modern humans and human language originated, have such large inventory sizes is because of the inclusion of clicks. These larger inventories allowed for more distinctions at an early stage of linguistic emergence before a level of combinatorial structure was necessary in order to maintain distinctions between linguistic signals. This presents an alternative to other theories about clicks being present in early language because they have a high affordance for sound symbolism.

In a more quantitative approach, Mühlenbernd and Rama tackle the topic of estimating the age of linguistic families by using phonemic diversity measures from across languages. Using tools from network theory, they show that the amount that unfaithful replication contributes to the diversity of phoneme inventories within a language family is a good predictor for the age of the language family. These findings show that the current structure of sound systems in modern languages can lead us to make good inferences about their evolution.

#### 2.2.3 *Ontogeny and phoneme categories*

Moving on to focus on how individual level processes can affect trends at the level of a population, Wedel and Fatkullin model show how speech categories can shift or be maintained as a result of competition and pressures for contrast in learning and use. They use exemplar modelling to investigate the feedback loop between perception and production, investigating the effects of variation in competing categories, context, and frequency effects. They compare the predictions of their simulations and mathematical analysis to trends in real world languages, such as phoneme category mergers. For

example the trend found in earlier work (e.g. Wedel et al. 2013) that the more minimal pairs a phoneme distinction has, then the less likely a phoneme merger is to happen.

Finally, Thompson and de Boer tackle language development explicitly in interaction with cultural evolution. They use a Bayesian model to simulate category learning. Their model is able to generalise knowledge of category structure between sound classes without assumptions that sound classes are all identical. They use their model to argue that the principles of cultural transmission encourage solutions that allow for generalisation at the level of the individual.

## 3. Discussion

Collectively, these papers suggest that in order to understand why human sound systems are structured in the way that they are, we must gather evidence from all timescales of linguistic evolution. Firstly, understanding the anatomical capabilities of both non-human primates and humans allows us to make predictions about what effects are the results of anatomy, and what are the results of neural and cognitive mechanisms. Secondly, understanding mechanisms for cultural evolution can help us make inferences about why sound systems look the way they do, as well as make inferences about things such as the age of languages. Thirdly, understanding how sound systems are learnt, perceived, and produced at the level of the individual can inform us of how language is transmitted culturally at the population level.

This special issue is in no way a complete picture, but instead a selection of work demonstrating new techniques that can be applied to very old questions. There are, of course, still many existing questions and new questions being raised by the work presented here. Furthermore, new methods are being developed all the time to tackle questions in language evolution, as well as allow us to measure and compare old data, including things such as temporal structure, as covered in the tutorial section of this special issue. Evolutionary linguistics is proving to be a hotbed of collaboration and communication between disciplines, and I hope this special issue has provided a good example of the cross-pollination possible to investigate a single topic.

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