THE JOY OF SACS

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1. Introduction

This paper investigates an idea that was put forward (and hinted at in Fitch, 2000) by Tecumseh Fitch at the Cradle of Language conference in Stellenbosch, South Africa. The idea is that air sacs may have played an important role in early hominid vocalizations. Many other primates have air sacs, notably chimpanzees, gorillas and orangutans. It is therefore likely that our latest common ancestor also had air sacs, and the shape of a recently discovered Australopithecine hyoid bone (Alemseged *et al.*, 2006) also points in this direction.

Many functions have been proposed for air sacs, among them resonance chambers, sound radiators, CO_2 buffers to prevent hyperventilation and means to help exaggerate size. Whatever their function in other primates, the fact that humans are the only apes that do not have air sacs might be related to the fact that we have speech. Here I investigate the influence of the presence of an air sac on the set of (vowel) signals that can be produced.

2. Preliminary results

An articulatory model (based on Mermelstein, 1973) of the female vocal tract was extended with an air sac (figure 1 left). As all existing articulatory models were designed to model humans, no efforts were ever made to model air sacs. The model is therefore still under development. The present model consists of a simple side tube, with anatomically plausible dimensions, attached above the larynx of the standard articulatory model. A more sophisticated model, based partly on models of bird calls (Fletcher *et al.*, 2004) is under development.

Both models (with and without air sacs) produced 10 000 random articulations, and the first and second formants of these articulations were measured. These

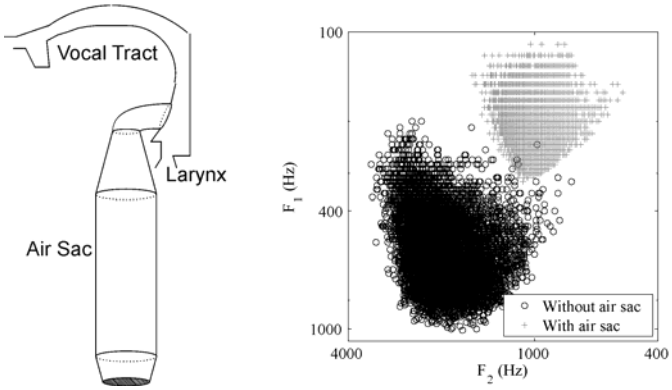

Figure 1: Right: the vocal tract model. Left: comparison of articulatory range with (grey plus signs) and without (black circles) air sac. The discreteness of the air sac data is an artifact of the accuracy with which formants were measured (10 Hz).

are presented in the right part of figure 1. A logarithmic scale is used, as this corresponds to humans' logarithmic perception of frequencies. It can be observed that the articulations made with the model with an air sac have lower formant frequencies and cover a smaller area of acoustic space than those of the model without an air sac ($\mu = 0.151$, $\sigma = 0.006$ versus $\mu = 0.324$, $\sigma = 0.009$).

3. Discussion

The observed lowering of formant frequencies supports the theory that air sacs help to exaggerate size, an evolutionary useful function (although whether low formants and air sacs really play a role in *primate* mate selection appears to be not yet known.) However, the price is a reduced ability to produce distinctive speech. Although communication is possible with a reduced repertoire of speech sounds, it is an intriguing possibility that humans lost air sacs because of speech.

Acknowledgement

The research is part of the NWO vidi project *Modelling the Evolution of Speech*.

References

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