ANATOMICAL BIASING OF CLICK LEARNING AND PRODUCTION: AN MRI AND 3D PALATE IMAGING STUDY

DAN DEDIU, SCOTT R. MOISIK
Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands
dan.dediu@mpi.nl,scott.moisik@mpi.nl

1. Investigating anatomical biases on speech sound systems

1.1. *Learning to produce clicks: Does vocal tract morphology matter?*

Clicks are among the most rare speech sounds, and their articulation depends upon a rarefaction gesture formed most typically between the tongue and the palate. It has been suggested (e.g., Traunmüller 2003) that click production might be subject to an effort bias associated with palate shape. Some have postulated (e.g. Allot 1994) that such anatomical biases on speech production could contribute to sources of variation driving phonological diversity.

The current paper presents results for data on click learning obtained from a larger imaging study (using MRI and 3D intraoral scanning) designed to quantify and characterize intra- and inter-population variation of vocal tract structures and the relation of this to speech production. The aim of the click study was to ascertain whether and to what extent vocal tract morphology influences (1) the ability to learn to produce clicks and (2) the productions of those that successfully learn to produce these sounds.

1.2. *Why examine clicks?*

Speakers of Khoisan-type languages (which are possibly the origin of click sounds, other non-Khoisan languages having borrowed them from Khoisan languages; see Traunmüller 2003) tend to have smooth palates lacking a prominence along the alveolar process (i.e. an alveolar ridge), as demonstrated by several studies (for a review, see Moisik & Dediu 2015). The suggested bias is that a prominent alveolar ridge requires more distortion of the tongue to form the linguo-palatal seal required for click production. Moisik & Dediu (2015)

show using biomechanical simulations that larger alveolar ridges increase muscular effort and reduce volume change.

2. The imaging study of phonetic learning of click production

To investigate this claim of a palate-shape bias on click production we conducted a study in which 79 participants were taught using auditory and visual aids how to produce (post-)alveolar (IPA notation [!]) and dental (IPA [|]) clicks, during which an audio recording was obtained. These participants were then scanned using both static and real-time MRI sequences and 3D intraoral scanning.

The results indicate that the presence of an alveolar ridge certainly does not prevent an individual from learning to produce click sounds (1). However, the subtle details of how clicks are produced may indeed be driven by palate shape (2), as illustrated in Fig. 1.

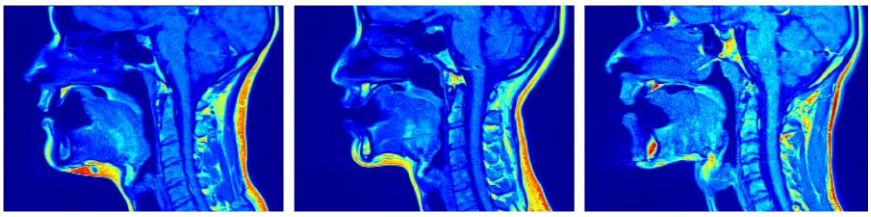

Figure 1. Three participants producing [!] (at the moment before release) in a static MRI sequence (10 second sustained articulation). From left to right, palate shape varies from steep to shallow; in correspondence with this, tongue blade placement is increasingly more anterior.

Thus we have some very preliminary evidence that individual articulatory strategies in click production are influenced by anatomical factors. Elucidating the influence of anatomy on phonetics will allow us to better understand the emergence and evolution of speech sound systems and to better infer the speech capabilities of extinct humans from fossil traces of their vocal tract structures.

References

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