



Can the location of the vocal tract bending constrain individual vowel articulation? Evidence from biomechanical modelling.

Ralf Winkler, Susanne Fuchs, Pascal Perrier, Mark Tiede

► To cite this version:

Ralf Winkler, Susanne Fuchs, Pascal Perrier, Mark Tiede. Can the location of the vocal tract bending constrain individual vowel articulation? Evidence from biomechanical modelling.. SMC 2011 - 6th International Conference on Speech Motor Control (SMC 2011), Jun 2011, Groningen, Netherlands. pp.19. hal-00605630

HAL Id: hal-00605630

<https://hal.science/hal-00605630>

Submitted on 30 Aug 2011

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Can the location of the vocal tract bending constrain individual vowel articulation? Evidence from biomechanical modelling.

Ralf Winkler¹, Susanne Fuchs¹, Pascal Perrier², Mark Tiede^{3,4}

¹ZAS Berlin, ²GIPSA-lab Grenoble, ³Haskins Labs New Haven, ⁴MIT Boston

Although native speakers of a given language all use the same phonemic inventory, speakers vary from one to another with respect to their acoustics and articulation. The variability among speakers may be driven by a variety of factors. This paper focuses on anatomical factors, in particular on the position of the bending of the vocal tract relative to its total length. For most acoustic tube models the relative position of the vocal tract bending does not matter for the simulation of vowels, since these models treat the vocal tract as a straight series of tubes. In contrary, the relative position of the vocal tract bending is supposed to be fundamental for tongue biomechanics, since the soft tongue body has to fit its surrounding vocal tract borders and muscles may not generate forces in exactly the same direction. If the relative bending position of the vocal tract is rather anterior (model A), the length of the horizontal dimension (palatal region) is short in comparison to the vertical dimension (pharynx). A more posterior location of the vocal tract bending (model B) corresponds to the reverse, if a similar vocal tract length is considered in both models. We expect a larger articulatory variability in the vertical dimension for model A and a larger variability in the horizontal dimension for B.

In order to test these hypothesis two biomechanical models were built. Both models were based on MRI data of one speaker. For model A we lengthened the original tissue contours of the pharynx by 1.5 cm in the vertical direction and for model B the oral cavity in the horizontal direction. For each model 8000 simulations were run by varying motor commands of the six major tongue muscles randomly around their values at tongue rest position. The biomechanical models were coupled with a harmonic acoustical model based on a distance to area function conversion to calculate the corresponding formants. Since we assume that auditory targets are the primary goal of speech production, the vowel targets for /a/, /u/ and /e/ were defined as identical formant ellipses for both models.

Results of our simulations provide evidence that articulatory variability of the tongue in the horizontal dimension is larger for model B than A, reaching the same acoustic vowel target ellipsis for /e/. For /u/ this effect is similar, but smaller. Furthermore, model A showed more articulatory variability in the vertical dimension than model B for vowel /a/ which is in agreement with the relatively large pharynx length. In our experiment articulatory variability is constrained by the relative position of the vocal tract bending. This position can shape the allowed degrees of freedom and constrains speaker specific articulatory precision for a given vowel target.