

ARTICULATORY ORAL SPACE MEASURES USING THE MODIFIED A-SPACE

Luis M. T. Jesus^{1,2}, André Araújo^{2,3}, Isabel. M. Costa^{1,2}

¹Escola Superior de Saúde da Universidade de Aveiro (ESSUA), Aveiro, Portugal

²Instituto de Engenharia Electrónica e Telemática de Aveiro (IEETA), Aveiro, Portugal

³Escola Superior de Tecnologia da Saúde do Porto, Instituto Politécnico do Porto, Porto, Portugal

I. INTRODUCTION

The X-ray microbeam method for measurement of articulatory dynamics has been used to acquire large amounts of data, with reduced X-ray dosage, resulting in one of the most widely used freely available speech production databases. The X-ray Microbeam Speech Production Database (XRMB-SPD), developed at Wisconsin University, USA, includes a vast amount of coordinate data describing articulatory movements, and acoustic and electroglotographic data collected simultaneously [3]. Honda et al. [2] examined the geometry of the vocal track of American English and Japanese speakers from the XRMB-SPD, using a quadrilateral (A-Space) limited by the palate plane, the anterior nasal spine-menton line, the outline of the posterior pharyngeal wall, and a line parallel to the palatal plane, passing through the menton and extending to the pharyngeal wall. In this study the A-Space of different speakers varied in shape. The vowel articulations adapted to the form of the A-Space whilst consonant articulations were independent.

The Modified A-Space method was used to select 4 speakers in a study that relates occlusal classes with vowel, fricative and stop production adaptations [1]. It allows the detailed characterization of the XRMB-SPD speakers not just in terms of mid-sagittal-plane area, but also in terms of antero-posterior distance, occlusal plane area, posterior pharynx wall tilt, mandible arch width, and oral cavity volume. This last measure has proven to be far more reliable and has revealed more speaker dependent characteristics than the measure previously proposed in [2].

II. METHOD

XRMB-SPD provides occlusion classification, dental measures, anthropomorphic measures, reference pellets coordinates, biteplate records and palatal outlines, for each of the 57 speakers. This was used to measure the articulatory oral space (AOS) in the absence of cephalometric analysis, based on the Modified A-Space described in Fig. 1.

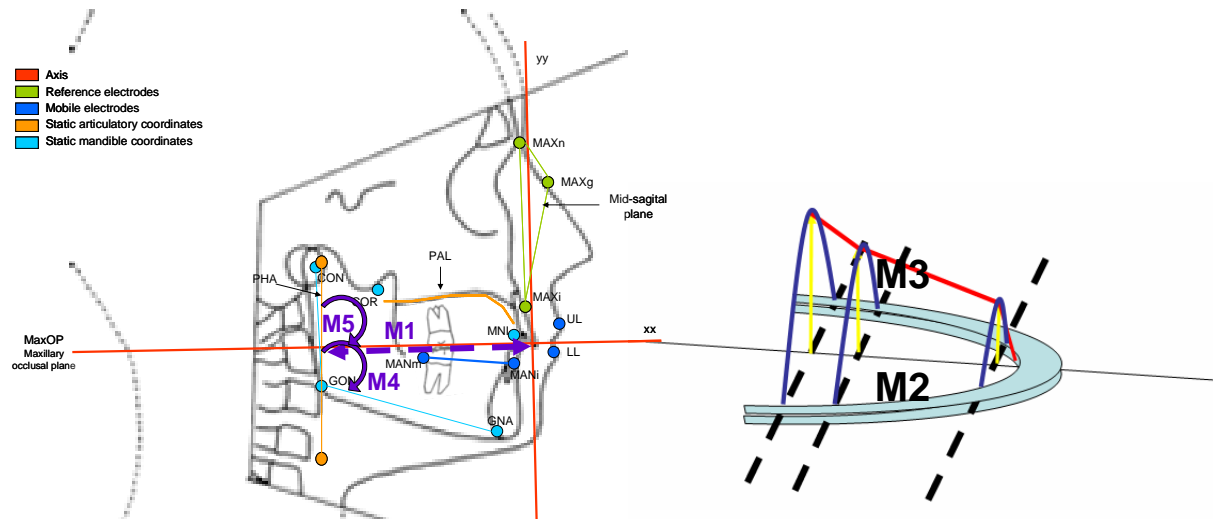


Fig. 1: Left – Mid-sagittal-plane coordinates included in the XRMB-SPD (MAXn and MAXg – bridge of the nose; MAXi – buccal surface of the maxillary incisors; MANm – juncture between the first and second mandibular molars; MANi – buccal surface of the central incisors; LL – lower lip; UL – upper lip; PAL – palate; PHA – middle pharynx wall; CON – condyle; COR – coronoid process; GON – gonion; GNA – gnathion; MNI – lingual surface of the maxillary incisors). Right – a three dimensional representation of the maxillary arch and mid-sagittal palate height of the anterior oral cavity (from the distal-buccal cusp tip of the second molar to the lips). The Modified A-Space measures M1, M2, M3, M4 and M5, are also represented.

We extracted the following measures of the AOS, as shown in Fig. 1 and 2: M1 – antero-posterior distance, calculated from the upper incisors to the posterior pharynx wall; M2 – mid-sagittal plane area, from the mandible to the palate midline; M3 – occlusal plane area, from the distal-buccal cusp tip of the second molar to the lips; M4 – posterior pharynx wall tilt, i.e, the angle between the pharynx and the occlusal planes; M5 – mandible arch angle, calculated with several mandible points; M6 – anterior oral cavity volume. Areas of trapeziums (A1, A2, A3, A5 and A6) and a triangle (A4), and volumes of convex hulls of cubes and tetrahedrons were used to estimate the AOS, as shown in Fig. 2.

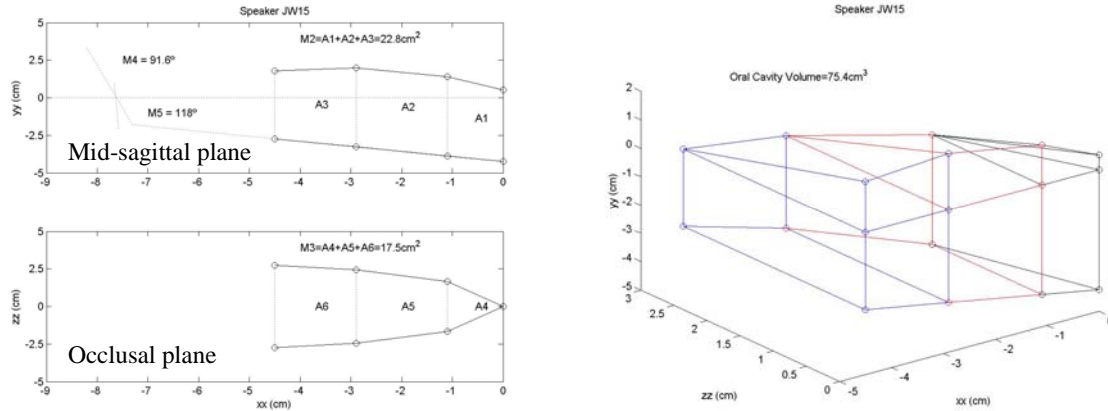


Fig.2 Measures M2, M3, M4, M5 and Oral Cavity Volume for speaker JW15, showing the mid-sagittal and occlusal planes and half of the oral cavity volume as reconstructed using the Modified A-Space.

III. RESULTS AND DISCUSSION

Results showed a considerably larger average oral cavity volume and greater antero-posterior distance AOS in male subjects than in females, as shown in Fig. 3. The Modified A-Space provided additional information, allowing the characterization of cranio-facial features and the selection of a uniform set of speakers in studies [1] involving XRMB-SPD. This method combines anatomical data and biomedical signals producing a reference dataset for research into speech production. We believe that this method may provide additional information to regular cephalometric analysis.

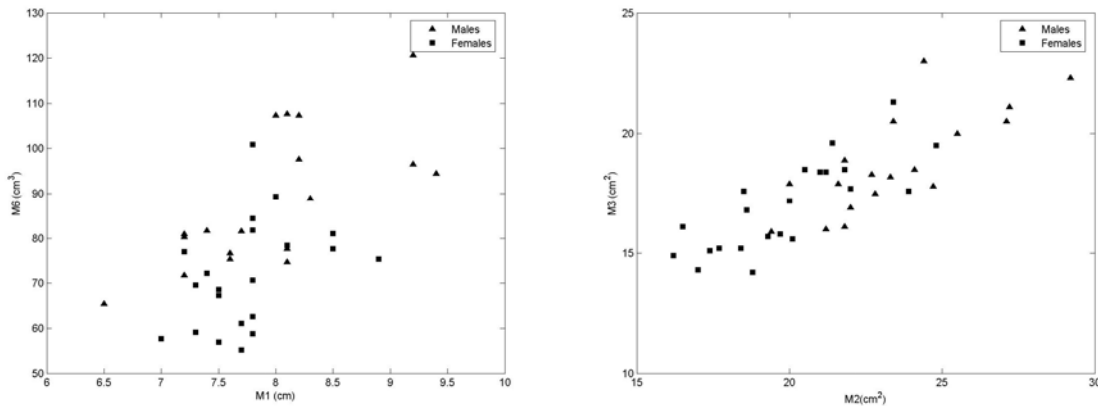


Fig. 3 M1, M2, M3 and M6 measures of the available 18 Class I male and 22 Class I female speakers.

V. REFERENCES

- [1] Araújo, A., A Influência de Diferentes Tipos de Oclusão Dentária na Produção de Sons da Fala. MSc. Thesis, Universidade de Aveiro, Aveiro, Portugal, 2007.
- [2] Honda, K., S. Maeda, M. Hashi, J. Dembowski, and J. Westbury, Human Palate and Related Structures: Their Articulatory Consequences. In: Proceedings of the ICSLP, Volume 2, Philadelphia, USA, 1996.
- [3] Westbury, J., X-ray microbeam speech production database user's handbook. University of Wisconsin, 1994.