Electropalatographic analysis of vowels in quasi-spontaneous speech

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Instrumental data on speech production physiology are crucial for our understanding of speech motor control, coarticulation and connected speech processes (Stone, 2010). However, instrumental physiological techniques, such as electropalatography (EPG), are mostly limited to laboratories and laboratory speech is often described as different from spontaneous speech (Celata and Calamai, 2012). It is therefore quite challenging to use instrumental physiological techniques for spontaneous speech recording and analysis. Particularly demanding for instrumental physiological analysis in both laboratory and spontaneous speech are vowels (Howard & Haselwood, 2012). Articulatory analysis of vowels is considered demanding mainly because of difficulties with determining tongue shapes and positions during speech. No single instrumental physiological technique provides a complete insight into vowel articulation and EPG might seem particularly unsuitable (Howard & Haselwood, 2012). EPG is instrumental physiological technique for recording and analysis of tongue-to-palate contact patterns during speech (Gibbon & Nicolaidis, 1999). Since tongue-to-palate contact is relatively low or even non-existent during vowel productions (Hardcastle & Gibbon, 1997), EPG is not the first choice when it comes to analysing vowels. However, some research data suggest that high vowels and some diphthongs can be analysed via EPG quite successfully (Byrd, 1995; Recasens & Espinosa, 2005; Gibbon et al. 2010). The analysis of low vowels using EPG is still problematic as well as separate quantification of vertical (high-low) and horizontal (front-back) position of each vowel using EPG data only.

Motivated by the review above, there are two aims in this investigation. The first aim is to elicit and record quasi-spontaneous speech in the laboratory using EPG. The second aim is to explore the possibilities of using EPG to quantify three Croatian corner vowels on the vertical (high-low) and horizontal (front back) axis of the vowel chart, which is comparable to the vowel chart based on acoustic data (F1, F2), in quasi-spontaneous speech.

Data were extracted from the R-kor corpus of Croatian speech containing simultaneous acoustic and EPG data. Speech material from eight female speakers of Standard Croatian with no speech or hearing impairments was utilised. A dialogue situation was set up in the form of a map task. Each speaker was asked to describe the path through a maze and read signs at 15 check-points marked throughout the path. Each sign contained a two-syllable CVCV word with one of the corner vowels of the Standard Croatian (/i, a, u/) in stressed and in unstressed position (e.g. “rasa”, /’rasa/, English translation: race). During the recording session each speaker repeated each vowel five times in the stressed and unstressed position. Stressed vowels were analysed in this investigation. Six indices were calculated for each vowel: total contact, dental closure, alveolar closure, postalveolar closure, palatal closure and velar closure. Total contact was used to quantify the vertical (high-low) position of each vowel on the vowel chart. A newly developed measure used other five indices to quantify the horizontal (front-back) position of vowels. Articulate Assistant software (Wrench et al. 2002) was used for EPG analysis, while the statistical significance of differences was tested using two-way ANOVA with replication (alpha 0.05).

The clustering of the results for each vowel showed that on the basis of EPG indices it was possible to produce a vowel chart for each of the speakers. Two-way ANOVA with replication showed that differences between vowels were statistically significant both for vertical ($F(7, 2) = 660.24$, $p<0.001$) and horizontal ($F(7, 2) = 122.78$, $p<0.001$) axis of the vowel chart. The interaction analysis returned significant results (vertical: $p<0.001$, horizontal: $p=0.01$) showing that individual speakers’ productions differed substantially. A newly developed measure for the quantification of vowels along the horizontal (front-back) axis proved to be more discriminative than the traditional CoG-based measure. The analysis of the variability of each of the indices showed that vowel /a/ is most variable in the majority of the speakers, while /i/ is least variable.

This investigation demonstrates one possibility of eliciting quasi-spontaneous speech in the laboratory using EPG. The investigation shows that EPG is sensitive enough to quantify vowels along vertical and horizontal axes of the vowel chart. The results of vowel variability are discussed in terms of Degree of Articulatory Constraint theory (Recasens et al. 1997).

References

Byrd, D. (1995). Palatogram reading a phonetic skill: A short tutorial. *Journal of the International Phonetic Association*, 24, 21–34.

Celata, C., Calamai, S. (2012). Introduction. *Italian Journal of Linguistics*, 24(1), 43–64.

Gibbon, F. E., Lee, A., Yuen, I. (2010). Tongue palate contact during selected vowels in normal speech.

The Cleft Palate Craniofacial Journal, 47(4), 405–412.

Gibbon, F. E., Nicolaidis, K. (1999). Palatography. In W. J. Hardcastle, N. Hewlet (eds.) *Coarticulation: theory, data and techniques*, Cambridge: CUP, 229–245.

Hardcastle, W. J., Gibbon, F. (1997). Electropalatography and its clinical applications. U: M. J. Ball, & C. Code (ur) *Instrumental Clinical Phonetics*. Whurr: London.

Howard, S., Haselwood, B. (2012). The contribution of phonetics to the study of vowels and vowel disorders. U: Ball, M. J., Damico, J. S., Gibbon, F. E. (ur) *Handbook of Vowels and Vowel Disorders*. Routledge: London, 61–112.

Recasens, D., Espinosa, A. (2005). Dispersion and variability of Catalan vowels. *Speech Communication*, 48(6), 645–666.

Recasens, D., Pallarès, M. D., Fontdevila, J. (1997). A model of lingual coarticulation based on articulatory constraints. *Journal of the Acoustical Society of America* 102 (1): 544–561.

Stone, M. (2010). Laboratory techniques for investigating speech articulation. In W. J. Hardcastle, J. Laver, F. E. Gibbon (eds.). *The Handbook of Phonetic Sciences*. Malden-Oxford-Chichester: WileyBlackwell. 9–38.

Wrench A. A., Gibbon, F. E., McNeill, A. M., Wood, S. E. (2002). *An EPG therapy protocol for remediation and assessment of articulation disorders*. In John H.L. Hansen; Brian L. Pellom (Eds.). *Proceedings of ICSLP-2002*: 965–968.