universidade de aveiro · ESTSP Escola Superior de Tecnologia da Saúde do Porto · ieeta instituto de engenharia electrónica e telemática de aveiro

Interspeech 2007, Antwerp, Belgium, 29/8/2007 (Session WeD.P2 - 14: Speech production II)

Vowel Production in Two Occlusal Classes

André Araújo †*, Luis M. T. Jesus ‡* and Isabel M. Costa ‡*

† Escola Superior de Tecnologia da Saúde do Porto, Portugal
‡ Escola Superior de Saúde da Universidade de Aveiro, Portugal
* Instituto de Engenharia Electrónica e Telemática de Aveiro, Portugal

---

universidade de aveiro · ESTSP Escola Superior de Tecnologia da Saúde do Porto · ieeta instituto de engenharia electrónica e telemática de aveiro

Introduction

- The influence of occlusal class in speech production has been studied using the **X-ray Microbeam Speech Production Database** (XRMB-SPD).
- The objective of the study was to relate the occlusal classes I and II with vowel production adaptations.

Introduction

- The **“Modified A-Space”** (Jesus, Araújo and Costa 2007) method was used to select **4 speakers** (1 class I male, 1 class I female, 1 class II male and 1 class II female).
- Articulatory and acoustic features of the **vowels [i, {, A, u]** were studied using different tasks and methods.

[i] – as in “ease”, [{] – as in “pat”,

[A] – as in “pot” and [u] – as in “lose”

universidade de aveiro
ESTSP Escola Superior de Tecnologia da Saúde do Porto
ieeta instituto de engenharia electrónica e telemática de aveiro

Occlusal Class

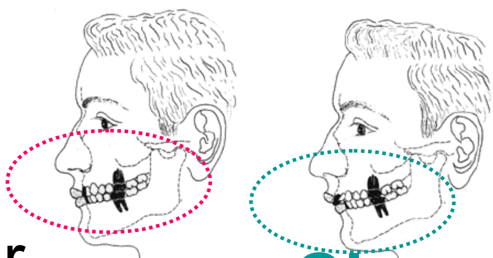


Figure 1
From Nojima and Gonçalves (2001)

- **Class I** malocclusion
  - Normal molar relationship
  - Other anterior teeth have problems like spacing, crowding, over or under eruption.
- **Class II** malocclusion
  - Upper molars are placed not in the mesiobuccal groove but anteriorly to it.

Method

- Selected **four subjects**, out of the 57 American English speakers in XRMB-SPD:
  - JW15 – Class I male
  - JW61 – Class II male
  - JW54 – Class I female
  - JW13 – Class II female

Method

- The selection was based on the **"Modified A-Space"** (Jesus, Araújo and Costa 2007) method, an extended and updated version of the "A-space" method proposed by Honda et al. (1996).

Method

- Several measures of the Articulatory **Oral Space (AOS)**, shown in Figure 2, were extracted for each subject, allowing the characterization and selection of the most representative subjects of each group.

Method

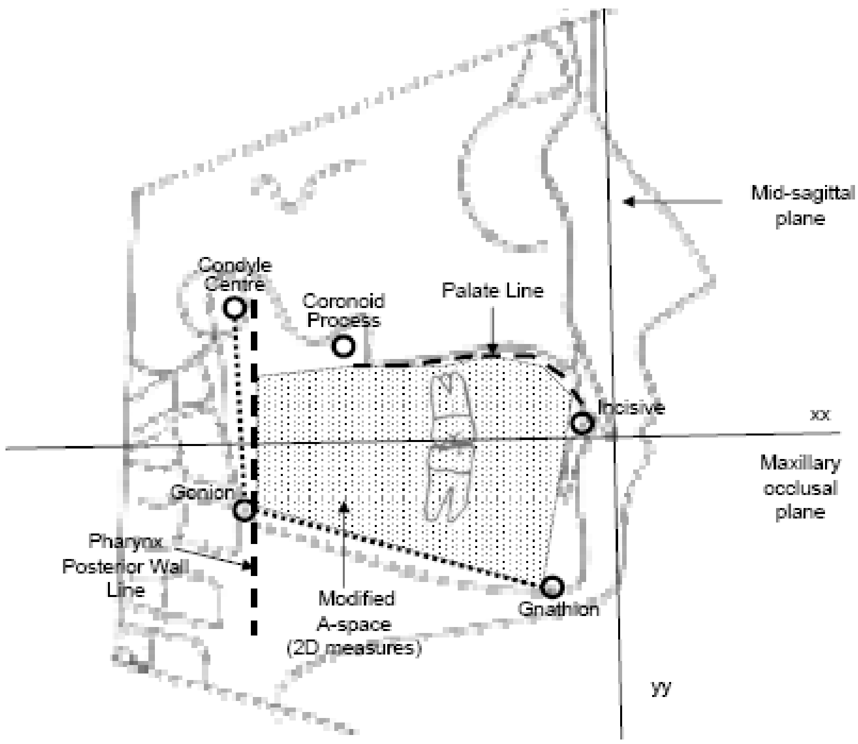


Figure 2

Method

- The selected subjects were also characterized using the outputs of *TF32* during:
  - task TP107 (swallowing),
  - tasks TP117 and TP118 (maximal tongue and lip protrusion) and
  - task TP106 (replicative jaw-"wagging").

Corpus

- Vowels produced in isolation (task TP014), preceded by [s] and followed by [d] (the words [sid], [s{d], [sAd] and [sud] in task TP013)
- Several productions in various words, totalizing **10 [i]**, **7 [{]**, **5 [A]** and **5 [u]** productions.

Method

- **Acoustic analysis** – Frequencies of **F1**, **F2** and **F3** were extracted from a stable region of each vowel .
- Formant values were then converted from Hertz (Hz) to Bark and used to represent each subject's vowel space.

universidade de aveiro
ESTSP Escola Superior de Tecnologia da Saúde do Porto
ieeta instituto de engenharia electrónica e telemática de aveiro

Method

- **Articulatory analysis** – task TP013 vowel productions.
- The coordinates of all pellets in the middle of the vowel were exported to text files to allow further processing with *Matlab*.

Method

- Images and measures describing the articulatory configuration of each vowel produced by each subject were also exported.
- Four parameters were analysed after image editing: **tongue posture**, **tongue elevation**, **mouth opening** and **lip configuration**.

universidade de aveiro
Escola Superior de Tecnologia da Saúde do Porto
ieeta instituto de engenharia electrónica e telemática de aveiro

Results

- Acoustically, there doesn’t seem to be any considerable difference in male speakers related to malocclusion, as shown Figure 3.
- Class II female speaker JW13 used a considerably wider vowel space than the Class I female speaker JW54.

Results

	[i]		[}]		[A]		[u]	
	F1 (Hz)	F2 (Hz)	F1 (Hz)	F2 (Hz)	F1 (Hz)	F2 (Hz)	F1 (Hz)	F2 (Hz)
P&B ♂	270	2290	660	1720	730	1090	300	870
JW15	321	2025	703	1737	726	1203	361	965
JW61	313	2062	698	1578	730	1142	375	963
P&B ♀	310	2790	860	2050	850	1220	370	950
JW54	395	2367	667	2015	811	1451	439	1123
JW13	332	2468	642	2250	919	1447	388	1035

Table 1

universidade de aveiro
ESTSP Escola Superior de Tecnologia da Saúde do Porto
ieeta instituto de engenharia electrónica e telemática de aveiro

Results

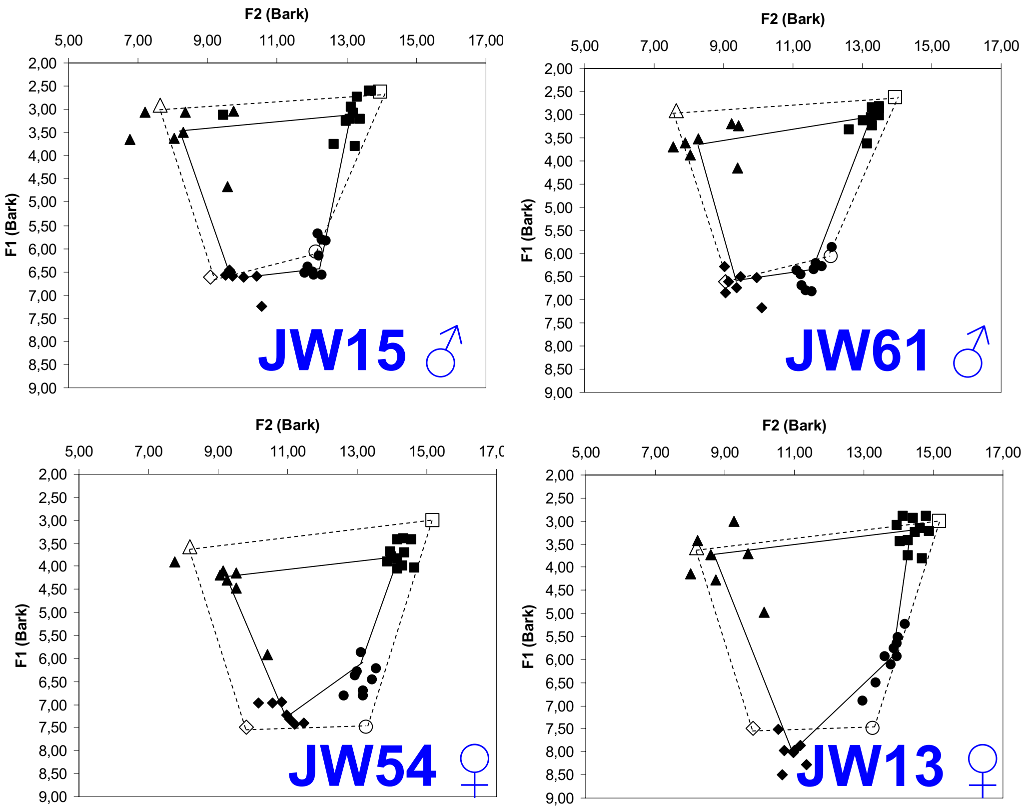


Figure 3
Vowel spaces of speakers JW15, JW61, JW54 and JW13 (filled lines) and from Peterson and Barney (1952) (dashed lines). ■□ - [i], ●○ - [{], ♦□ -[A], and ▲∆ - [u].

[i] Results

- JW15 and JW54 (Class I) present an elevation of the medium part of the tongue towards the palate.
- JW61 and JW13 (Class II) elevate the tongue at the most frontal region.
- Class II subjects present a more posterior position of lower incisors and lips than Class I subjects.

universidade de aveiro
ESTSP Escola Superior de Tecnologia da Saúde do Porto
ieeta instituto de engenharia electrónica e telemática de aveiro

[i] Results

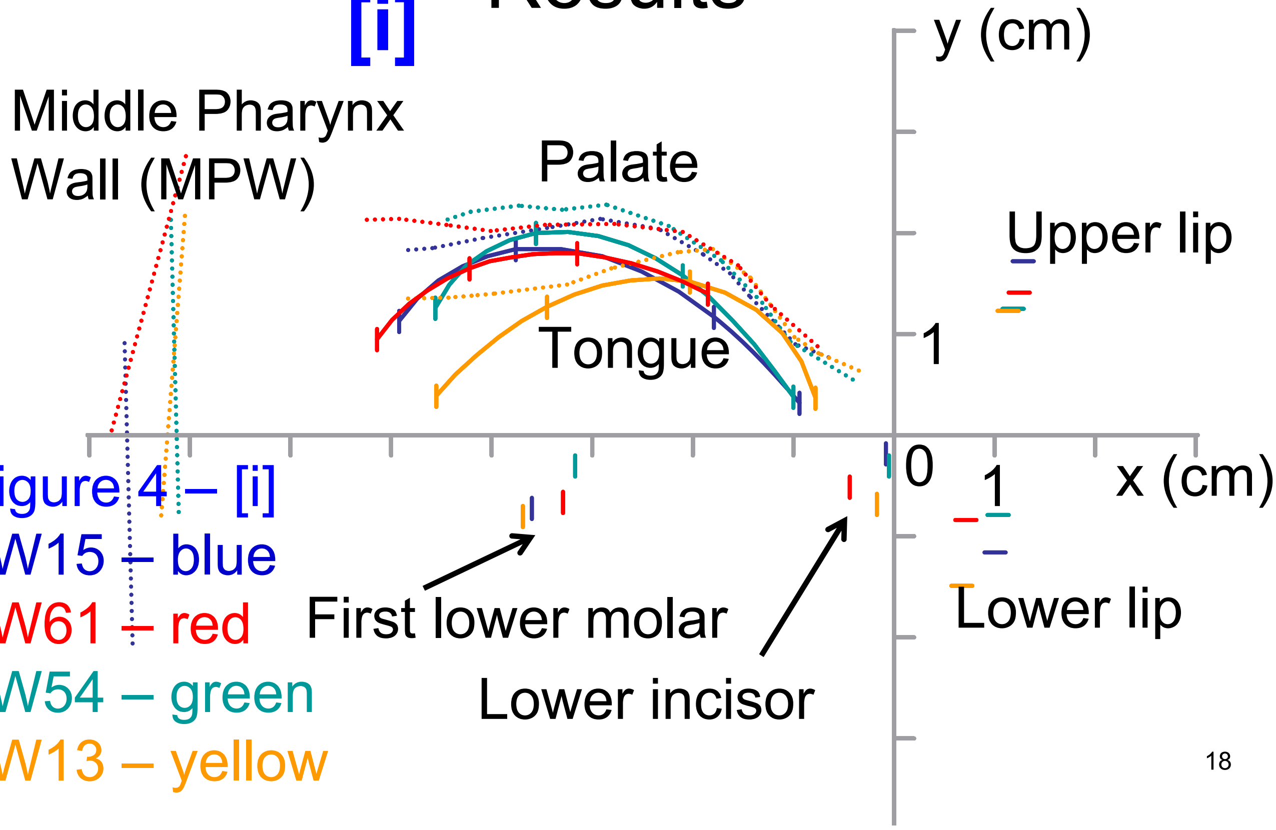


Figure 4 – [i]
JW15 – blue
JW61 – red
JW54 – green
JW13 – yellow

Results

[A]

- Speaker JW54 presents the highest tongue, mandible and lower lip position (see Figure 5).
- JW13 presents the lowest upper and lower lip, and tongue position.
- JW61 presents an elevated tongue dorsum and tongue back position, relative to the other subjects.

universidade de aveiro
ESTSP Escola Superior de Tecnologia da Saúde do Porto
ieeta instituto de engenharia electrónica e telemática de aveiro

Results

[A]

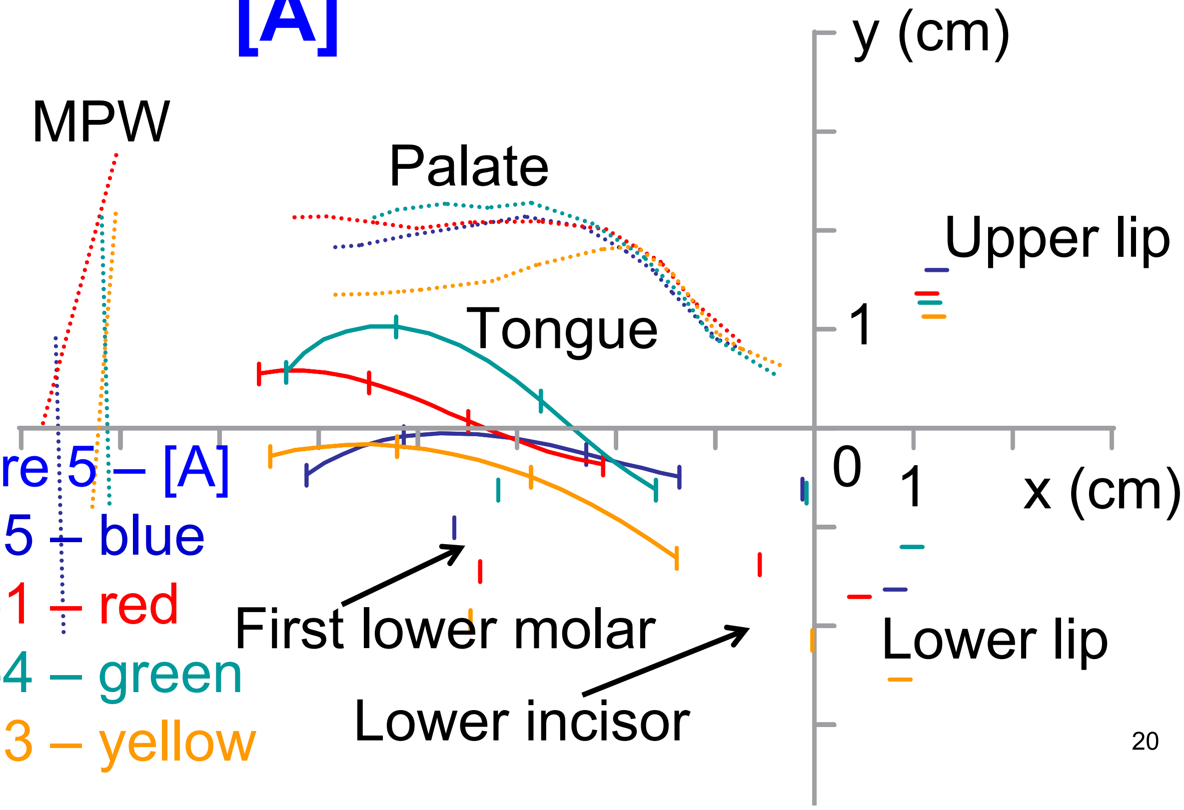


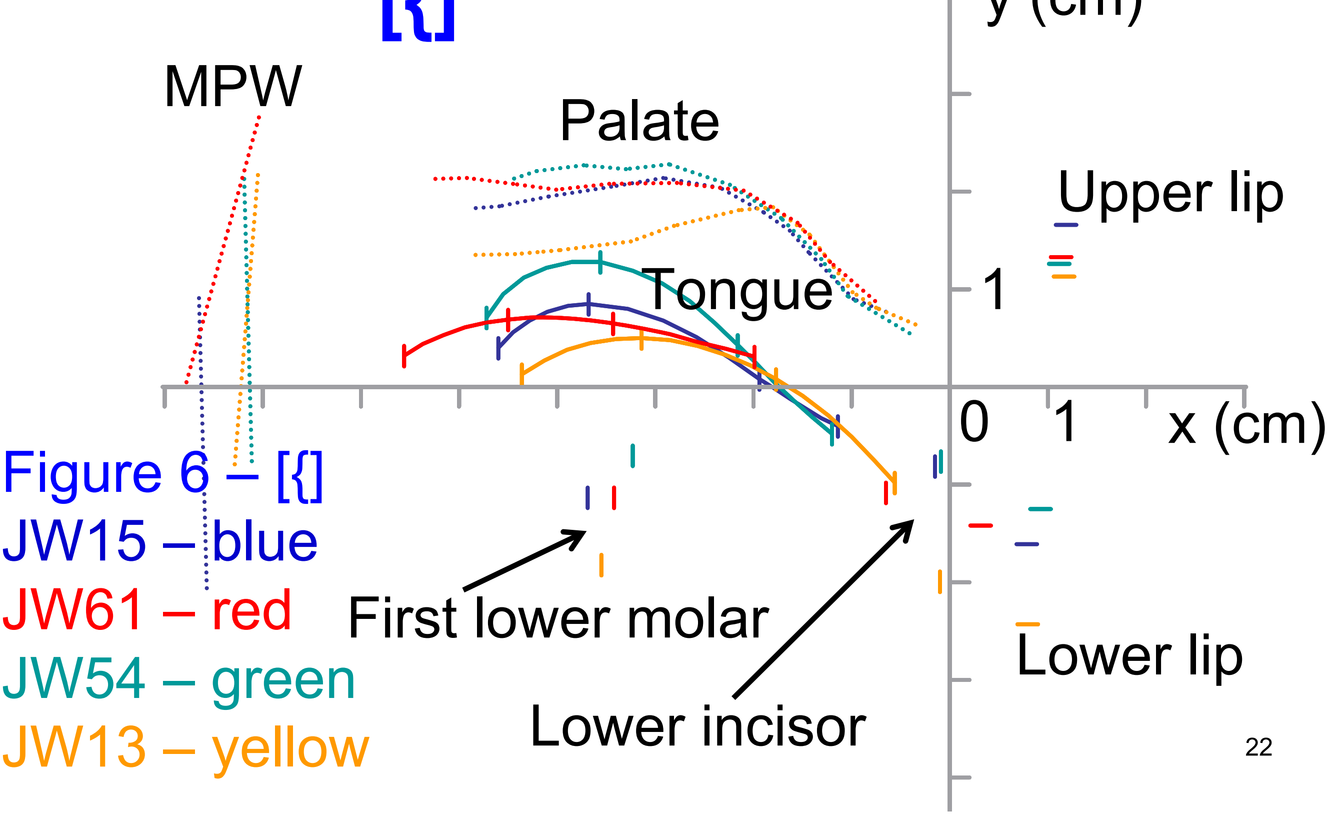
Figure 5 – [A]
JW15 – blue
JW61 – red
JW54 – green
JW13 – yellow

[{] Results

- Medium region of JW54's tongue with highest elevation (see Figure 6).
- JW61's articulatory position was more posterior than Class I subjects (JW15 and JW54):
  - Tongue almost horizontal and retracted from apex to the back of the dorsum.
  - Mandible and lower lip were also in a more posterior place.

universidade de aveiro
ESTSP Escola Superior de Tecnologia da Saúde do Porto
ieeta instituto de engenharia electrónica e telemática de aveiro

[{] Results



[u] Results

- JW13's tongue position was lower than the other subjects, but the distance to his palate was approximately the same as other subjects (see Figure 7).
- The mandible height was roughly the same in all subjects.

[u] Results

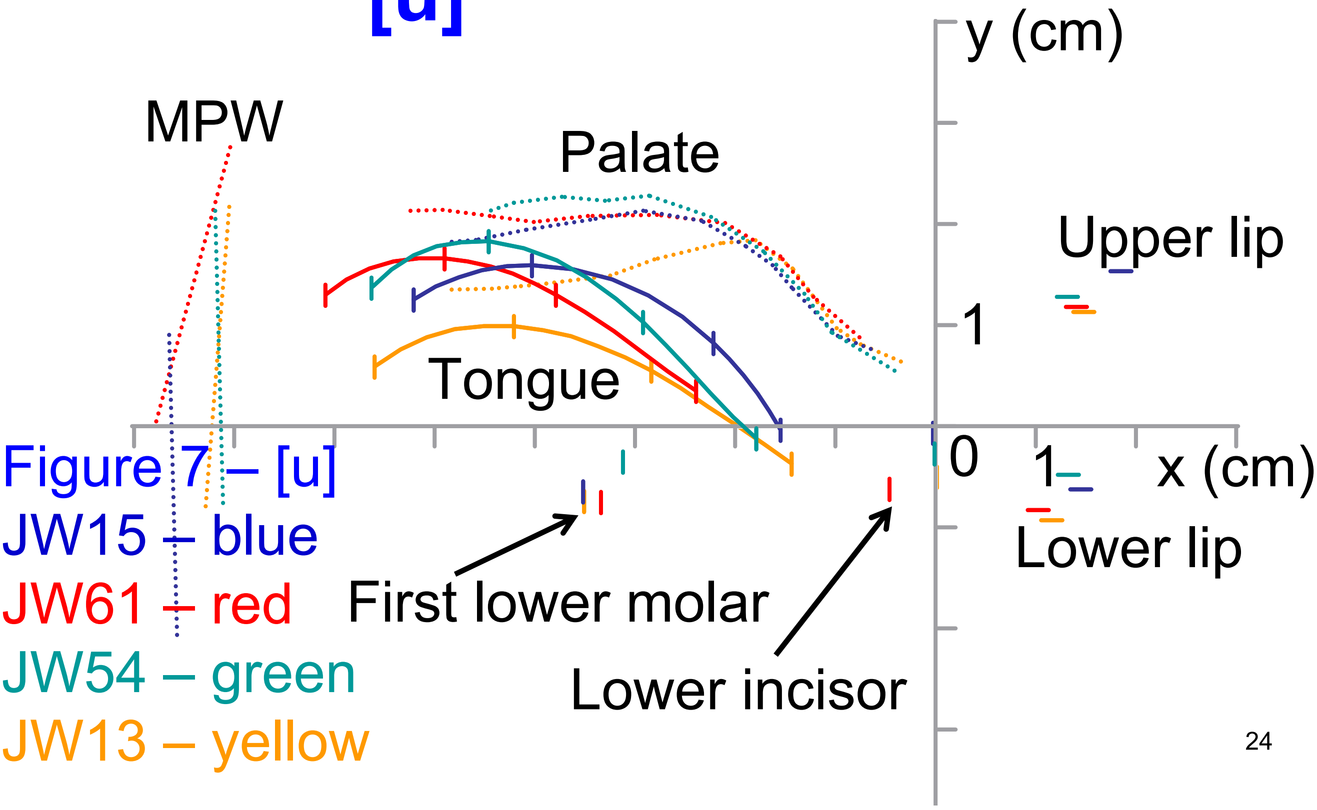


Figure 7 – [u]

Conclusions

- MPW of female subjects in a more anterior location than male, which may explain the higher second formant frequency values.
- Differences in F1 frequencies between female subjects may be related with the dimensions of the posterior region of the vocal tract.

Conclusions

- In [i, {, u] productions the back tongue pellet was located more anteriorly for JW13, suggesting that the pharyngeal cavity may be larger, producing lower F1 values.
- In [A] production this pellet is in a more posterior region for JW13, resulting in a higher F1.

Conclusions

- The Class II female speaker had lower [i, {, u] first formant frequencies than the Class I female subject.
- Class II subjects used different articulatory postures to functionally adapt speech to their structural configuration (occlusal class and palate).

Future Work

- The type of adaptations found should be described using cephalometric data contributing to a better understanding of normal, adapted and pathological speech production.
- These could be related to muscular groups involved in speech, which could be different from those described for normal speech.

References

- Nojima, L. and Gonçalves, M., “Classificação de Angle e Simon”, Odontologia.com.br, 2001.
- Honda, K. et al., Human Palate and Related Structures: Their Articulatoy Consequences. In: Proceedings of the ICSLP, 1996.
- Jesus, L., A. Araújo and I. Costa (2007). Articulatory Oral Space Measures Using the Modified A-Space. In: Proceedings of MAVEBA, 2007.
- Peterson, G. and H. Barney, “Control Methods in a Study of Vowels”, JASA, 24(2):175-184, 1952.

universidade de aveiro
ESTSP Escola Superior de Tecnologia da Saúde do Porto
ieeta instituto de engenharia electrónica e telemática de aveiro

Acknowledgements

- Supported (in part) by research grant number R01 DC 00820 from the National Institute of Deafness and Other Communicative Disorders, U. S. National Institutes of Health.
- This work was developed as part of the MSc in Speech and Hearing Sciences at the Universidade de Aveiro, Portugal.