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The Influence of Occlusal Class in the Production of Voiceless Fricatives

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Introduction: The aim of this study was to relate the production of voiceless fricatives with the type of dental occlusion. The articulatory gestures during the production of consonant sounds such as the voiceless fricatives /f/, /s/ and /ʃ/, seem to be disturbed for *type II class* (Angle's classification) individuals, which frequently require the training of compensatory articulation to get a "normal" acoustic output. This work is central to the first two authors' clinical practice in Speech and Language Therapy in which it is frequent the need to treat articulatory disorders.

Method: We used the X-ray Microbeam Speech Production Database (XRMB SPD) developed at the University of Wisconsin (Westbury 1994). The selected corpus for this study was composed of fricatives /f/, /s/ and /ʃ/, produced in nonsense words in a stressed syllable. We used the nonsense words /ɐˈfa/, /ɐˈsa/ and /ɐˈʃa/ from task 16 (citation VCV's), which were examples phonotactically possible in European Portuguese. We chose these examples because we wanted to relate the results with our clinical practice in Portugal.

There were 14 male individuals registered in the database with *normal occlusal class*, according to Angle's classification (Morris 2004, pp. 162, 166; Westbury 1994, p. 24), who could be used to observe the "normal" articulatory gestures in fricative sounds. From this group of individuals we only used 4 subjects because some of the other speaker's records were missing task 16. The "normal" subjects were 20, 21, 22 and 26 years old. We also selected a 20 year old male with *type II class* for comparison.

We analysed the anatomical structures involved in articulation and the articulatory gestures of all the subjects, and studied the distance of the tongue pellets to the palate and duration of each fricative production. We used the TF32 and XYD programs by Paul Milenkovic to analyse and import the data into Excel and MatLab. We then calculated the distance from each tongue pellet to the palate and ploted the data for further analysis.

Results: The *type II class* individual had a retracted lower lip (relative to the upper lip), a tipped pharynx (relative to the vertical plane) and a horizontal posture of the tongue (a compensatory posture), when compared to the *normal class* speakers.

There were no significant differences between the two occlusal classes in terms of the tongue posture during the production of /f/, because there is no cavity in front of the constriction, and most of the noise is generated between the front teeth and the lips (Stevens 1998, pp. 389, 411).

The production of /s/ by *normal class* individuals was characterised by a constriction around the first tongue pellet (in the ventral tongue – approximately 9mm from the apex) located approximately 12mm after the reference pellet (the maxillary incisors), as shown in Figure 1. The production of /ʃ/ for the *normal class* group has the minimal constriction around 15mm (relative to the same reference pellet). The *type II class* individual produced /s/ and /ʃ/ more posteriorely than the *normal class* speakers (/s/ – 15mm; /ʃ/ – 20mm).

During the production of /s/ by the *type II class* speaker, the first pellet (P1) was lower than for the *normal class* individuals, as shown in Table 1. In contrast, the second (P2) and third (P3) pellets were higher for the *type II class* subject. The major differences between the two classes were related to the height of the third (P3) and fourth (P4) tongue pellets (located in the tongue base), that were raised in all productions by the *type II class* subject in relation to the *normal class* group. This may be related to the described compensatory posture of the pharynx that could have interactions with the tongue base muscles.

We also calculated the difference between the place of minimal constriction for pellet 1 (P1) during the production of fricatives /s/ and /ʃ/. Results showed a 4 mm difference between /s/ and /ʃ/ (mean of the four *normal class* individuals), which differs from the 7 mm differences previously reported by Narayanan, Alwan and Haker (1995, p. 1336).

Conclusions: There were significant anatomical and posture differences between the two occlusal classes. Although the place of articulation and the height of the tongue vary between subjects, the speakers were able to produce suitable acoustic outputs for each fricative. The *type II class* subject needed an adjustment of the articulatory gesture to produce /s/ and /ʃ/ with the required constriction.

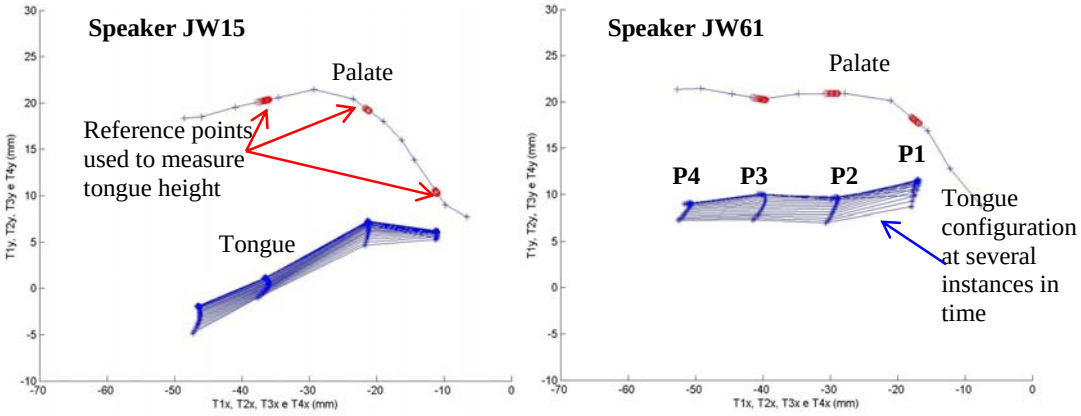

Figure 1 Results for fricative /s/ produced by *normal class* (JW15) and *type II class* (JW61) speakers.

Fricative	Occlusal Class	P1-Pal (mm)	P2-Pal (mm)	P3-Pa (mm)	Duration (ms)
/f/	Normal	15	20	18	156
	Type II	22	18	13	131
/s/	Normal	5	17	19	204
	Type II	7	12	11	110
/ʃ/	Normal	5	7	11	182
	Type II	5	5	5	151

Table 1 Normal (mean values of 4 subjects) and Type II distance of the tongue pellets to the palate (P1-Pal, P2-Pal and P3-Pal) for each fricative production.

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