

+ Escola Superior de Saúde da Universidade de Aveiro, 3810-193 Aveiro, 8017 1BJ, UK

# Abstract

This study of the acoustic characteristics of **European Portuguese and British English** fricatives as produced by two bilingual subjects, consisted of time and frequency analysis of words in a carrier sentence. Time-averaged power spectra were calculated and parameterised in order to aid comparisons across speaker, across corpus, and across language, and to gain insight into the production mechanisms underlying the language-specific variations.

# 1. Background

**Previous acoustic phonetic studies of bilingual** speech have been mainly focused on categorical perception of plosives.

- **Spanish and English**
- **VOTs and voicing perception of Spanish and English differed [Abramson and Lisker (1973),** Williams (1977), Bond et al. (1980), Konefal and Fokes (1981)].

**.French and English** 

- French and English monolingual speakers have different VOTs; bilinguals use an "intermediate" voicing contrast [Caramazza et al. (1973)].
- Two voicing cues were observed, overall duration of voicing in French VCVs and length of English vowels. Only marginal differences between monolinguals and bilinguals [Watson] (1990)].
- . French-English bilinguals did not always produce monolingual-like VOTs [Hazan and **Boulakia (1993)].**

# 2. Type of Bilinguality

To measure degree of bilinguality, language biographies, self-evaluat judgements of bilingual productio monolingual speakers of Portugue **English (as proposed by Hamers p. 40)).** 

**Result: our subjects have develop** and compound bilinguality".

**Subjects in this study** 

- . Two adult bilingual siblings, with history of hearing or speech dis
  - PS a 22-year-old male; **RS an 18-year-old female.**

# **3.** Corpora Design Recording

The corpora of Portuguese fricativ and English fricatives /f, v,  $\theta$ ,  $\delta$ , s, of:

. Corpus 1a - sustained fricatives vowels;

. Corpus 1b - fricatives sustained a levels;

. Corpus 2 - nonsense words repea . Corpus 3 - real words produced i sentence;

. Corpus 4 - sentences including wo Corpus 3.

#### **Recordings:**

. Sound-treated booth (B & K 4165 microphone 1 m from the subject, measurement amplifier), Sony TC recorder (16 bits, sampling frequency 48kHz).

# A CASE STUDY OF PORTUGUESE AND ENGLISH BILINGUALITY

# Luis M. T. Jesus<sup>†</sup>, Christine H. Shadle<sup>‡</sup>

## 4. Analysis Method

, we used tion, and	The time waveforms of all the corpus words were manually segmented. This revealed many		. Di	<b>1r</b> 8
on by ese and of and Blanc (2000,	devolced examples, which we classified using acoustic and Lx signals [Jesus (2001)].	The grea	media ter tha	n du an th
	To generate averaged power spectra:	Port (198	ugues 0), Cry	e [Je ystal
ped a "balanced	. Corpus 1a, 1b: time-averaged one hundred 10 ms Hamming windows.	et al.	. (1997 ignific	')] m
h no reported sorders:	. Corpus 3: time-averaged nine 10 ms Hamming windows	between Portu		
	Four parameters of each spectrum were then	Devo exce	oicing pt for	anal /ð/ p
	calculated [Jesus and Shadle (2002)]:	For	both P	ortu
	. F - peak frequency of lowest major spectral peak, averaged within place across tokens;	examples were		
and	$A_{d}$ – dynamic amplitude. The difference between the maximum amplitude value of the averaged power spectrum occurring between 500Hz and	when the perc words, there w and English.		
ives /f, v, s, z, ∫, 3/ , z, ∫, 3/ consisted	20kHz, and the minimum amplitude between 0 and 2kHz;		180	
proceed by	. S' <sub>p</sub> - the slope of the line fit to all the spectral amplitude points from 500Hz to F;		160 - 140 -	
at different effort	. S <sub>p</sub> - the slope of the line fit to all points from F to <b>20kHz</b> .	(SM	120 -	;
ated 12 times; in a frame		ation (	100 -	
vords from		Dur:	80 -	
			60 -	
			<b>40</b> ∟	/1
5 1/2 inch , B & K 2636 CD-D7 DAT			Figure in Cor line; >	e 1: ] pus < - S

### 5. Results

### ation and Devoicing

uration of the unvoiced fricatives was always hat of the voiced fricatives, which agrees with esus (2001)] and English [Hogan and Rozsypal] and House (1988), Stevens et al. (1992), Pirello nonolingual results.

difference in duration by place of articulation, or uguese and English (see Figure 1).

lysis: more than 50% of the fricatives devoice, produced by PS.

uguese and English, most word-final fricative e totally devoiced.

centage of devoicing was plotted by position in was no significant difference between Portuguese



Median duration of fricatives /f, v,  $\theta$ ,  $\delta$ , s, z,  $\int$ , 3/**3. Portuguese - solid line; English - dashed Speaker PS; o - Speaker RS.** 

### 5.2. Parameterisation of Sp

In plots of  $A_d$  and  $S_p$  by fricative, /s, z,  $\int$ , 3/lower  $S_n$  than /f, v,  $\theta$ ,  $\delta$ / for Speaker RS.

The values of  $A_d$  and  $S_p$  for / $\theta$ ,  $\delta$ / produced l to fall in between the values for /f, v/ and /s.

Figure 2 shows Speaker RS results for A<sub>d</sub> v each language.



Figure 2: Corpus 3 (Speaker RS): o - /f/, 7  $\triangle - /\delta/, \# - /s/, \Diamond - /z/, \times - /s/ \text{ and } \Box - /z/.$ 





pectra	On $A_d$ vs. $S_p$ and $S'_p$ vs. $S_p$ plots, there are separate clusters of sibilants and /f, v, $\theta$ , $\delta$ / for Speaker RS.	
have higher A <sub>d</sub> and	However, Speaker PS produces 3 clusters: sibilants, /f, v/, and /θ, ð/.	
by Speaker PS seem 5, z, <b>∫</b> , 3/.	Results from both subjects seem, for the most part, to be consistent, and the same for Portuguese and English fricatives.	
<b>s. S<sub>p</sub> by fricative, for</b>	The A <sub>d</sub> ranges of the male French monolingual studied by Shadle and Mair (1996) and the two female Portuguese monolinguals studied by Jesus and Shadle (2002) are similar to Rs's.	
lese	The male bilingual speaker PS has a smaller range of $A_d$ for all fricatives than the female speaker RS, which is similar to the range of the two male Portuguese monolinguals studied by Jesus and Shadle (2002).	
	6. Conclusions	
	Devoicing occurs more often in word-final than word-initial position, both for Portuguese and English fricatives.	
glish	The percentage of totally devoiced Portuguese examples produced by the four monolingual subjects studied by Jesus (2001) was higher than for English examples produced by the two bilingual subjects, but Portuguese and English bilingual results were very similar.	
	A combination of parameters $A_d$ and $S_p$ and of parameters $S_p$ and $S'_p$ was useful for separating the fricatives by sibilance. Results for Portuguese and English fricatives seem to be very similar.	
	Acknowledgments	
0.5 1	This work was partially supported by Fundação para a Ciência e a Tecnologia, Portugal.	
$\frac{1}{\sqrt{v}} - \frac{1}{\sqrt{v}} - \frac{1}{\theta}$	ICSLP 2002 INTERSPIECE 2002 INTERSPIECE 2002 INTERSPIECE 2002 ICSLP 2002 ICSLP 2002	

# Bibliography

Abramson, A. S. and L. Lisker (1973). Voice-timing perception in Spanish word-initial stops. *Journal of Phonetics 1*, 1-8.

Bachman, L. F. and A. S. Palmer (1996). *Language Testing in Practice: Designing and Developing Useful Language Tests*. Oxford: Oxford University Press.

Bond, Z. S., J. E. Eddey, and J. J. Bermejo (1980). VOT del Español to English: Comparison of a language-disordered and normal child. *Journal of Phonetics 8*, 287-291.

Caramazza, A., G. H. Y. Komshian, E. B. Zurif, and E. Carbone (1973). The acquisition of a new phonological contrast: The case of stop consonants in French-English bilinguals. *Journal of the Acoustical Society of America 54* (2), 421-428.

Crystal, T. H. and A. S. House (1988). A note on the durations of fricatives in American English. *Journal of the Acoustical Society of America* 84(5), 1932-1935.

Hamers, J. F. and M. H. A. Blanc (2000). *Bilinguality and Bilingualism* (Second ed.). Cambridge: Cambridge University Press.

Hazan, V. L. and G. Boulakia (1993). Perception and production of a voicing contrast by French-English bilinguals. *Language and Speech 36* (1), 17-38.

Hogan, J. T. and A. J. Rozsypal (1980). Evaluation of vowel duration as a cue for the voicing distinction in the following word-final consonant. *Journal of the Acoustical Society of America* 67(5), 1764-1771.

Hughes, A. (1989). *Testing for Language Teachers*. Cambridge: Cambridge University Press.

Jesus, L. M. T. (2001). *Acoustic Phonetics of European Portuguese Fricative Consonants*. Ph. D Thesis, Department of Electronics and Computer Science, University of Southampton, Southampton, UK.

Jesus, L. M. T. and C. H. Shadle (2002). A parametric study of the spectral characteristics of European Portuguese fricatives. *Journal of Phonetics*. In press.

Konefal, J. A. and J. Fokes (1981) Voice onset time: The development of Spanish/English distinction in normal and language disordered children. *Journal of Phonetics 9*, 437-444.

Pirello, K., S. E. Blumstein, and K. Kurowski (1997). The characteristics of voicing in syllable-initial fricatives in American English. *Journal of the Acoustical Society of America 101*(6), 3754-3765.

Shadle, C. H. and S. J. Mair (1996). Quantifying spectral characteristics of fricatives. In *Proceedings of the International Conference on Spoken Language Processing (ICSLP 96)*, Philadelphia, USA, pp. 1517-1520.

Stevens, K. N., S. E. Blumstein, L. B. Glicksman, M. Burton, and K. Kurowski (1992). Acoustic and perceptual characteristics of voicing in fricatives and fricative clusters. *Journal of the Acoustical Society of America 91*(5), 2979-3000.

Sundara, M. and L. Polka (2001). Bilingual speech production: The case of simultaneous acquisition. *Journal of the Acoustical Society of America 110*(5), 2685.

Watson, I. (1990). Acquiring the voicing contrast in French: A comparative study of monolingual and bilingual children. In J. N. Green and W. A. Bennett (Eds.), *Variation and Change in French: Essays Presented to Rebecca Posner on Occasion of her Sixtieth Birthday*, pp. 37-60. London: Routledge.

Watson, I. (1991). Phonological processing in two languages. In E. Bialystok (Ed.), *Language Processing in Bilingual Children*, Chapter 2, pp. 25-48. Cambridge: Cambridge University Press.

Williams, L. (1977). The perception of stop consonant voicing by Spanish-English bilinguals. *Perception and Psychophysics 21*(4), 289-297.