VALENCIAN FRICATIVE CONTRASTS: ARTICULATION AND PERCEPTION

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SUBJECT: Characterization of the fricative consonants /z/, /s/ and /ʃ/ in Valencian Catalan, as displayed in the hyperarticulate speech of the materials Fonet. Practiques de fonètica (Gonzalvez et al. 2007).

GOALS: (a) To study some acoustic properties of the sibilants /z/, /s/ and /ʃ/: length, harmonicity (HNR) and three spectral moments: center of gravity (COG), peak and skewness, and to determine if these parameters serve to distinguish consistently the pair /z/-/s/ and the pair /ʃ/-/s/.

(b) To explore the extent to which speakers with advanced skills in Catalan are able to perceive the contrast /z/-/s/ and the contrast /ʃ/-/s/.

(c) To obtain reference values for each consonant in an accurate style in order to compare them, in further research, with values observed in normal speech.

1. MATERIALS (Gonzàlvez et al. 2007)

➤Type II test sequences: Paired pronunciations of fricatives, produced by a unique subject: one in an actual word, containing either [z] or [ʃ], & the other in a parallel pseudoword, with the voiceless alveolar [s] replacing (in the same segmental context) the original [z] or [ʃ] sounds (usually, [ʃ] takes a transitional on-glide [j] after a vowel in Valencian, but not in the Alacant variety under study here):

Actual word

Parallel pseudoword

3. PERCEPTION OF THE CONTRASTS

3.1. PERCEPTION TESTS

Two different ABX tasks were carried out, using Perceval (André et al. 2003).
Stimuli selection: 4 tokens of each sibilant were randomly selected from the nuclear core which better represents each segment in the materials (Gonzàlvez et al. 2007): stimuli whose peak & center of gravity values were at most 1 standard deviation above or below the mean.
The intensity of the stimuli was already normalized in the source material.
Duration of the stimuli: 80 ms or 60 ms ([z] vs. [s]); 100 ms or 75 ms ([[] vs. [s]).
Experiment design: Within each length, two tokens of each sibilant were randomly paired (AB); alternate X-stimuli had the same length:

[kóza]	cosa	'thing'	[kósa]
[matéʃ]	mateix	'same'	[matés]

2. ACOUSTIC CHARACTERIZATION OF THE CONTRASTS

2.1. PROCEDURE AND ANALYSIS

Tokens analyzed:

✓ 34 pseudo-minimal pairs of [z] vs. [s], always in onset position: e.g., [kɔ́za]-[kɔ́sa]

✓ 16 pseudo-minimal pairs of [[] vs. [s], mostly in word-final codas: e.g., [maté[]-[matés]
 > The acoustic analysis was carried out with PRAAT (Boersma 2001). Segmentation and labeling of the target sibilants were done manually, based on spectrogram and waveform.
 > Acoustic measurement of the following parameters: harmonicity (HNR), duration and three spectral moments: center of gravity (COG), peak & skewness. Except for duration & harmonicity, all measures were taken using a 20ms window placed in the middle of the frication noise.
 > Since we are interested in place of articulation correlates, when comparing the spectral moments, we filtered the signal to exclude the regions below 1000Hz and above 11000Hz.
 > Main statistical test: Paired samples t-tests, using SPSS. Variables:

IV: segment DV: HNR; duration; COG, peak & skewness

2.2. CONTRAST [Z] VS [S]

PREDICTIONS: In accordance with the literature, we expect the voiced sibilant [z] to be shorter and to have higher HNR. We do not expect, though, significant differences in the spectral moments.

► **Duration & HNR**: Tests yield a significant effect of the variable 'segment' on duration $[t_{(40)}=-21.402, p<.001, \eta^2=.92]$ and HNR $[t_{(40)}=10.469, p<.001, \eta^2=.73]$, in both cases in the expected direction:

Duration: M_[z] 88.71 ms (SD 14.19 ms)



- ✓ Task 1: 4 paired [z]-[s] stimuli x 2 X-stimuli
- ✓ Task 2: 4 paired [ʃ]-[s] stimuli x 2 X-stimuli

 Subjects: 20 UV undergraduate students, with advanced skills in Catalan; submitted to both tests
 960 responses for test = 4 AB-stimuli x 2 alternate X-stimuli x 2 lengths x 3 trials x 20 subjects
 Main statistical test: Three-way repeated measures ANOVA test, using SPSS. Variables: Factors: task, trial & duration
 DV: hit rate response

3.2. RESULTS

PREDICTIONS: Given the narrow difference in the spectral moments referred to the contrast [[]-[s], and the considerable inter-speaker overlap between these segments, the perception of this contrast should be poorer in comparison with the perception of the contrast [z]-[s].

► **Task**: ANOVA yields a main effect of 'task' $[F_{(1,19)}=37.493, p<.001, \eta_p^2=.664]$, in the expected direction: a greater hit rate in the [z]-[s] test (response variance among speakers is also clearly higher in the [ʃ]-[s] test; the sample means are displayed in the figure on the right): • HR_{[ʃ]-[s]}: M. 68.65% (SD 16.84%) • HR_{[z]-[s]}: M. 90.73% (SD 7.14%)

✓ In the same line, listeners' **response time** for the []-[s] test is statistically slower than for the [z]-[s] test [$t_{(959)}$ =7.461, p<.001, η^2 =.05]:

• RT_{[J]-[s]}: M. 1226.81 ms (SD 697.08 ms)





Spectral moments: The tests show that there are no significant differences in COG $[t_{(40)} = -.932, p = .357, \eta^2 = .02]$ and peak $[t_{(40)} = .497, p = .622, \eta^2 = .01]$. [Notice, though, that, if the signal is not filtered, the spectral moments display remarkable differences.]

✓ There is, instead, a significant effect of the variable 'segment' on skewness [$M_{[z]}$ 1.11 (SD .78), $M_{[s]}$ 1.62 (SD .87); $t_{(40)}$ = -4.279, p<.001, η^2 =.31], indicating that the voiceless segment tends to have a slightly stronger concentration of energy in the lower frequencies (cf. Jongman et al. 2000: 1257).

2.3. CONTRAST [ʃ] VS [S]

PREDICTIONS: There may be a contrast in duration & HNR between both segments, but now major differences in the spectral moments are expected as well: in particular, we expect [] to have lower COG & peak values and higher skewness than [s].

> Duration & HNR: Tests yield a significant effect of the variable 'segment' on duration, with minimal differences $[t_{(15)}=-2.938, p=.010, n^2=.37]$, and HNR $[t_{(15)}=-5.443, p<.001, n^2=.66]$: • Duration: M_[] 271.44 ms (SD 98.95 ms) M_[s] 309.69 ms (SD 119.82 ms) • HNR: M_[] .20 dB (SD 1.62 dB) M_[s] 2.06 dB (SD 1.05 dB)





• RT_{[z]-[s]}: M. 1019.13 ms (SD 573.03 ms)

✓These results confirm the hypothesis that speakers should have more difficulty in perceiving the contrast []-[s].

50-[ʃ] vs. [s] test [z] vs. [s] test

Trial: The performance of the subjects tends to improve in each trial, but the differences are not statistically significant: $F_{(2,38)}=1.173$, p=.320, $\eta_p^2=.058$.

>Duration: A small effect of 'duration' [$F_{(1,19)}$ =5.021, p=.037, η_p^2 =.209] indicates that longer stimuli produce slightly higher hit rates: HR_{short}: M. 77.81%, SD 21.10%, vs. HR_{long}: M. 81.56%, SD 18.40%.

>Interaction: All interactions turn out to be non significant: 'test x trial' $[F_{(2,38)}=.443, p=.645, \eta_p^2=.023]$; 'test x duration' $[F_{(1,19)}=1.192, p=.289, \eta_p^2=.059]$; 'trial x duration' $[F_{(2,38)}=.081, p=.923, \eta_p^2=.004]$, & 'test x trial x duration' $[F_{(2,38)}=2.652, p=.084, \eta_p^2=.122]$

4. CONCLUDING REMARKS

- Acoustic analysis: The acoustic measures support the presence of a double contrast /z/-/s/ and /ʃ/-/s/ in Valencian Catalan, although with a narrow margin in the last pair.
- Open issue: To investigate to which extent the contrasts are maintained in normal speech throughout the Valencian variety & to analyze if the attested patterns tend to enlarge or to reduce the distance between each pair of fricative sibilants.
- Perception: The perception of the contrast [[]-[s] is clearly poorer than the perception of the contrast [z]-[s], which could explain a certain tendency towards the neutralization of the first pair.

Open issues:

- To investigate whether the inclusion of additional acoustic cues in the perception test, such as formant transitions, improves fricative perception.
- To determine if there is a correlation between the speakers' hit rate response in the []-[s] test and the maintenance of the contrast between both segments.

p<.001, η^2 =.69] and peak [t₍₁₅₎ = -4.153, p=.001, η^2 =.53] distinguish consistently (although with a close margin) the two fricative targets, but the spectral skewness does not [t₍₁₅₎ = - 2.022, p=.061, η^2 =.21].

✓On the whole, the subject displays minimal

overlap for the spectral mean analyses (see figure on the right), but **lower distance** between [J] and [s] values than in other Catalan dialects (e.g., Eastern Catalan, Recasens 1986; Majorcan, Recasens & Espinosa 2006, 2007) or in other languages (Nartey 1982, Jongman et al. 2000), due probably to the especially fronted realization of [J] in Valencian (cf. Recasens & Espinosa 2006, 2007). Furthermore, if we compare this speaker's values with those of a second subject (Type I test, Gonzàlvez et al. 2007), there is considerable **inter-speaker overlap**. Both facts suggest that listeners might have some difficulties in discriminating both segments.

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