

# 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. Pràctiques de fonètica* (Gonzàlvez 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
[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., [kóza]-[kósa]
- ✓ 16 pseudo-minimal pairs of [ʃ] vs. [s], mostly in word-final codas: e.g., [matéʃ]-[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

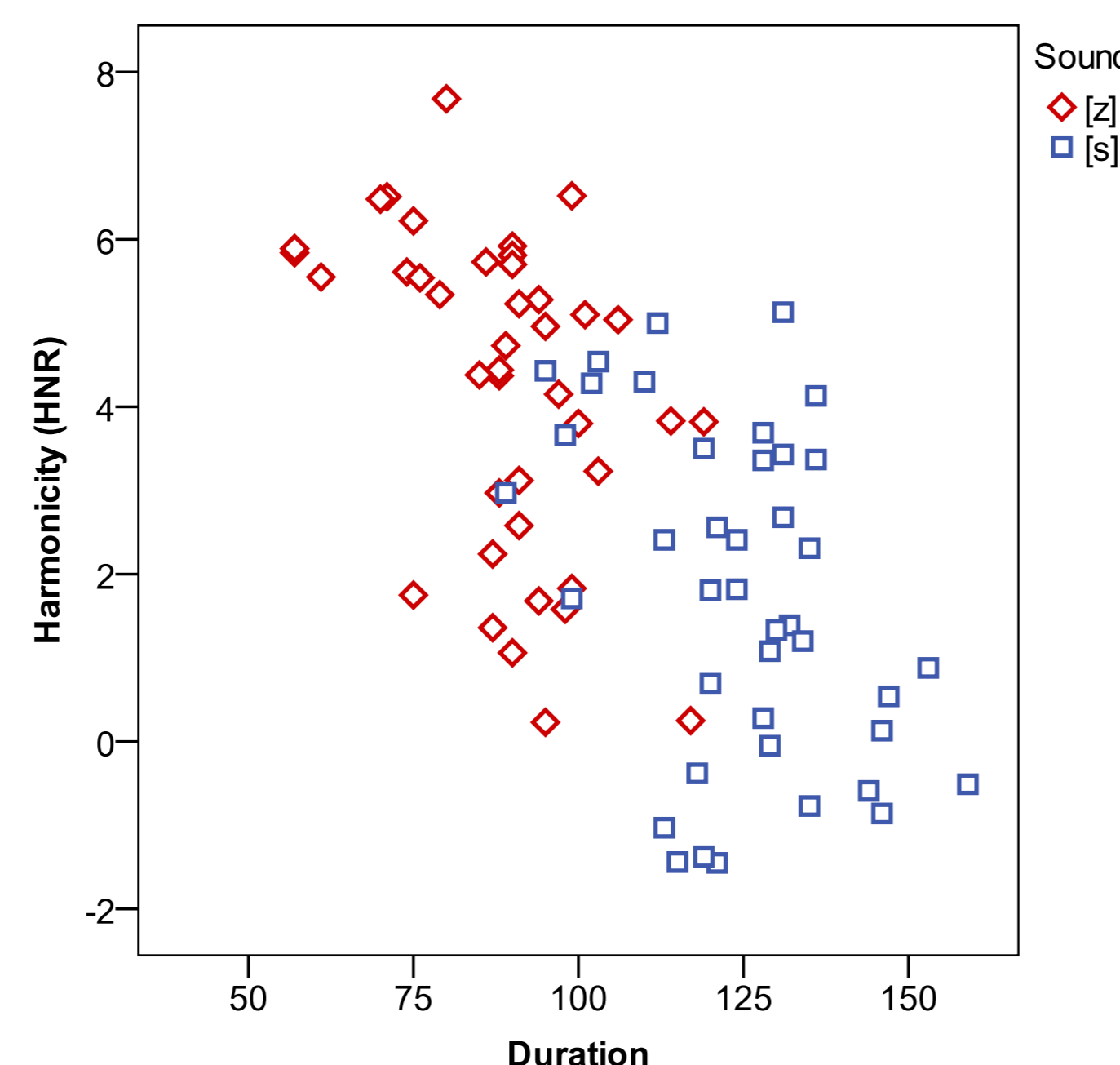
### 2.2. CONTRAST [Z] VS [S]

> **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)  
 $M_{[s]}$  124.46 ms (SD 15.83 ms)
- HNR:  $M_{[z]}$  4.23 dB (SD 1.90 dB)  
 $M_{[s]}$  1.77 dB (SD 1.98 dB)

> **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);  $t_{(40)}=-4.279, p<.001, \eta^2=.31$ ], indicating that the voiceless segment tends to have a slightly stronger concentration of energy in the lower frequencies (cf. Jongman et al. 2000: 1257).

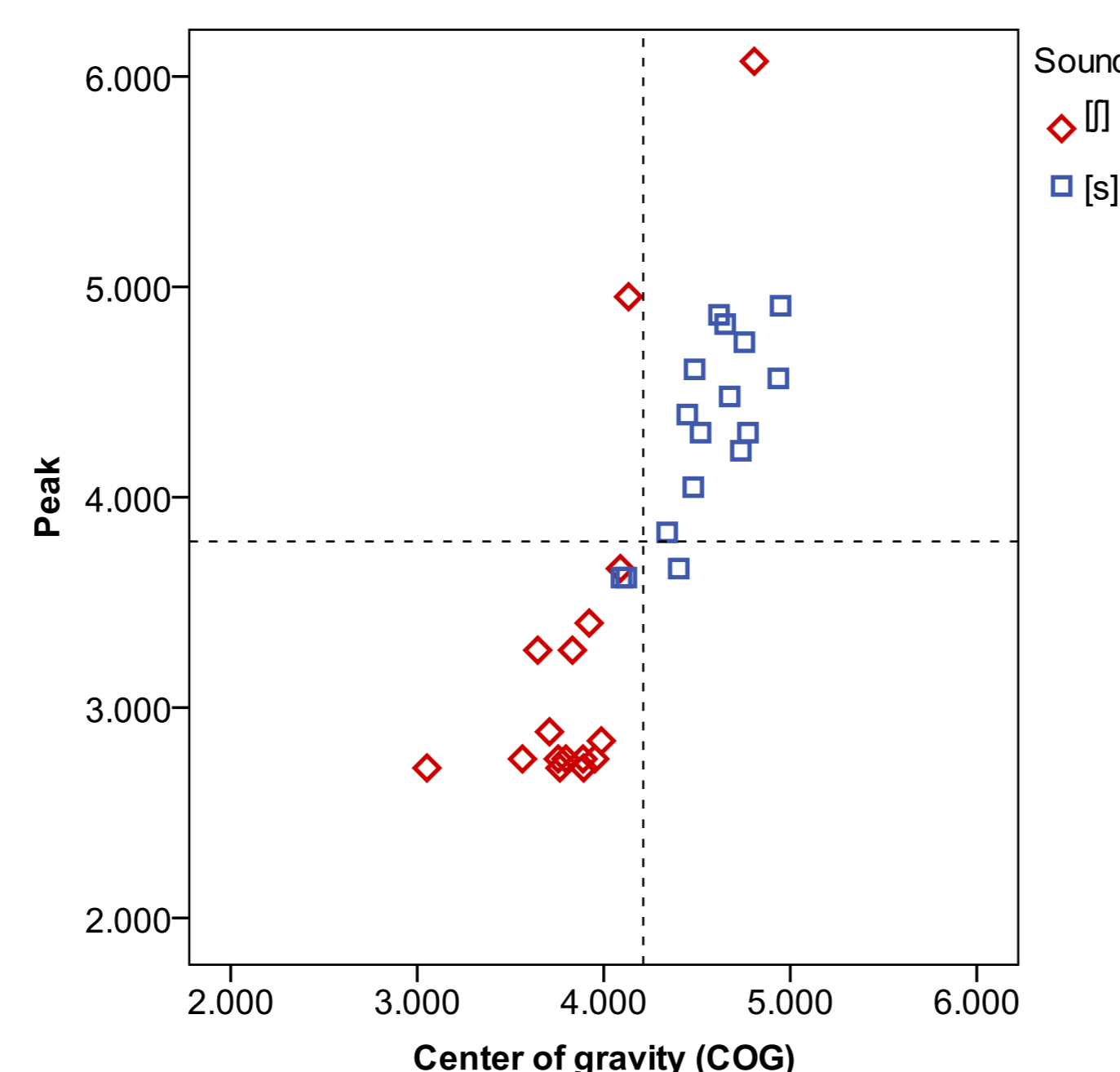
### 2.3. CONTRAST [ʃ] VS [S]

> **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 [ʃ] 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 [ $t_{(15)}=-2.938, p=.010, \eta^2=.37$ ], and HNR [ $t_{(15)}=-5.443, p<.001, \eta^2=.66$ ]:

- Duration:  $M_{[ʃ]}$  271.44 ms (SD 98.95 ms)  
 $M_{[s]}$  309.69 ms (SD 119.82 ms)
- HNR:  $M_{[ʃ]}$  .20 dB (SD 1.62 dB)  
 $M_{[s]}$  2.06 dB (SD 1.05 dB)

> **Spectral moments:** COG [ $t_{(15)}=-5.726, p<.001, \eta^2=.69$ ] and peak [ $t_{(15)}=-4.153, p=.001, \eta^2=.53$ ] distinguish consistently (although with a close margin) the two fricative targets, but the spectral skewness does not [ $t_{(15)}=-2.022, p=.061, \eta^2=.21$ ].



✓ On the whole, the subject displays **minimal overlap** for the spectral mean analyses (see figure on the right), but **lower distance** between [ʃ] 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 [ʃ] 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.

## 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 ([ʃ] vs. [s]).

> Experiment **design:** Within each length, two tokens of each sibilant were **randomly paired** (AB); alternate X-stimuli had the same length:

- ✓ 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 [ʃ]-[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<sub>[ʃ]-[s]</sub>: M. 68.65% (SD 16.84%)
- HR<sub>[z]-[s]</sub>: M. 90.73% (SD 7.14%)

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

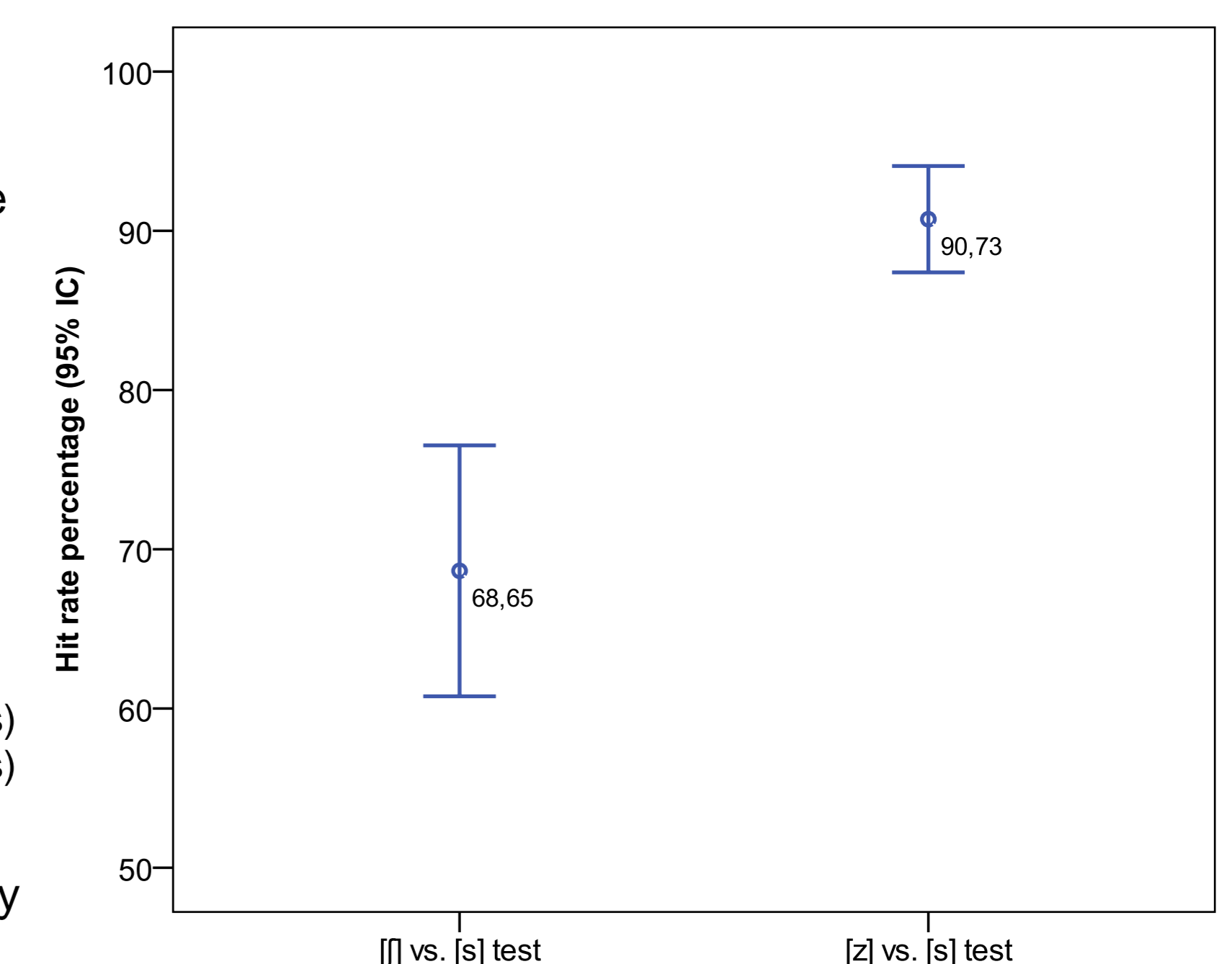
- RT<sub>[ʃ]-[s]</sub>: M. 1226.81 ms (SD 697.08 ms)
- RT<sub>[z]-[s]</sub>: M. 1019.13 ms (SD 573.03 ms)

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

> **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' [ $F_{(1,19)}=5.021, p=.037, \eta_p^2=.209$ ] indicates that longer stimuli produce slightly higher hit rates: HR<sub>short</sub>: M. 77.81%, SD 21.10%, vs. HR<sub>long</sub>: 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 [ʃ]-[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 [ʃ]-[s] test and the maintenance of the contrast between both segments.

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