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THE ROLE OF CONSONANTAL DURATION AND TENSENESS IN THE PERCEPTION OF VOICING DISTINCTIONS OF PORTUGUESE STOPS

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ABSTRACT

Though often described as the main correlate of the distinction voiced *vs* voiceless stops of Portuguese, glottal vibrations (thus, [voiced] feature) seem to be less important than consonantal duration. This study provides data that suggest that the differences of consonantal duration between Portuguese voiced and voiceless stops are highly significant and that the manipulation of this variable significantly changes voicing processing among Portuguese native listeners.

GENERAL PRESENTATION

This paper aims to present and to discuss some results of research into the role of consonantal duration (CDR) and [tense] feature in the voicing oppositions of Portuguese stops.

Six oral stops exist in European Portuguese (henceforth: Portuguese): the voiced /b d g/ and the voiceless /p t k/.

Following Chomsky and Halle [1], the acoustic and phonetic correlate of the voiced/voiceless opposition is the presence/absence of glottal vibration.

Portuguese, however, presents allophonic realizations of /b d g/ without glottal vibration: [b̥ d̥ g̥]. These allophones are processed by native listeners of Portuguese as voiced [2].

There are some studies that show that [b̥ d̥ g̥] are found also in Spanish and that there, too, these allophones are processed as voiced consonants [3, 4].

To a certain point, CDR may explain these perceptual data. Several studies of Portuguese [5, 6, 2] and Spanish [7] have shown that mean CDR is higher in voiceless consonants than in voiced ones.

Since CDR is one of the main acoustic correlates of tenseness [1], some authors [2, 4, 8] have suggested that in Portuguese and Spanish, at the level of distinctive features, the [+tense]/[-tense] opposition may be the fundamental opposition in the separation between voiceless and voiced stops. Thus, in their proposals, the presence/absence of glottal vibrations (i. e., the opposition [+voiced]/[-voiced]) is a redundant, secondary opposition in the organization of the consonantal systems of these languages (these assumptions are clearer among the studies related to Spanish).

It is our aim, in this paper, to go deeper into the importance of these questions in Portuguese.

EXPERIMENTAL PROCEDURE

Corpus

The material for acoustic analysis and the stimuli of the perception tests were extracted from a corpus of spoken Portuguese. This corpus was recorded in an anechoic chamber and was produced by five male adult native speakers of Portuguese, whose dialects were very similar to the "pattern-dialect" of Portuguese; they read one set of sentences with different syntactic structures three times at least.

In all the sentences, sequences with the phonetic structure [aCá] (C=[p t k b d g]) could be isolated and submitted to acoustic analysis.

Acoustic Analysis

In the acoustic study, the CDR of the intervocalic consonant of the above mentioned [aCá] sequences was measured. This measurement corroborated the results of previous studies [5, 6, 2]: Portuguese voiceless stops show mean CDR values that are higher than mean CDR values of voiced ones (voiceless mean CDR > 120 ms; voiced mean CDR < 100 ms - see Table 1). In this study, these differences were evaluated by an Analysis of Variance which showed that they are highly significant (p=0.000).

Table 1. CDR (minimum, maximum and mean values and standard deviations) of each Portuguese stop. Unit: ms

	[p]	[t]	[k]	[b]	[d]	[g]
min	116	105	110	54	43	46
max	147	153	131	108	99	105
mea	132	133	123	80	70	75
SD	13	23	10	17	15	14

Perception Tests

Rationale

Acoustic data from previous studies [5, 6, 2] and our own acoustic study lead us to formulate the following hypothesis: if CDR is an important acoustic cue for the distinction between voiced and voiceless stops, then the manipulation of this variable will interfere in the processing of that distinction.

More precisely, if it is possible to build stimuli from natural Portuguese speech with the phonetic structure [aCá] (C=stop), in which C has the invariant duration of 100 ms, the identification of voicing will be more affected with voiceless stops than with voiced ones. Although mean CDR of voiced stops is below 100 ms, several realizations of [b d g] with CDR values very close to 100 ms were found. In the case of voiceless stops, one single realization (=[t]) was found in this study with a CDR value near 100 ms (=105 ms).

Stimuli

The stimuli of our perception tests consisted of 6 of the [aCá] (C=[p t k b d g]) sequences studied in our acoustic analysis, which form non-words in Portuguese.

All the stimuli were produced by the same speaker. In all of them, C was replaced by a portion of white noise (WN). The spectra of the adjacent vowels and the VC-CV transitions were entirely preserved in this manipulation.

The WN portions did not have the same duration in all the stimuli, which were divided into two sets (A and B):

- *set A:* C was replaced by a portion of WN with the same duration as the replaced consonant;
- *set B:* C was replaced by a portion of WN with the invariant duration of 100 ms.

Subjects

The subjects of the perception tests were 9 non-paid naïve (phonetically untrained) subjects. None of them reported suffering or having suffered from auditory disease. They were divided into two groups:

- *Group I:* 6 native listeners of Portuguese;
- *Group II:* 3 native listeners of German (n=2) and Italian (n=1).

Method

Subjects listened to the stimuli through binaural stereophonic headphones in individual sessions of testing which were divided into two distinct parts. These sessions took place in a quiet room.

Firstly, subjects listened to the stimuli of *set A* (WN=CDR); afterwards, they listened to the stimuli of *set B* (WN=100 ms).

Each stimulus was presented 3 times (6 consonants X 3 presentations = 18 stimuli per session), in a random order. Stimuli were presented spaced by a pause of 3 s.

Subjects were asked to transcribe the intervocalic consonant orthographically on special forms. They were all told that a noise could be heard and that this would not affect the identification of consonants; they were encouraged not to leave blank spaces, i. e., they were told that they should identify all the stimuli.

At the end of each session, the orthographic transcriptions were immediately converted into phonetic transcriptions by the experimenter, who asked the subjects for explanations whenever he had any doubts about their transcriptions.

RESULTS

Table 2 displays the results of the perceptual tests. The analysis of answers considered only voicing (i. e., if a subject identified the place or the manner of articulation of a consonant wrongly, but voicing was correctly identified, his/her answer was taken as correct).

Table 2. Percentage of correct identifications of voicing with voiceless and voiced stops by both groups of subjects and in both sets of stimuli

	Voice-less		Voic-ed	
	Native	Non Native	Native	Non Native
WN= CDR	62.9 %	70.4 %	94.4 %	100 %
WN= 100 ms	22.7 %	18.5 %	83.5 %	92.6 %

The differences of voicing processing between the two sets of stimuli are significant ($p<0.05$) only in the native listeners' group with voiceless stops. On the other hand, the manipulation of CDR did not significantly ($p\geq0.05$) alter the voicing processing in either the non-native listeners' group with voiceless and voiced stops, or the native listeners' with voiced stops (the values of p here stated were obtained from the *t* statistics).

GENERAL DISCUSSION AND CONCLUSIONS

The differences that we found and their significancy levels lead us to accept our initial hypothesis: CDR is an important acoustic cue for the processing of the distinction between voiced/voiceless stops, at least for native listeners of Portuguese.

If we consider only the native listeners' group, the differences of voicing processing were significant only with voiceless stops because of the manipulated values of CDR. In the set B of stimuli, the value of WN (=100 ms) is clearly below the minimum and mean values found in the set of voiceless stops. In voiced stops, this invariant CDR of 100 ms is higher than their mean CDR, although several realizations of /b d g/ with CDR values not very far from 100 ms were found.

Our results support the proposals of previous studies of Portuguese [2] and also of Spanish [3, 4, 8] which claim that in these languages [tense] feature is a very steady correlate of the opposition voiced/voiceless among stops: the present study shows that, in Portuguese, voiced and voiceless stops have significantly different mean CDR values - which are among the main acoustic correlates of tenseness - and that these acoustic differences are perceptually important.

This importance of CDR for the voicing processing seems to be more important in some languages than in others, as is shown by the different results of perceptual tests with listeners from different languages.

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REFERENCES

[1] Chomsky, N., & Halle, M. (1968), *The Sound Pattern of English*, New York: Harper & Row.

[2] Viana, M. do C. (1984), *Etude de Deux Aspects du Consonantisme du Portugais: Fricatisation et Dévoisement.* Ph. D. diss., Université des Sciences Humaines de Strasbourg.

[3] Alarcos Llorach, E. (1950), *Fonología Española,* Madrid, Gredos.

[4] Veiga, A. (1985), "Consideraciones relativas a la actuación y límites de las oposiciones fonológicas interrupto/continuo y tenso/flojo en español", *Verba - Anuario Galego de Filoloxía,* vol. 12, pp. 253-285.

[5] Delgado Martins, M. R. (1975), "Vogais e Consoantes do Português: Estatística de Ocorrência, Duração e Intensidade", *Boletim de Filologia,* tomo XXIV (Fascs. 1-4), pp. 1-11.

[6] Viana, M. do C. (1979), "O índice duração e a análise acústica das oclusivas orais em português", *Boletim de Filologia,* tomo XXV, pp. 1-20.

[7] Martínez Celdrán, E. (1984a), "Cantidad e intensidad en los sonidos obstruyentes del castellano: hacia una caracterización acústica de los sonidos aproximantes", *Estudios de Fonética Experimental,* vol. I, pp. 73-129.

[8] Martínez Celdrán, E. (1984b), "¿Hasta qué punto es importante la sonoridad en la discriminación auditiva de las obstruyentes mates del castellano?", *Estudios de Fonética Experimental,* vol. I, pp. 245-291.