Context Effects in the Auditory Identification of Spanish Fricatives /f/ and /θ/: Hyper and Hypospeech.

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Abstract: The present study deals with the effect of vocalic contexts on the recognition of Spanish fricatives /f/ and /θ/. Two forms of speech (Hypo and Hyperspeech) were considered. The statistical analysis showed that isolated fricative segments were equally recognized in Hypo and Hyperspeech. Including the vowel significantly improved recognition of both fricatives for both forms of speech, except for the combination /f/+/e/. For this particular combination, an acceptable recognition rate is only achieved in the whole word condition for both forms of speech. Our results show that: a) Clear speech is not necessarily more intelligible than hypospeech; and b) The role of vocalic context in the recognition of /f/ and /θ/ is similar for both forms of speech.

INTRODUCTION

It has been shown that the vocalic context affects the perceptual identification of the fricatives /θ/ and /f/, although fricative noise is also an important cue (1). In this study context effects for both /f/ and /θ/ were examined for two types of speech: Hypo and Hyperspeech. In Hyperspeech both the fricative noises and vocalic transitions are carefully articulated, while in Hypospeech we expect less complete vocalic transitions and poorly defined fricative noises. It is considered that Hyperspeech is more intelligible than Hypospeech (2), "formant undershoot" being a typical phenomenon of hypospeech.

PERCEPTUAL AND ACOUSTIC ANALYSIS

The subjects were 26 University students with normal hearing who had volunteered for the experiments plus 2 of the authors. Four conditions were considered: 1) Fricative noise; 2) Fricative noise plus 51.2 ms of the following vowel; 3) Fricative noise plus the whole vowel; 4) Whole word. The tokens used in the study were Spanish words whose initial syllable was formed by the combination of /θ/ or /f/ with one of the two vowels /e/, /u/. For each FV combination 10 words were used. Two of the authors served as speakers: one allows for the Hypospeech form and the other allows for the Hyperspeech form. Percent of correct responses for each FV combination in each of the four conditions, for both Hypo and Hyperspeech, can be seen in Table 1. Statistical analysis showed that fricative noise is equally recognized for Hypo and Hyperspeech. Including the vowel improves recognition for every FV combination: /θ/+/e/ (Hypo: $F(1,18) = 43.58, p < 0.00005$; Hyper: $F(1,18) = 40.33, p < 0.00005$), /$\theta$/+/u/ (Hypo: $F(1,18) = 41.69, p < 0.00005$; Hyper: $F(1,18) = 156.75, p < 0.00005$), /f/+/u/ (Hypo: $F(1,18) = 19.44, p < 0.0003$; Hyper: $F(1,18) = 29.30, p < 0.00005$). For /f/+/e/ including the vowel degrades the recognition of the fricative for Hyperspeech, while there is a slight improvement for Hyperspeech ($F(1,18) = 4.49, p < 0.048$). This particular combination shows significant differences for Hypo and Hyperspeech in conditions 2 ($F(1,18) = 7.77, p < 0.01$) and 3 ($F(1,18) = 6.47, p < 0.02$). There are no significant differences between conditions 2 and 3; between conditions 3 and 4 significant differences showed up only for /f/+/e/ (Hypo: $F(1,18) = 23.95, p < 0.0001$; Hyper: $F(1,18) = 8.30, p < 0.01$). For this combination satisfactory recognition rate of the fricative is only achieved in the whole word condition.

As a first step in the acoustic analysis, differences in energy and duration between the two forms of speech were statistically analyzed, being significant for isolated fricative noise, vowel and whole word, indicating acoustic differences between both forms of speech: fricative noises in the Hypo form are shorter and have less energy than in Hyperspeech. Differences in the vocalic transitions between Hypo and Hyperspeech are also expected. Vocalic transition was characterized as the difference in the frequency location of the first three formants between the first and fifth vocalic pulses after the fricative noise. For each type of speech and combination, signals can be divided into two groups: 1) Those for which the fricative identification

TABLE 1. Percent of correct responses for each FV combination in each one of the four conditions: 1) Fricative noise, 2) Fricative noise plus 51.2 ms of the following vowel, 3) Fricative noise plus the whole vowel, 4) Whole word. Top: Hypospeech, bottom: Hyperspeech.

	Cond. 1		**Cond. 2**		**Cond. 3**		**Cond. 4**	
	/e/	/u/	/e/	/u/	/e/	/u/	/e/	/u/
/θ/	70.0	56.1	98.2	95.0	99.3	92.1	99.6	100.0
/f/	64.6	87.9	47.1	98.9	50.4	98.6	92.1	99.6
/θ/	72.5	61.1	98.9	98.6	98.9	96.4	99.3	100.0
/f/	60.7	83.2	73.9	99.6	74.3	100.0	93.2	100.0

improves in condition 2 with respect to condition 1; and 2) Those for which there is no improvement. Tokens were selected as belonging to any of the groups by means of a statistical procedure. For the combination /f/+/e/ in Hypospeech all the tokens belonged to the second group. Analysis of variance with group as the independent factor for each type of speech and FV combination separately, showed a significant effect of the second formant transition for /f/+/e/ in Hyperspeech ($F(1,8) = 13.93, p < 0.006$). In both types of speech /θ/+/e/, /θ/+/u/, and /f/+/u/ have similar transitions for both groups. Since in the Hypo form the vocalic transition of /θ/+/e/ is similar for groups 1 and 2, the transitions of /θ/+/e/ and /f/+/e/ in that form of speech were compared. The analysis of variance showed a significant effect of the third formant transition ($F(1,18) = 5.44, p < 0.003$). In the Hyper form /$\theta$/+/e/ has similar transitions for signals of both groups, while /f/+/e/ has distinct transitions for both groups. All the signals of /θ/+/e/ were compared with both groups of signals of /f/+/e/. An analysis of variance with fricative as the independent factor showed that signals belonging to group 1 of /f/+/e/ and the /θ/+/e/ tokens have significant differences in the transitions of the first ($F(1,12) = 5.54, p < 0.04$), second ($F(1,12) = 13.95, p < 0.003$), and third formants ($F(1,11) = 33.51, p < 0.0001$). A similar analysis showed that the tokens belonging to group 2 of /f/+/e/ and the tokens of /θ/+/e/ have significant differences in the transition of the third formant ($F(1,13) = 19.77, p < 0.0007$). Since in both types of speech /θ/+/u/ and /f/+/u/ have similar transitions for both groups, for each form of speech all signals of /θ/+/u/ and /f/+/u/ were compared. In the Hypo form, the analysis of variance does not show significant effects. In the Hyper form significant effects for the first ($F(1,12) = 5.43, p < 0.04$) and second ($F(1,17) = 16.09, p < 0.0009$) formants showed up.

DISCUSSION

Perceptual identification of the fricatives /θ/ and /f/ is not affected by the form of speech (Hypo and Hyperspeech), except for the combination /f/+/e/, for which there are slight differences between the two forms of speech. Fricative noises are perceptually similar, and fricative identification improves including the vowel. However, no differences in the vocalic transitions of a particular fricative+vowel combination could be found between signals for which there is an improvement and signals for which there is no improvement. So this improvement could be a consequence of other effects, such as integration of adjacent acoustic segments. An excepcion to this behavior is the /f/+/e/ combination. For this particular combination, vocalic transition could be as important as the phenomenon of integration.

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