

# PERCEPTION OF THE HIGH VOWEL CONTINUUM: A CROSSLANGUAGE STUDY

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## ABSTRACT

An imitation task in which speakers of English and of Brazilian Portuguese repeated a randomized list of monosyllables recorded by a native speaker of Standard French confirmed observations that French /y/ is usually pronounced as an /u/-like vowel by English speakers, and as an /i/-like vowel by Portuguese speakers. The results of a perceptual test in which the same speakers were asked to identify a set of synthetic stimuli constituting a high vowel continuum (from /i/ to /u/) revealed that the accented pronunciations of French /y/ by English and Portuguese speakers are accounted for by the fact that these speakers perceive and divide the high vowel continuum in different ways.

## 1. INTRODUCTION

A phenomenon familiar to second-language (L2) instructors is the inability of some learners to produce sounds of the target language not present in their native--or first (L1)--language inventory. For example, evidence from speech production reveals that, in attempting to speak a second-language whose inventory contains the 3 high vowels /i/, /y/, and /u/, native speakers of languages whose inventory contains only the 2 high vowels /i/ and /u/ find it difficult at first to pronounce the target vowel /y/. When anything at all is done in the L2 classroom to correct this situation, the problem is usually addressed by means of articulatory instruction, and the students are advised to produce a high vowel which is at the same time front and rounded. The fact

that, in spite of such straightforward instruction, beginners often go on mispronouncing the target vowel /y/, show a low rate of success in imitation tasks, and fail to detect any difference between their faulty pronunciations and the target sound, suggests that a faulty production of the target sound may be attributable--at least in part--to its faulty perception. This interpretation is not new, and it is inferred from production evidence in general, and imitation experiments in particular, that a sound occurring in L2 but not in L1 is judged to belong to an L1 category, a process labelled "interlingual identification" [3]. The purpose of this paper is to demonstrate that accented pronunciations of the French vowel /y/ by speakers whose native languages contain only the 2 high vowels /i/ and /u/ reflect the way such speakers perceive and divide the high vowel continuum.

## 2. PROCEDURE

This hypothesis was tested by means of an experiment consisting of an imitation task (to establish in a systematic way how each subject pronounced the target vowel /y/), and of a perceptual task (to establish how subjects divided the high vowel continuum in terms of the categories of their respective native languages). In addition to native speakers of Standard French, 2 groups of 10 speakers each (ranging in age from 25 to 32) took part in the experiment: speakers of Canadian English, who have been observed to replace French /y/ with an /u/-like vowel [9]; and speakers of Brazilian Portuguese, who have been

observed to replace French /y/ with an /i/-like vowel.

In the imitation task, each subject was asked to repeat a randomized list of monosyllables recorded by a male native speaker of Standard French, and containing the vowels /i/, /y/, /u/, and /a/ in different consonantal contexts. In the perceptual task, English and Portuguese subjects were asked to identify as /i/ or /u/ 3 sets of randomized synthetic stimuli constituting a high vowel continuum (from /i/ to /u/), with one set consisting of isolated vowels and the other 2 of vowels in the environments /b/\_\_\_ and /d/\_\_\_ respectively. (Only the results for the isolated vowel stimuli will be reported here.) The French subjects which took part in the experiment were asked to identify each of the synthetic stimuli as one of the three vowels /i/, /y/, or /u/. The stimuli were synthesized in cascade at a 10-kHz sampling rate using Klatt's [5] cascade/parallel speech synthesizer. The vowel portion of the stimulus was 200 ms long and varied along the F2 dimension between 500 and 2500 Hz in 100 Hz steps, with F1 held constant at 250 Hz. F3 was held constant at 2212 Hz for stimuli with F2 values between 500 and 1800 Hz, and was calculated according to the following formula for stimuli with F2 values above 1800 Hz:  $F3 = 1.4 \times (F2 - 220)$  [6]. F0 decreased linearly from 120 Hz at the start of the vowel to 100 Hz at its end. The 21 members of each continuum were presented 10 times each in random order for forced-choice identification. They were low-pass filtered at 4800 Hz and delivered binaurally through TD-149 earphones.

## 3. ANALYSIS

**3.1. Production (Imitation Task)**  
The items recorded for each subject during the imitation task were digitized and presented in randomized order to 3 native speakers of Standard French for evaluation on a 7-point scale: 1 = /i/ or /i/-like vowel; 2 = vowel between /i/ and /y/, but closer to /i/; 3 = vowel between /i/ and /y/, but closer to /y/; 4 = /y/ or /y/-like vowel; 5 = vowel between /y/ and /u/, but closer to /y/; 6 = vowel between /y/ and /u/, but closer to /u/; 7 = /u/ or /u/-like vowel. On the basis of this scale, a score between 1 and 4 indicates a

vowel between /i/ and /y/, and a score between 4 and 7 a vowel between /y/ and /u/. The stimuli were presented on-line on a Zenith 286 microcomputer, by means of software developed at the University of Alberta, and delivered binaurally through TD-149 earphones. When they were not successful in repeating French /y/ as /y/ or an /y/-like vowel, Portuguese speakers repeated it 95% of the time as /i/ or an /i/-like vowel (generally a lax variant thereof), or as a vowel described by the 3 French judges as falling between /i/ and /y/. They repeated French /y/ as /u/, an /u/-like vowel, or even a vowel between /y/ and /u/ only 5% of the time. Their mean score for these non-/y/ productions was 2.13.

On the other hand, when English speakers did not succeed in repeating French /y/ as /y/ or an /y/-like vowel, they were found to repeat it as /u/ or an /u/-like vowel (a lax variant thereof), or as a vowel between /y/ and /u/ 92% of the time, and as an /i/-like vowel or a vowel between /y/ and /i/ 8% of the time. Their mean score for these non-/y/ productions was 5.01. These results support observations that Portuguese speakers generally replace French /y/ with an /i/-like vowel, and that English speakers generally replace it with an /u/-like vowel [8].

## 3.2. Perceptual Task

The results of the perceptual task (both pooled and individual) were analyzed to yield crossover boundary values between adjacent vowel categories, and to produce graphs of the identification functions.

As shown in Figs. 1 and 2, the crossover boundary between /i/ and /u/ is located much higher on the F2 scale for English speakers (1900 Hz) than for Portuguese speakers (1575 Hz). A comparison of the English and Portuguese labeling functions with those obtained from native speakers of Standard French (Fig. 3) shows that stimuli with F2 values ranging between 1500 and 2100 Hz, which are identified as /y/ by French speakers, are most of the time labeled as /u/ by English speakers and as /i/ by Portuguese speakers.

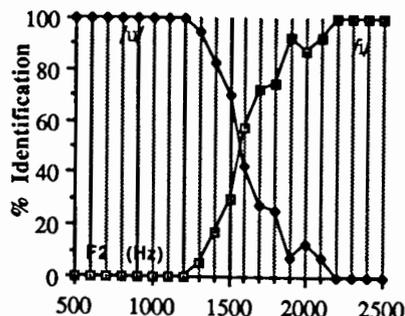


Fig. 1: Portuguese Identification Functions

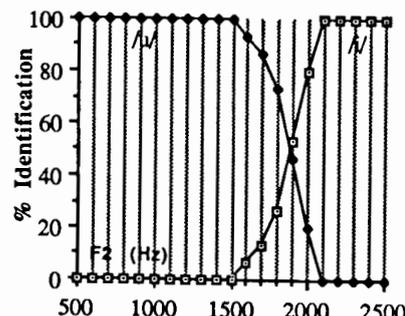


Fig. 2: English Identification Functions

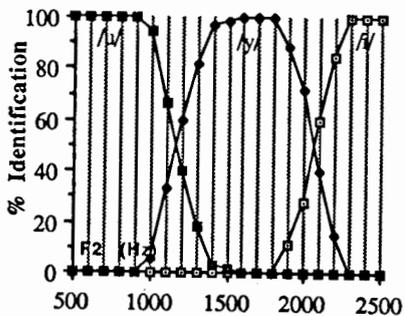


Fig. 3: French Identification Functions

Although this comparison of the labeling functions by the three groups of subjects is of interest inasmuch as it reveals how these three groups of subjects divide the high vowel continuum in their respective languages, it should not form the basis

for an explanation of the phenomenon of interlingual identification. When called upon to imitate French /y/, L2 learners do not have access to French categorization functions, but only to natural tokens of that vowel pronounced by native French speakers. To understand the process of interlingual identification, one must therefore relate mean F2 values of the vowel /y/ obtained from production data to the L2 learners' identification functions. The average value of F2 for French /y/ has been given as 1850/1900 Hz at the high end of the range [1] [2], and as 1675 Hz at the lower end [6]; the average F2 value of the French tokens presented to the English and Portuguese subjects in the imitation task of the experiment reported here was 1760 Hz, with extreme values of 1612 Hz and 1824 Hz. It can be seen from Figs. 1 and 2 that most tokens with such values fall within the bounds of the /i/ category for Portuguese speakers, and within the /u/ category for English speakers.

#### 4. DISCUSSION

4.1. The parallelism between the results of the imitation task and those of the perceptual task appear to support the hypothesis that accented pronunciations of L2 sounds by untrained speakers may be perceptually motivated. It suggests that, in early stages of L2 learning, learners perceive L2 sounds in terms of their L1 phonological systems, through the process of "equivalence classification" [3]. Thus, they may classify separate L2 phonemes as acoustically different realizations of the same L1 category, even if they perceive the acoustic differences in question. Once assigned to that category, the intended target speech sound is actualized according to their L1 phonetic realization rules. In the case of Portuguese speakers, most tokens of French /y/ fall within the bounds of the Portuguese /i/ category. Once assigned to this perceptual category, such tokens are imitated by Portuguese speakers in such a way that they are perceived by French speakers as belonging to their own /i/ or /y/ categories (see Fig. 3). On the other hand, for English speakers, most tokens of French /y/ fall within the bounds of the English /u/ category. Once

assigned to this category, such tokens are imitated by English speakers in such a way that they are perceived by French speakers as belonging to their own /u/ or /y/ category. The fact that intended French /u/, as pronounced by English speakers, is often perceived by French speakers as /y/ is further evidence that English speakers assign both French /y/ and /u/ to their single /u/ category; English /u/ being characterized by higher F2 values than its French counterpart [4], its realizations cover a range which straddles the French /y/ and /u/ categories.

4. 2. The results of this study further provide evidence that there exist differences in the way different languages divide the high vowel continuum. The results of the perceptual test for English speakers agree with the findings of Stevens et al. [8] who, in their crosslanguage study of vowel perception, observed a peak in the discrimination functions for both English and Swedish speakers, as one passed from the unrounded /i/ to the rounded /y/. Because the English speakers were able to perceive the acoustic differences between /i/ and /y/ in spite of the fact that there is no distinction between an /i/ and an /y/ category in English, the authors concluded that some natural perceptual boundary must exist between these two vowels. The identification functions represented in Fig. 2 indicate that, although English has only two high vowel categories labelled /i/ and /u/, the perceptual boundary between these two categories nearly coincides with the perceptual category between /i/ and /y/ in French (see Fig. 3) and in Swedish [8]. It seems likely, therefore, that the discrimination peak observed by Stevens et al. for their English subjects occurred not because of a natural perceptual boundary in the region, but because the stimuli being discriminated belonged to two separate categories. In addition, a comparison of the English and Portuguese identification functions (see Figs. 1 and 2) shows that the perceptual boundary between the two high vowels /i/ and /u/ does not occur in the same location in different languages, and suggests that the location of this perceptual boundary in languages having only two high vowels is the result of

linguistic experience rather a reflection of some basic property of the auditory mechanism.

#### 5. REFERENCES

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