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# ASSESSING THE PHONETIC LEVEL IN L2 VOWELS PRODUCTION WITH THE VISUVO SOFTWARE: CASE OF CZECH LEARNERS ACQUIRING CONTRASTS BETWEEN FRENCH MID VOWELS e/ɛ, ø/œ AND o/ɔ

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## ABSTRACT

The VisuVo software is designed to visually compare formants of vowels as uttered by different speakers, in isolation and in different contexts or prosodic positions. Both researchers and teachers can use the software. VisuVo aims to evaluate the initial phonetic level of a learner and to trace the progress in L2 vowels realisation compared to a set of pre-recorded references. VisuVo has an interactive and simple interface to handle. Its features and output graphics are illustrated by a study of contrasts between the French mid vowels e/ɛ, ø/œ and o/ɔ produced in isolation and in symmetrical contexts /p, t, k, R/ by 10 native non-southern French speakers representing the reference, and 10 Czech learners of French to be tested.

**Keywords:** pronunciation assessment, vowels, formants, French as a Foreign Language (FFL), Czech

## 1. INTRODUCTION

### 1.1. Teaching and Assessment in Phonetics

Since the appearance of the *communicative approach* in the 1970s, perfect pronunciation of L2 sounds is no longer an objective. Still, learners may wish to go unnoticed for their foreign accent and to speak, ideally, like natives [3]. Teachers should therefore compare the particularity of phonetic-phonological systems of L1 and L2, their prosody and segments, their phonotactic rules and coarticulation patterns leading to allophonic variations [2]. Coarticulation habits are language dependant [12]. Once the vowels have been inserted in the spoken chain, the formant frequency values in the middle part of the vowels, on one side, and the direction of the formants during the transition between the vowel and the surrounding consonants, on the other side, depend on many factors, such as the language itself, surrounding consonants, prosodic position (initial, final, stressed, etc.), style (hyper- or hypo-articulated) and speech rate [11]. The mastery of allophonic variations should therefore be included in the curriculum.

An objective evaluation of an exact phonetic level acquired by a learner is hardly possible on the sole basis of perceptual judgments. Human assessors can be helpful, of course, as they can normalise the incoming speech and categorise sounds without any big difficulty; they cannot, however, perform fine acoustic analyses enabled by modern technological means [1]. The difficulty in objectively assessing different phonetic levels is reflected by the Common European Framework of Reference for Languages (CEFR) [5], which does not provide clear criteria for distinguishing between six levels of phonological skill (A1, A2, B1, B2, C1 and C2), and confuses levels C1 and C2. Progress in the acquisition of new phonological contrasts is gradual, and teachers should therefore appreciate different stages of phonetic progress [7]. Machines can help and, in this perspective, VisuVo (VISUalisation of VOWels) can be considered a tool for teachers to objectively assess different phonetic levels.

### 1.2. Acoustic Target

To study deviations in L2 pronunciation, researchers and teachers need to refer to a phonetic norm defined by native speakers' productions [9]. The same vocalic timbre can be achieved with different articulatory strategies [13], so that vowels are more easily defined in acoustic terms, that is in terms of their formant frequencies. The current French segmental system includes 3 nasal vowels and ten oral vowels /i, e, ɛ, a, u, o, ɔ, y, ø, œ/. Back vowels can be adequately defined by the first two formants (the upper formants have no perceptual weight [6]), front vowels by the first three formants, and the vowel /i/ by the first four formants. A closer distance between F3 and F4 defines the French vowel /i/, so that F4 is important in the acoustic definition of vowels with /i/-like timbre [14].

## 2. AIM OF THE STUDY

The objective of this paper is to present the VisuVo diagnostic tool. VisuVo is a piece of specialised software which can quickly and interactively generate three types of graphs representing vocalic

formants from a large database. The graphs are vowel triangles, allophonic variations tracers and contrasts diagrams. They aim to highlight acoustic differences in the pronunciation of L2 vowels compared to pre-recorded L1 formant frequency values as a reference, and display learners' progress.

In this study, VisuVo illustrates three first formants (F1 to F3) of French mid vowels  $e/\epsilon$ ,  $\emptyset/\alpha$  and two first formants of  $o/\omega$ , as produced by 10 Czech learners and 10 native non-southern French speakers (reference). The Czech language has five phonologically short vowels /a, e, i, o, u/ (/e/ and /o/ being sometimes transcribed in recent Czech literature with /ɛ/ and /ɔ/) and five long ones /a:, e:, i:, o:, u:/. The Czech language (unlike French) does not make contrast between rounded/unrounded front vowels, nor between mid-open/mid-close vowels.

The question is to what extent Czech learners can acquire contrasts between  $e/\epsilon$ ,  $\emptyset/\alpha$  and  $o/\omega$ ? Which are the consonantal contexts that facilitate learning of the three contrasts?

### 3. METHODOLOGY

#### 3.1. Corpus and Speakers

The corpus, derived from a larger body [10], consists of the mid vowels /e,  $\epsilon$ /, / $\emptyset$ ,  $\alpha$ / and /o,  $\omega$ / pronounced:

1. in isolation (i.e. between two short pauses so as to avoid coarticulatory phenomena), inserted in carrier sentences, such as « *Tôt, il a dit <ô> comme dans tôt.* » (“*Soon, he said <u> like in soon.*”)

2. intrisyllabic logatoms CVCVCVC (where C = /p, t, k, R/) inserted in carrier sentences, such as « *Le mot *kaukauka* peut bien coller.* » (“*The word *kaukauka* matches well.*”)

The corpus includes recordings of female speakers without any known hearing problems, namely:

1. Ten native non-southern French, aged between 21 and 48 (M = 28,5), 4 repetitions.

2. Ten Czech advanced learners (Learners 1 to 10), aged between 25 and 28 (M = 25,7), 10 repetitions.

Productions of French natives were used to define the French reference in the present study.

#### 3.2. Recording and Data Processing

All instructions were given in writing. The recordings were made in a quiet room with a headband microphone AKG C 520 L and a sound card Edirol UA 25 connected to a Mac computer. The set of sentences was recorded with a sampling

frequency of 44100 Hz and a sampling rate at 16 bits. Recordings were preceded by a training phase.

Ten target vowels of two corpora were labelled and analysed using the Praat software [4]. The formant values were automatically calculated with the formula To Formant (burg) of the Praat system (analysis window: 25 ms). All values taken semi-automatically were checked and corrected manually, when necessary.

## 4. RESULTS

### 4.1. Average Values

The differences in F1, F2 and F3 (in Bark, expressed as a percentage) of the mid vowels realised by the French speakers (FR) and Czech learners (CZ) are summarized in Table 1.

The *French native speakers* realised the contrast between mid vowels with a systemic difference in F1. According to the consonantal context, the difference in F1 varies between 25 % and 34 % for the pair  $e/\epsilon$ , between 23 % and 30 % for  $\emptyset/\alpha$ , and between 26 % and 31 % for  $o/\omega$ . The difference in F2 is equal to or less than 6 % for pairs  $e/\epsilon$  and  $\emptyset/\alpha$ , and between 13 % and 22 % for the pair  $o/\omega$ . The difference in F3 doesn't exceed 3 % for all pairs.

The *Czech learners* do not exhibit a difference in F1 and F2 between mid vowels  $e/\epsilon$  and  $o/\omega$ , except for F1 of  $e/\epsilon$  produced in isolation and F2 of  $o/\omega$  realised in a labial context where the difference represents 5 %. According to Flanagan [1], a 5 % formant difference corresponds to a *just noticeable difference* for vowel formant frequencies F1 and F2, but it is probably not large enough to distinguish between two different phonemes. In contrast, vowels  $\emptyset/\alpha$  are produced with a difference in F1 between 5 % (in certain contexts) and 15 % (in isolation). The difference in F3 never exceeds 1 %.

The average vocal formants of  $e/\epsilon$ ,  $\emptyset/\alpha$  and  $o/\omega$  produced by natives and learners, in different consonantal contexts and prosodic positions (the first, mid and the last vowels in logatoms) is illustrated in Figure 1 generated by VisuVo. Finally, the strengthening of contrasts between  $e/\epsilon$  and, in particular,  $\emptyset/\alpha$  produced by the Czech learners in isolation is illustrated in Figure 2. We note a difference in mean values of F1.

### 4.2. Individual Variability

The study of 10 replicates of vowels individually performed by 10 learners shows that acoustic cues constituting contrasts vary from learner to learner. A quasi-systematic acoustic difference between pair

vowels indicates that learners have created two different categories for the vowels in contrast.

Vowel triangles F1/F2 (in Bark) of Figures 3 and 4 generated with VisuVo make it possible to compare performances of different learners according to phonetic contexts.

In isolation (Figure 3), Learner 2 does not distinguish between e/ε, but the majority of occurrences of ø/œ and o/ɔ have different F1 and F2 (yet the difference is lower than in natives). Learner 9 achieves e/ε and o/ɔ with a difference in two formants (again, the difference is lower than in natives). The contrast between ø/œ in Learner 9 is based on F2 contrary to F1 in natives.

In a dental context (Figure 4), Learner 2 produces the contrast e/ε with a difference in F2 primarily, and does not distinguish between ø/œ and o/ɔ. Learner 3 pronounces e/ε with a difference in F1 and F2, but, in contrast to natives, the [ε] is produced, on average, with a lower F1 than [e]. The contrasts between ø/ and o/ɔ are essentially based on F2.

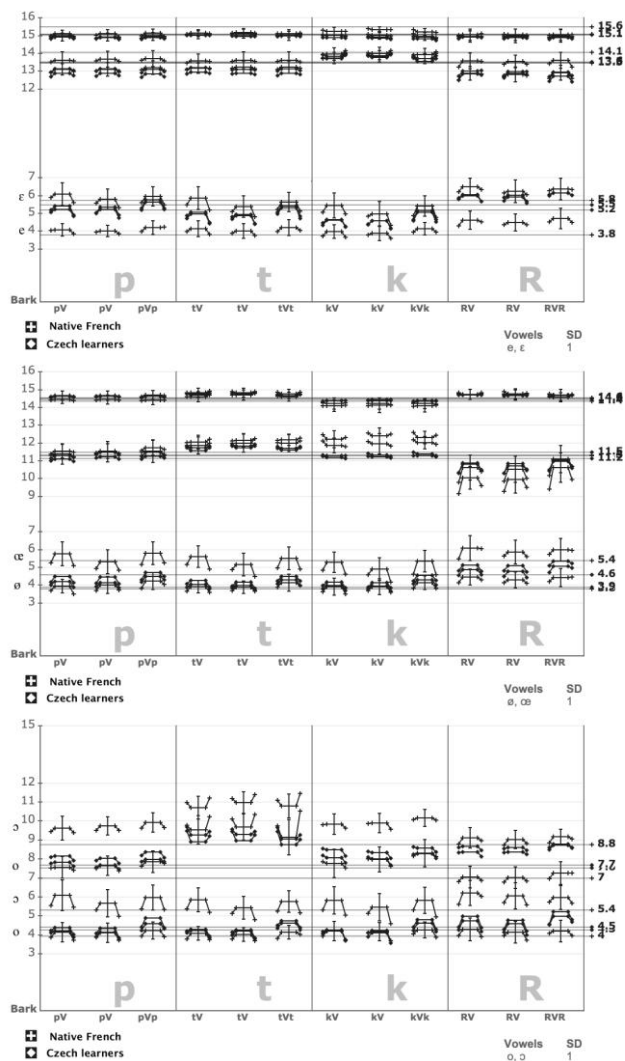
### 5. CONCLUSION

Native French speakers systematically produce the contrast between mid vowels based on the main acoustic cue F1, traditionally correlated to the degree of aperture. These contrasts are an obvious phonetic difficulty for Czech learners who generally do not distinguish e/ε and o/ɔ, and realise the contrast ø/œ with less acoustic difference than natives. This result shows that the difficulty of acquiring four contrastive degrees of aperture instead of three is not the same for all vowels. Indeed, the contrast between phonemically new vowels ø/œ (two new phonemes for Czech learners) is more approximated than the contrasts between phonemically similar vowels e/ε and o/ɔ.

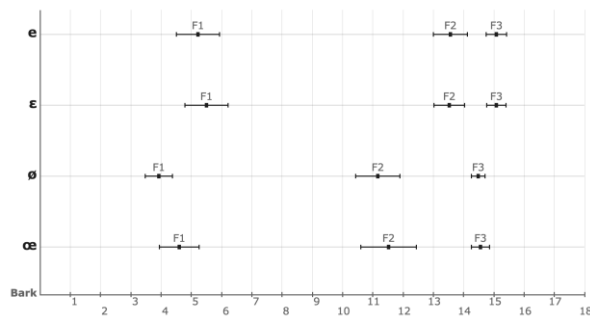
A detailed analysis of formant frequencies eased by the use of VisuVo shows that 1) performances in the production of contrasts vary from learner to learner, 2) some contexts appear to facilitate contrasts implementation, and 3) a number of potentially specific problems for a given learner can be easily identified. In order to objectively evaluate different stages of phonetic progress, teachers should be advised to complete their perceptive appreciation by visualisation of formant frequencies, as done easily by VisuVo.

**Figure 1:** Average formants F1, F2 (F3) (in Bark) of vowels e/ε, ø/œ and o/ɔ produced in isolation (horizontal strokes) and in logatoms CVCVCVC (where C = p, t, k, R) in the first, second and the last vowel by 10 native French speakers (cross, 4

repetitions per speaker) and 10 Czechlearners (rhombus, 10 repetitions per speaker). Values taken at 1/3, 1/2 and 2/3 of vowel lengths. The standard deviation is one.

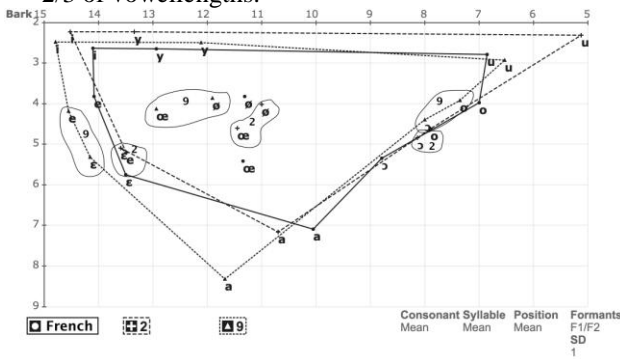


**Figure 2:** Average formants F1, F2 and F3 (in Bark) of vowels e/ε, ø/œ produced in isolation by 10 Czechlearners (10 repetitions per speaker). Values taken at 1/3, 1/2 and 2/3 of vowel lengths. The standard deviation is one.

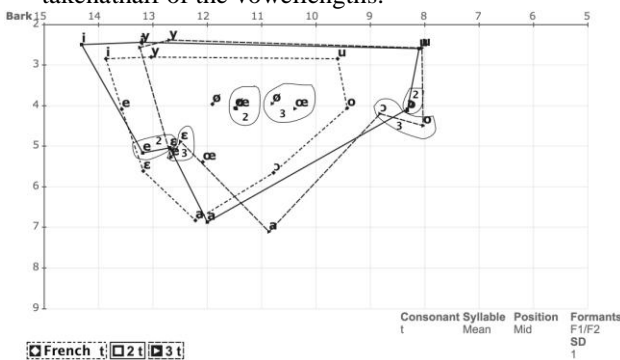


**Figure 3:** Triangle F1/F2 (in Bark) of 10 French oral vowels repeated in isolation 4 times by 10 natives (circle) and 10 times by Learner 2 (cross)

and Learner 9 (triangle). Values taken at 1/3, 1/2 and 2/3 of vowel lengths.



**Figure 4:** Triangle F1/F2 (in Bark) of 10 French oral vowels repeated in logatoms VtVtVt 4 times by 10 natives (rhombus) and 10 times by Learner 2 (square) and Learner 3 (triangle). Values taken at half of the vowel lengths.



**Table 1:** Difference of average formants (in percentages) F1, F2 (F3) (in Bark) of vowels e/ε, ø/œ and o/ɔ produced in isolation (0) and in logatoms CVCVCVC where C = p, t, k, R by 10 native French speakers (FR, 4 repetitions per speaker) and 10 Czech learners (CZ, 10 repetitions per speaker). Values taken at half of vowel lengths.

Ctx	Vw	Diff. F1 %		Diff. F2 %		Diff. F3 %	
		FR	CZ	FR	CZ	FR	CZ
0	e/ε	34	5	4	0	3	0
	ø/œ	30	15	1	3	1	1
	o/ɔ	26	4	20	1		
p	e/ε	30	4	5	2	1	0
	ø/œ	29	7	1	2	1	0
	o/ɔ	30	4	21	5		
t	e/ε	27	2	3	1	1	0
	ø/œ	26	5	2	1	1	0
	o/ɔ	28	2	13	3		
k	e/ε	25	2	2	1	2	0
	ø/œ	23	5	3	1	1	0
	o/ɔ	26	2	19	4		
R	e/ε	27	2	6	2	0	0
	ø/œ	27	6	5	0	0	0
	o/ɔ	31	4	22	2		

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