Phonetic Attrition in Vowels' Quality in L1 Speech of Late Czech-French Bilinguals

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Abstract. This study examines phonetic attrition of the first language (L1) affected by second language (L2) in Czech speakers living in Toulouse (late Czech-French bilinguals – CF). We compared the production of vowels by 13 CF and 13 Czech monolinguals living in the Central Bohemian Region (C). CF had been living in France for at least one year and started to learn French when they were more than 6 years old. Both C and CF were speakers of Common Czech. We recorded their production in reading task and semi-spontaneous speech and performed measurements of vowel formants. Results show a statistically significant difference between F1 of CF [aː] and F1 of C [aː], and between F3 of CF [iː] and F3 of C [iː]. These findings are discussed in relation to the perceptual approach suggesting that several vowels can be perceived as different in C and CF production.

Keywords: Phonetic attrition · Vowels' quality · Late Czech-French bilinguals

1 Introduction

Intensive use of an L2 can influence the speaker's L1 at the phonetic level [14], a phenomenon often branded as first language phonetic attrition or phonetic cross-linguistic influence. The former, first language attrition, refers to the non-pathological decline of previous L1 language skills [13], which happens as a "natural consequence of decrease in the [L1] use" [12] and consists of long-term changes due to extensive, and not necessarily recent, L2 contact [6]. The latter, cross-linguistic influence (CLI), introduced by [24], refers to any kind of effect that

Supported by a doctoral grant of the French Research Ministry, a Charles University PhD scholarship, the Charles University project SVV – 2019, *Jazyk a nástroje pro jeho zkoumání*, and by the Charles University project Progres Q10 *Language in the shiftings of time, space, and culture.*

P. Sojka et al. (Eds.): TSD 2020, LNAI 12284, pp. 348–355, 2020.
https://doi.org/10.1007/978-3-030-58323-1_38

one language may have on another. For [21], L1 attrition is one among these possible kinds of effect, a position we will adopt here.

For now, only a small part of studies in the area of phonetic attrition and CLI examined vowels by acoustic measurement (see, *e.g.,* [4,17]). In addition, there is no study on the influence of L2 French on L1 Czech at the phonetic level, although several interesting differences exist in the vowel systems of both languages (see [16]). The present paper proposes to fill this gap with a study investigating phonetic attrition in vowels' quality in the L1 speech of Czechs who have been living in France for more than one year and started to learn French after the age of six (henceforth CF, late Czech-French bilinguals).

1.1 Comparison of Czech and French Vowels

Without [ə], Czech comprises 10 monophthongal not nasalized vowels [25] and French 11 monophthongal not nasalized vowels [18]. Czech distinguishes short and long vowels contrary to French, where vowel's length is not a phonological feature. The articulatory features of these Czech and French vowels are described in Table 1 showing that these languages do not attribute the same articulatory properties to [ɛ], [a] and [o]. Some inconsistencies exist among authors in the IPA symbols used for certain vowels (see [16]). We use the symbol [u], and not [ʊ], for Czech /u/ for the reason of simplicity and the symbol [ɛ] for Czech /e/ because this sound is acoustically slightly nearer to French [ɛ] than to French [e].

Table 1. Articulatory properties of Czech and French not nasalized monophthongal vowels, (white column = Czech vowels, gray column = French vowels). Vowels with the same IPA symbol, but different articulatory properties are in bold. Source [16,18]

Anteriority		Front			Central	Back	
Lip shape		unrounded		rounded	unrounded	rounded	
Degree of aperture	Close	ɪ, iː	i	y		u, uː	u
	Close-mid		e	ø			**o**
	Mid	**ɛ**, ɛː				**o**, oː	
	Open-mid		**ɛ**	œ			ɔ
	Open		**a**		**a**, aː		ɑ

Regarding the link between articulatory and acoustic properties of vowels, the F1 is traditionally determined by degree of aperture and F2 by anteriority and lip articulation [18,25]. The F3 can also be determined by lip shape [18]. [29] also suggests to include F3 and F4 in acoustic studies of French vowels because F4 with F3 makes a prominent energy packet in the high frequencies (F3/F4). Therefore, in our study, we will analyse F1, F2, F3 and F4.

Based on the results of [10,20,26,27], Table 2 compares F1 and F2 means of Czech and French not nasalized vowels. In the present study, we focus on the

production of CF, all female speakers, in a reading task (hereafter RT) and semi-spontaneous speech (hereafter SS). Therefore, the formants obtained from the production of only female speakers in RTs and SSs are compared in Table 2. [26] studied Czech vowels of 48 women aged from 20 to 30 years reading a continuous text. [27] analysed the production of 9 French women reading the monosyllables formed by either /pV1/, where V1 was /e/, /o/, /u/, /y/, or /ø/, or /pV2R/ where V2 was /i/, /ɛ/, /a/, /ɔ/, or /œ/. In [20], 10 Czech women aged 25–34 years commented spontaneously on 20 objects. [10] analysed a speech of 15 French women mainly extracted from broadcast news. We are conscious that the F1 and F2 means in Table 2 cannot be considered as reference values for any female speaker because each study used for the creation of Table 2 has its limitations. For example, [28] reproaches [27] that the /R/ used in coda position could lengthen the previous vowel and consequently increase the F1 value and decrease the F2 value.

The frequency difference limen (DLF) refers to the difference in the frequency values perceptible by the human ear [16]. The DLF for F1 is 10–30 Hz and 20–100 Hz for F2 according to [9]. In Table 2, the F1 values of vowels that differ in Czech and French from 30–60 Hz are in slight gray, and in dark gray when the difference is higher than 60 Hz. F2 values are in slight gray when the difference between Czech and French is 100–200 Hz, and in dark gray when the difference is more than 200 Hz. Table 2 does not contain the values of Czech [oː], as this vowel, infrequent in Czech speech, will not be analyzed in our study. Regarding F3 and F4, to the best of our knowledge, there is no study comparing these formants of Czech and French vowels produced in RTs and SSs. Only studies of formant values of vowels in isolation in Czech and French give means of F3 and F4 for certain vowels [16,19].

In our study, all CF were living in the Toulouse area. [8] supports that French spoken in Toulouse differs from standard French although more than one variety of Toulouse French exists [7,8]. For a majority of speakers from Toulouse, the phonological differences between French [e] and [ɛ], [œ] and [ø], [a] and [ɑ], and [ɔ] and [o] are absent in minimal pairs [8], while other speakers from Toulouse may respect these differences according to the position rule [7,8]. Thus, from a phonological point of view, vowels in Toulouse French can differ from vowels of standard French. However, as far as we know, no study focused entirely on acoustic properties of Toulouse French vowels. Hence, we can only suppose that the Czech vowels of CF may be more influenced by vowels of Toulouse French than standard French. However, no prediction about this can be made as an acoustic study of Toulouse French vowels is lacking.

Taking into account all these considerations, we made the hypothesis that the phonetic CLI is more likely to occur in vowels which are acoustically slightly dissimilar in French and in Czech and in vowels which exist only in one of both languages.

Table 2. F1 and F2 of Czech and French vowels for female speakers in RTs and SSs according to [10,20,26,27]. (CZ = Czech, FR = French).

	Reading task				Semi-spontaneous speech			
Formant	F1		F2		F1		F2	
Language	CZ	FR	CZ	FR	CZ	FR	CZ	FR
i	NA	350	NA	2400	NA	348	NA	2365
iː	328.5	NA	2603	NA	287	NA	2504	NA
ɪ	492.1	NA	2251.2	NA	411	NA	2177	NA
y	NA	350	2050	NA	NA	371	2063	NA
e	NA	450	NA	2300	NA	423	NA	2176
ɛ	686.3	650	1823	2000	650	526	1726	2016
ɛː	709.5	NA	1904.3	NA	671	NA	1825	NA
a	780.9	750	1480.2	1550	733	685	1322	1677
aː	801.2	NA	1417.6	NA	784	NA	1436	NA
ø	NA	450	NA	1650	NA	420	NA	1693
œ	NA	550	NA	1650	NA	436	NA	1643
u	415.3	350	1003.6	850	330	404	1221	1153
uː	343.6	NA	757	NA	341	NA	851	NA
o	528	450	1166.2	950	474	438	1161	1140
ɔ	NA	600	NA	1200	NA	528	NA	1347

2 Method

We recorded the Czech production in RT and in SS of 13 female native Common Czech speakers (mean = 35.1 years) living in the Central Bohemian region of the Czech Republic (hereafter C) and 13 CF speakers of Common Czech (mean = 34.2 years). All CF have not never lived in any region where some variety of Czech different from Common Czech is spoken. They all declared not to think to speak Czech with some specific accent as for example Moravian accent in socio-linguistic form filled after recording. The average of their length of residence in France was 9.9 years (min = 1.42 year, max = 28.25 years). All C and CF speakers were aged 20–50 years, hence the stability of their f_0 was assured [11].

In the RT, the speakers read a short text chosen from [5]. In the SS, they talked for one minute and a half about one or more proposed topics such as plans for holidays or the next weekend, describing a typical day, job, studies, family, hobbies, etc. CF were recorded in a quiet recording studio (PETRA) at University of Toulouse using a Neumann TLM 49 microphone and sound card MOTU ULmk3. They received a small reward for participation. C were recorded in a quiet, comfortably furnished office with a low level of ambient noise and short natural reverberation in Prague. A head-mounted condenser microphone (Bayerdynamic Opus 55) was plugged directly into a pocket recorder set to uncompressed 48 kHz 16-bit mode.

All recordings were orthographically transcribed. Their semi-automatical segmentation and labeling in Praat [2] were corrected manually. Vowels' boundary placement was guided by the presence of full formant structure. Initial glottal

stops and final voice decay time were not considered to be part of the vowel. Vowels ending by the schwa of hesitation, vowels in foreign words such as English names of movies or names of French cities, unpronounced and semi-pronounced vowels in the recordings of SS were excluded from the analysis. Vowels preceded or followed by nasal consonants in RT and in SS were excluded from the analysis too, since nasal context coarticulation may lead to uncontrolled extra formants. The Czech conjunction /a/, meaning "and" in English, longer than 150 ms was considered as a hesitation and excluded from analysis (*cf.* [23]). The conjunction /a/ with duration lower than 150 ms was labelled as a short Czech [a] and included in analysis. Formants were measured automatically using Praat script computing the mean of formant value from the second third of the vowel duration. This way, we resolved the issue of the effect of coarticulation on the formant value. In total, the analysis involved 10 147 vowels.

The data were analyzed in RStudio [22] using the packages lme4 [1], dplyr [31], rPraat [3], and ggplot2 [30]. We computed the mean value of each formant of each vowel for each task and each group separately. The significance level was set at $\alpha = 0.05$. In order to examine differences between C and CF vowels' formant values, we performed linear mixed-effects models for each formant of each vowel. We analyzed the relationship between group and formants' values. We had intercepts for speakers and words of the vowel's occurrence as random effects. As fixed effects, we entered group and task. Visual inspection of residual plots did not reveal any obvious deviations from homoscedasticity or normality. P-values were obtained by likelihood ratio tests of the full model with the effect in question against the model without the effect in question.

3 Results

The analysis showed that the group affected F1 of [a:] ($\chi^2(1) = 5.6428, p = 0.01753$) increasing the F1 value of CF by 51.17 Hz ± 21.18 (standard errors). This result is also visible on the Fig. 1 showing F1 and F2 fields with values in Hertz of C and CF obtained in RT and in SS. The group affected also F3 of [i:] ($\chi^2(1) = 7.5502, p = 0.006$) increasing the F3 value of CF by 114.41 Hz ± 40.13 (standard errors). There were no other significant results.

4 Discussion and Conclusions

Our study showed a significant difference between the groups in F1 value of [a:] and in F3 value of [i:]. By comparison of [a:] F1 value of our C in Table 3 with its values in Table 2, we suppose that the C [a:] F1 corresponds to the standard pronunciation of this vowel in Common Czech. Similarly, comparing the [i:] F3 value of our C with [20] results, we assume that the [i:] F3 of C corresponds to the standard pronunciation of this vowel in Common Czech.

As shown by [14], studies of phonetic L1 attrition and CLI support two possible explanations for sound changes: 'assimilation' and 'dissimilation'. In the former case, L1 sounds shift towards L2 sound's norms. In the latter case,

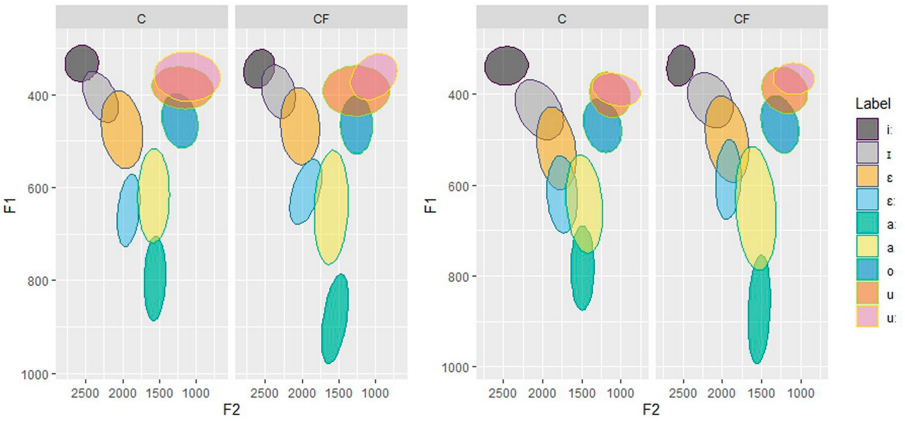

Fig. 1. Czech vowels in RT (left) and in SS (right) plotted in the F1-F2 plane. The ellipses indicate 50% of the formant values, shown in Hz

Table 3. Formant values of C and CF vowels which are supposed to be perceived as different. (v = vowel, m = mean, CI = confidence interval, light gray = C, dark gray = CF, RT = reading task, SS = semi-spontaneous speech)

v	F1m	F1_CI	v	F2m	F2_CI	v	F2m	F2_CI	v	F3m	F3_CI
RT			SS			SS			RT		
a:	791	767, 815	i:	2421	2377, 2465	ɛ:	1746	1701, 1792	i:	3236	3189, 3282
a:	881	855, 907	i:	2515	2490, 2541	ɛ:	1912	1838, 1986	i:	3368	3313, 3424
SS			ɪ	2023	2000, 2046	a	1481	1465, 1496	SS		
ɪ	439	434, 444	ɪ	2140	2115, 2166	a	1589	1570, 1608	i:	3115	3075, 3154
ɪ	417	411, 423	ɛ	1831	1814, 1848				i:	3320	3278, 3361
a:	778	765, 791	ɛ	1943	1924, 1962						
a:	861	844, 879									

the speaker tries to maintain a difference between L1 and L2 sound, which leads to deepening of the acoustic distance between these two sounds. In the light of this suggestion, the significant difference in [a:] F1 value between groups may be considered as the result of dissimilation: the acoustic distance between CF [a:] F1 and French [a] F1 is bigger than the difference between C [a:] F1 and French [a] F1 (see Table 2 and 3). For the CF [i:] F3 value, we can speak about assimilation. According to the study of vowels in isolation [16], the F3 of French [i] is significantly higher than the F3 of Czech [i:]. Therefore, the F3 of CF [i:] is probably influenced by French [i].

Using a perceptual approach, we suppose that DLF can predict if two sounds will be perceived as the same or different. Hence, Table 3 presents formants' mean values for vowels which are expected to be perceived differently in C and

CF production: confidence intervals of formants are not overlapping between C and CF and the difference in formants' mean value between C and CF is equal to or higher than DLF. [aː] F1 and [iː] F3 have been already discussed above. For the others, we suppose that, due to the assimilation, F1 and F2 of CF' [ɪ] is probably influenced by French [i] as well as F2 of CF' [ɛ] and [ɛː] is by French [ɛ] and F2 of CF' [a] by French [a]. F2 of [iː] is higher in CF than in C probably due to a small dissimilation. Table 3 shows also that the differences between groups in formant values, which can be perceived by the human ear, are more frequent in SS than in RT. This observation is in agreement with the findings of [15].

Taken together, this paper showed tendencies of phonetic attrition on vowels in L1 production of CF, which are statistically significant or perceptually predictable. The study of inter-speaker variation in the results should allow us to better understand the results.

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