HIGH VOWEL CONTRASTS AMONG BILINGUAL CHILDREN LEARNING ENGLISH AND FRENCH*

Brenna Haimes-Kusumoto
University of Manitoba

The primary aim of this study was to investigate the nature of the Canadian English–Canadian French bilingual child's phonemic inventory in the lexicon, specifically whether bilinguals' phonological system(s) are autonomous or interdependent (Best 1994; Flege 1995; MacLeod 2006). The ancillary goals were to explore: (a) the differences and similarities in patterns of production between simultaneous and consecutive bilinguals and English monolinguals (in this study) as well as English and French monolingual adults and adult bilinguals (MacLeod et al. 2009; Martin 2002); (b) the effect of age of exposure to French; (c) the effect of experience on production; and (d) the effect of phonetic similarity of the two languages in the case of [i, ɪ, u, ʊ] and dissimilarity in the case of French [y, ʏ].

To pursue these areas the present study addresses three questions using a series of pairwise comparisons:

(1) Are there differences in production between each group?;
(2) Is there an effect of age of exposure to French?;
(3) Is there an effect of experience on production?

1. Introduction

This paper deals with the issue of childhood bilingualism, both simultaneous acquisition of two first languages (L1s), and consecutive acquisition of an established L1 followed later by an additional language (L2). This study investigated the production of English and French high vowels [i, ɪ, u, ʊ, y, ʏ] by three groups of eight to twelve year old children in the Greater Toronto area: simultaneous bilinguals (SBs), consecutive bilinguals (CBs) and English monolinguals.[1]

Previous studies that have investigated the nature of bilingual's phonology in the lexicon have focused on adult bilinguals. Guion (2003) found a distinct difference in the specific strategies of adaptation of Quichua and Spanish vowel inventories between simultaneous, early, mid and late adult

* This research was partially supported by an institutional grant to University of Toronto's department of Linguistics from the Social Sciences and Humanities Research Council of Canada. I am grateful for the helpful comments and questions of the audiences of the May 2010 CLA meeting and for the supervision of Dr. Kevin Russell in the statistical analysis for the present version of the paper. Any errors in the present copy are, of course, my own.

[1] Due to the paucity of French monolingual children in the Greater Toronto Area, a French monolingual group was not included in this study.

Actes du congrès annuel de l'Association canadienne de linguistique 2010.
Proceedings of the 2010 annual conference of the Canadian Linguistic Association.

bilinguals', and a correlation between the acquisition of L2 vowels and the raising of native Quichua vowels. She found that early Quichua-Spanish bilinguals who had successfully acquired Spanish vowel categories produced raised native Quichua vowels in a process of adaptive dispersion to accommodate the second vowel system. She interpreted the latter as evidence of a bidirectional effect between L1 and L2 and proposed that this reorganization occurred to perceptually polarize the difference between the two vowel systems. These two languages have quite small vowel inventories compared to Canadian English and French, so in principle the vowels of Quichua and Spanish have more acoustic space within which to maneuver to adaptively disperse.

MacLeod et al. (2009) focused on productions of the similar high vowels present in both Canadian English and Canadian French, [i, ɪ, u, ʊ], by early bilinguals compared to monolinguals of both languages. They found that early bilinguals' vowels were produced in a nearly monolingual-like manner in both of their languages; so they were capable of forming separate categories for acoustically similar vowels across their two languages. They also found an influence of French lax vowels on English lax vowels; the bilinguals produced English lax vowels higher (with lower F1 values) and less dispersed tense-lax pairs along the F1 dimension than their English monolingual peers. This provides evidence among lax vowels suggesting a bidirectional influence between the two languages. Martin's (2002) investigations of young adults' Québec French vowel spaces support MacLeod et al.'s (2009) findings with regard to French.

The performance of participants in Guion (2003) and MacLeod et al. (2009) support prior observations from adult second language research that the earlier the L2 is acquired, the more likely it is that the learner will be capable of creating and supporting separate categories for both languages, particularly when the vowels are acoustically similar. By implication, the later an individual in exposed to the L2, the more likely it is that L2 categories will not be created[2] but L1 categories will be used in their place. Both studies' findings support a bidirectional influence between a bilingual's two languages rather than the unidirectional L1 influence on the L2, which was historically a focus in the field of adult second language research.

1.1 The Vowel Inventories Of Canadian English And Canadian French

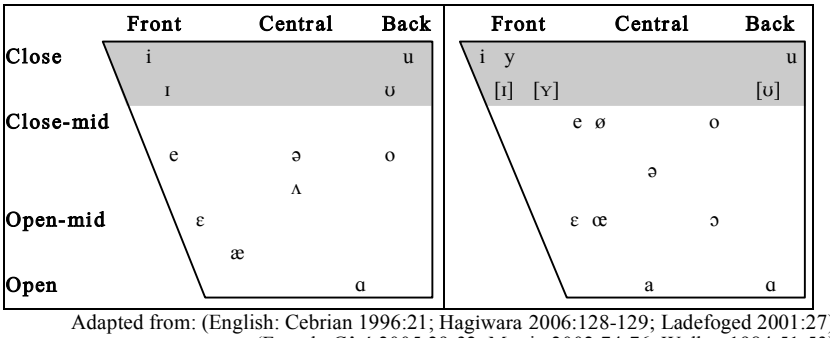
Both inventories are quite large, Canadian English is typically described as having 15 vowel phonemes (Hagiwara 2006:128-129), and Canadian French is generally described as having 16 (Côté 2005:30; MacLeod 2006:150) or 15 vowel phonemes (Walker 1984:51-53).

The crucial differences, on which I focused, between the high vowel inventories of French and English are: First, in English, the tense-lax alternation is phonemic and contrastive, while in Canadian French, the

[2] This phenomenon has been described using various terms, such as *perceptual assimilation* (Best 1994), *equivalence classification* (Flege 1995).

alternation is allophonic; and second, there are two phonemes, /i/ and /ɪ/, occupying the high front phonetic vowel space in English, while in Canadian French there are two phonemes /i/ and /y/, together with their four allophones [i, ɪ, y, ʏ] (see example Figure 1 below).

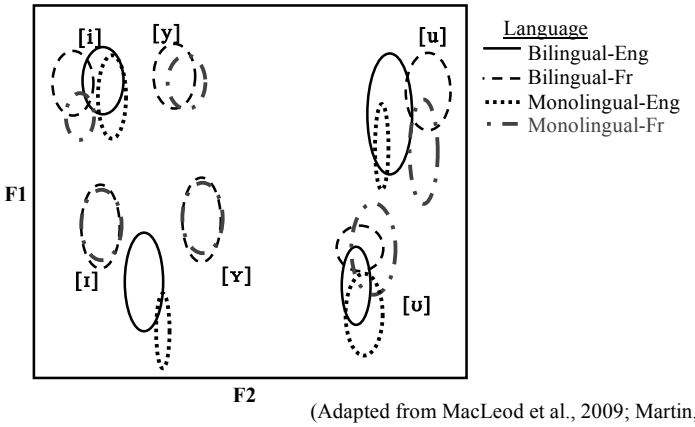
Figure 1. Canadian English and Canadian French Vowel Inventories



Adapted from: (English: Cebrian 1996:21; Hagiwara 2006:128-129; Ladefoged 2001:27); (French: Côté 2005:29-32; Martin 2002:74-76; Walker 1984:51-53).

In terms of acoustic output, MacLeod et al (2009) reported four patterns following a visual inspection of participants' vowel productions (Figure 2 provided for visual reference): (1) English lax vowels were produced lower (with higher F1 values) than French lax vowels; (2) French tense-lax vowel pairs were thus closer along the F1 dimension than the phonemic English tense-lax vowel pairs; (3) there appears to be more separation between French front-back pairs along the F2 dimension than in English, and; (4) bilinguals produced tense vowels in both languages higher (with lower F1 values) than their monolingual counterparts (381). In addition Martin (2002) found that, (5) French /y/ and [ʏ] were produced with roughly the same amount of spread along both F1 and F2 dimensions as /i/ and [ɪ] (83-85).

Figure 2. Adult Bilingual And Monolingual Vowel Spaces



(Adapted from MacLeod et al., 2009; Martin, 2002).

2. Methodology

2.1 Participants

The three groups of participants were comprised of: (1) *Simultaneous bilinguals* acquired both languages from birth; they have two L1s. These children had one francophone parent, most attended French school and had more opportunity to use both languages at home, though not in extra-curricular activities; (2) *Consecutive bilinguals* acquired French as an L2 through French immersion school at junior or senior kindergarten, or grade one after L1 English was already established. They had fewer or no communicative opportunities in French outside of school; (3) *English monolinguals (E-Monos)* are native speakers of English.

2.2 Stimuli

Target vowels were elicited in real words in varied cloze or incorrect carrier sentences as part of a picture-naming production study presented as a guessing game. I pronounced the entire carrier sentence without the target word and the child repeated the sentence, filling in the cloze or correcting the error based on the image provided (see samples in Figure 3). The need to keep children's attention and engagement through the elicitation overrode the need to control for stress.

The recordings were made on a Samson Zoom H4 portable recorder using an Audio-Technica model 831b miniature cardioid condenser microphone clipped to the right-hand side of the speaker's shirt, within 20 centimeters of the speaker's mouth. Recorder quantization was 16-bit, and sampling frequency was 44100 Hz. These recordings were transformed into digital "WAV" format prior to analysis. From these elicitations the frequency of the first and second vowel formants were measured from elicited data in both languages using PRAAT 5.1.18 (Boersma and Weenink 2009).

Figure 3. English and French elicitation task slides

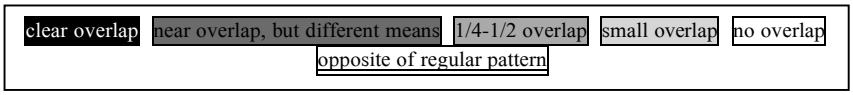
3. Results and Discussion

A visual inspection of participant vowel spaces, a number of t-tests and linear regressions were performed to investigate the differences between vowels and between groups.

3.1 Pairwise Comparisons

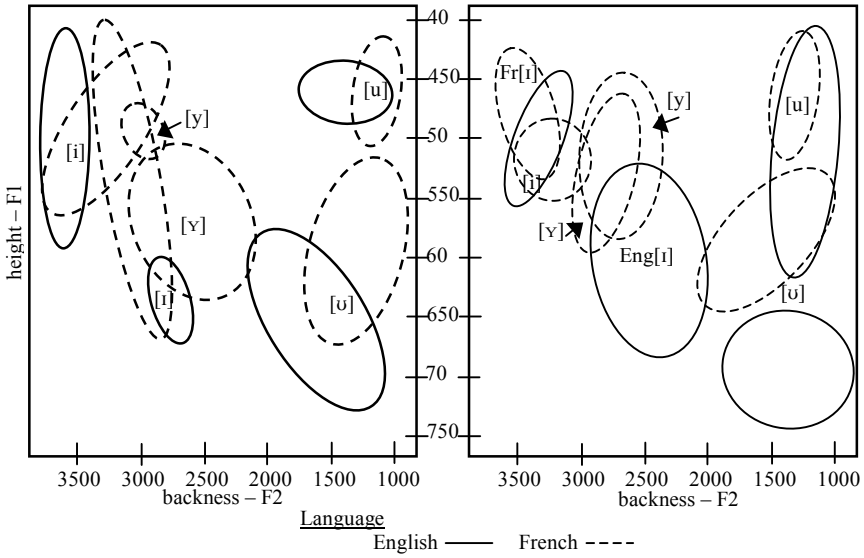
The results of each pairwise comparison are presented in a table, which breaks down each participant's productions along height (F1) and backness (F2) dimensions. The table indicates the level of overlap using a graded scale, the key for which is included in Figure 4 below.

Figure 4. Key to degree of overlap in pairwise comparison tables



The tables are based upon visual inspection of vowel productions, such as those in Figure 5 below.

Figure 5. A representative example of SB (at left) and CB Vowel Productions



3.1.1 Tense/Lax Pairs

In a comparison of productions of tense and lax pairs in each language, the effect of phonological status was evident, but the effect of group was not.

3.1.1.1 English Tense/Lax Pairs

Visual inspection of English acoustic vowel spaces, the results of which are reflected in Tables 1 and 2, confirmed that participants in each group produced the expected configuration of tense /i/ and /u/ as higher than lax /ɪ/ and /ʊ/. The results of the t-tests provide a more precise account of the difference between vowels. Along the height (F1) dimension English /i/ was not significantly

higher than /ɪ/ (F1: SB, CB, EMonos $p > .05$). The difference in height between English /u/ and /ʊ/ was significant across all groups (F1: SB $p = .0004$, CB $p = .006$, EMonos $p < .0001$).

The anticipated significant difference in backness (F2) was realized for the front tense-lax pair, with /i/ significantly less front than /ɪ/ (F2: SB $p = .01$, CB $p < .0001$, EMonos $p = .0002$), with but not the back tense-lax pair (F2: SB $p > .64$, CB $p > .8$, EMonos $p > .12$). In fact, as can be seen in Table 2, across all participants /u/ and /ʊ/ were interchangeably produced as further back.

Table 1. Pairwise comparison of English /i/ and /ɪ/

Sbs	Eng /i/ and /ɪ/ height	Eng /i/ and /ɪ/ back	CBs	Eng /i/ and /ɪ/ height	Eng /i/ and /ɪ/ back	E-Monos	Eng /i/ and /ɪ/ height	Eng /i/ and /ɪ/ Back
Bob	/i/>/ɪ/	/i/</ɪ/	Beth	/i/>/ɪ/	/i/</ɪ/	Alex	/i/>/ɪ/	/i/</ɪ/
Damon	/i/>/ɪ/	/i/</ɪ/	Cole	/i/>/ɪ/	/i/</ɪ/	Julia	/i/>/ɪ/	/i/</ɪ/
Ella	/i/>/ɪ/	/i/</ɪ/	Curtis	/i/>/ɪ/	/i/</ɪ/	Mark	/i/>/ɪ/	/i/</ɪ/
Émilie	/i/>/ɪ/	/i/</ɪ/	Jenn	/i/>/ɪ/	/i/</ɪ/	Max	/i/>/ɪ/	/i/</ɪ/
Fred	/i/>/ɪ/	/i/</ɪ/	Lily	/i/>/ɪ/	/i/</ɪ/	Rosie	/i/>/ɪ/	/i/</ɪ/
Marlo	/i/>/ɪ/	/i/</ɪ/	Sarah	/i/>/ɪ/	/i/</ɪ/	Talia	/i/>/ɪ/	/i/</ɪ/

Table 2. Pairwise comparison of English /u/ and /ʊ/

Sbs	Eng /u/ and /ʊ/ height	Eng /u/ and /ʊ/ back	CBs	Eng /u/ and /ʊ/ height	Eng /u/ and /ʊ/ Back	E-Monos	Eng /u/ and /ʊ/ height	Eng /u/ and /ʊ/ Back
Bob	/u/>/ʊ/	/u/>/ʊ/	Beth	/u/>/ʊ/	/u/</ʊ/	Alex	/u/>/ʊ/	/u/>/ʊ/
Damon	/u/>/ʊ/	/u/>/ʊ/	Cole	/u/>/ʊ/	/u/</ʊ/	Julia	/u/>/ʊ/	/u/</ʊ/
Ella	/u/>/ʊ/	/u/</ʊ/	Curtis	/u/>/ʊ/	/u/>/ʊ/	Mark	/u/>/ʊ/	/u/=/ʊ/
Émilie	/u/>/ʊ/	/u/>/ʊ/	Jenn	/u/>/ʊ/	/u/</ʊ/	Max	/u/>/ʊ/	/u/</ʊ/
Fred	/u/>/ʊ/	/u/</ʊ/	Lily	/u/>/ʊ/	/u/=/ʊ/	Rosie	/u/>/ʊ/	/u/</ʊ/
Marlo	/u/>/ʊ/	/u/</ʊ/	Sarah	/u/>/ʊ/	/u/</ʊ/	Talia	/u/>/ʊ/	/u/</ʊ/

Linear regressions[3] for both English tense-lax pairs (see Figures 6 and 7) suggest that participants exposed to French at a younger age and those with more years of experience with French produced less difference between English tense-lax pairs (*/i/ & /ɪ/*, *Age* r^ = .098, $p = .13$, *Years* r^ = -.029, $p = .48$; */u/ & /ʊ/*, *Age* r^ = .066, $p = .17$, *Years* r^ = .058, $p = .17$). For /i/ and /ɪ/, age of exposure to French was a stronger predictor than years of experience with French, though neither were significant. For /u/ and /ʊ/ both predictors were equal.

[3] Due to space constraints, all figures that follow are summary linear regressions probing overall differences in production due to either age of exposure to French, or years of accumulated experience with French. These regressions are based upon pairwise comparisons of the combined difference in Hertz of F1 and F2 and therefore do not speak directly to height or backness differences.

Figure 6. Overall production difference in English /i/ and /ɪ/

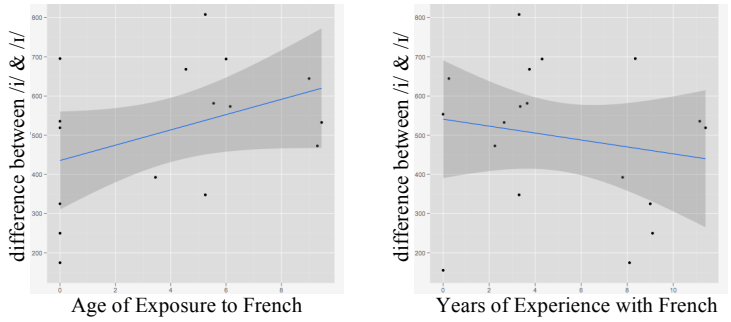
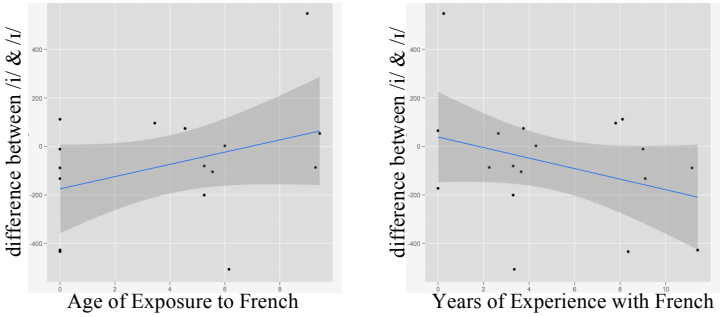


Figure 7. Overall production difference in English /u/ and /ʊ



My interpretation of these findings is, as in Macleod et al. (2009), the bidirectional effect of French allophony was stronger in bilinguals who had earlier age of exposure to French and more communicative opportunities in French.

3.1.1.2 French Tense/Lax Pairs

In French, participants in each group produced the expected configuration of tense phonemes /i/, /y/ and /u/ as higher than lax allophones [ɪ], [ʏ] and [ʊ], aside from a few isolated cases (See Tables 3, 4 and 5). As predicted, the difference in height was not significant (F1: */i/ & [ɪ]*, SB $p > .31$, CB $p > .9$; */y/ & [ʏ]*, SB $p > .1$, CB $p > .47$; */u/ & [ʊ]*, SB $p > .09$, CB $p > .14$). However, upon visual inspection of acoustic vowel spaces, it was found that English vowels were produced higher by both groups of bilinguals than monolinguals, as predicted MacLeod et al. (2009).

SBs and half of CBs produced lax front allophones [ɪ] further back than tense front phonemes /i/, though not significantly (F2: SB $p = .61$, CB $p = .54$). As expected [ʏ] was produced further back than /y/ by all but one SB, and contrary to expectation, /y/ was produced further back than [ʏ] by all but one CB. In neither case was the difference significant (F2: SB $p = .11$, CB $p = .2$).

Tense back phoneme /u/ was produced consistently further back than lax allophone [ʊ], with the expectation of one participant in each group. Contrary to expectation, the difference was not significant (F2: SB $p = .09$, CB $p = .48$).

Table 3. Pairwise comparison of French /i/ and [ɪ]

SBs	Fr /i/ and [ɪ] height	Fr /i/ and [ɪ] Back	CBs	Fr /i/ and [ɪ] height	Fr /i/ and [ɪ] back
Bob	/i/=[ɪ]	/i/<[ɪ]	Beth	/i/≥[ɪ]	/i/>[ɪ]
Damon	/i/>[ɪ]	/i/=[ɪ]	Cole	/i/>[ɪ]	/i/>[ɪ]
Ella	/i/>[ɪ]	/i/≤[ɪ]	Curtis	/i/≥[ɪ]	/i/>[ɪ]
Émilie	/i/>[ɪ]	/i/<[ɪ]	Jenn	/i/>[ɪ]	/i/<[ɪ]
Fred	/i/>[ɪ]	/i/≤[ɪ]	Lily	/i/<[ɪ]	/i/<[ɪ]
Marlo	/i/<[ɪ]	/i/<[ɪ]	Beth	/i/<[ɪ]	/i/>[ɪ]

Table 4. Pairwise comparison French /y/ and [ʏ]

SBs	Fr /y/ and [ʏ] height	Fr /y/ and [ʏ] Back	CBs	Fr /y/ and [ʏ] height	Fr /y/ and [ʏ] back
Bob	/y/<[ʏ]	/y/<[ʏ]	Beth	/y/<[ʏ]	/y/>[ʏ]
Damon	/y/>[ʏ]	/y/<[ʏ]	Cole	/y/>[ʏ]	/y/>[ʏ]
Ella	/y/>[ʏ]	/y/<[ʏ]	Curtis	/y/>[ʏ]	/y/>[ʏ]
Émilie	/y/>[ʏ]	/y/<[ʏ]	Jenn	/y/>[ʏ]	/y/>[ʏ]
Fred	/y/>[ʏ]	/y/>[ʏ]	Lily	/y/>[ʏ]	/y/>[ʏ]
Marlo	/y/>[ʏ]	/y/<[ʏ]	Sarah	/y/>[ʏ]	/y/<[ʏ]

Table 5. Pairwise comparison of French /u/ and [ʊ]

SBs	Fr /u/ and [ʊ] height	Fr /u/ and [ʊ] back	CBs	Fr /u/ and [ʊ] height	Fr /u/ and [ʊ] back
Bob	/u/<[ʊ]	/u/>[ʊ]	Beth	/u/>[ʊ]	/u/>[ʊ]
Damon	/u/>[ʊ]	/u/>[ʊ]	Cole	/u/<[ʊ]	/u/<[ʊ]
Ella	/u/>[ʊ]	/u/≤[ʊ]	Curtis	/u/>[ʊ]	/u/>[ʊ]
Émilie	/u/>[ʊ]	/u/>[ʊ]	Jenn	/u/<[ʊ]	/u/>[ʊ]
Fred	/u/>[ʊ]	/u/>[ʊ]	Lily	/u/>[ʊ]	/u/>[ʊ]
Marlo	/u/>[ʊ]	/u/>[ʊ]	Sarah	/u/>[ʊ]	/u/≥[ʊ]

Linear regressions for each front French tense-lax pairs (see Figures 8 and 9) suggest that participants exposed to French at a younger age and those with more years of experience with French produced a larger difference between French front tense-lax pairs in the hypothesized directions (*/i/ & [ɪ]*, *Age* $r^2 = .025$, $p = .28$, *Years* $r^2 = .063$, $p = .22$; */y/ & [ʏ]*, *Age* $r^2 = .488$, $p = .007$, *Years* $r^2 = .485$, $p = .007$). The effects were equal for both predictors but the effect was significant for only front rounded vowels /y/ and [ʏ]. No effect was found for age of exposure to French or years of experience with French for back rounded vowels.

Figure 8. Overall production difference in French /i/ and [ɪ]

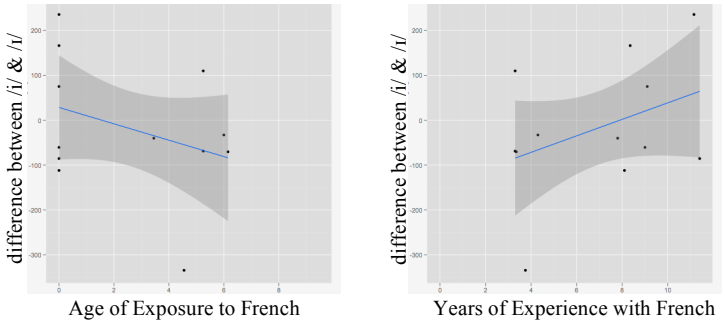
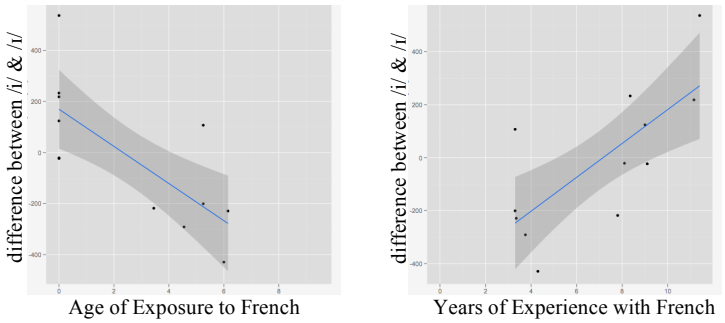


Figure 9. Overall production difference in French /y/ and [ʏ]



My interpretation of these findings is, as in Macleod et al. (2009) and Guion (2003), older bilinguals are more likely to produce L2 vowels that are more similar to L1 vowels. In this case, rather than producing equivalent English vowels in French it would appear that participants with either later exposure to French, or less experience with French are more influenced by a standard French dialect and/or that they perceive the slight allophonic difference in vowels as acoustically variant instances of the same phoneme and produce only the one vowel, whether it be equivalence classification to just the tense vowel or otherwise.

3.1.2 English/French Pairs

A large amount of overlap was expected between English-French pairs of acoustically similar tense vowels. As was anticipated, no significant difference was found between English and French front tense vowels, /i/, along either height or backness dimensions (F1: SB, CB $p > .05$; F2: SB $p = .61$, CB $p = .95$).

It was hypothesized that back tense /u/ would be produced at a similar height across both languages, but that French /u/ would be produced further back from English. French /u/ was not produced further back by half of CBs and two out of six SBs, which is contrary to the pattern found by MacLeod et

al. (2009) in early adult bilinguals and monolinguals. The remaining minority of two SBs and one CB produced the pattern found by MacLeod et al. with French /u/ produced more peripherally along both F1 and F2 dimensions, though differences were not significant (F1: SB $p = .7$, CB $p < .11$; F2: SB $p = .46$, CB $p = .92$). An observation from visual inspection of the vowels is that simultaneous bilinguals did produce clearer differentiation between English and French /u/, but not enough to reach significance.

Table 6. Pairwise comparison of English /i/ and French /i/

CBs	Eng /i/ and Fr /i/ height	Eng /i/ and Fr /i/ back	CBs	Eng /i/ and Fr /i/ Height	Eng /i/ and Fr /i/ Back
Bob	F/i/<E/i/	F/i/>E/i/	Beth	F/i/≥E/i/	F/i/>E/i/
Damon	F/i/≤E/i/	F/i/>E/i/	Cole	F/i/≥E/i/	F/i/>E/i/
Ella	F/i/>E/i/	F/i/<E/i/	Curt	F/i/>E/i/	F/i/<E/i/
Émilie	F/i/≥E/i/	F/i/>E/i/	Jenn	F/i/≥E/i/	F/i/≥E/i/
Fred	F/i/<E/i/	F/i/>E/i/	Lily	F/i/≥E/i/	F/i/>E/i/
Marlo	F/i/<E/i/	F/i/>E/i/	Sarah	F/i/<E/i/	F/i/>E/i/

Table 7. Pairwise comparison of English /u/ and French /u/

SBs	Eng /u/ and Fr /u/ height	Eng /u/ and Fr /u/ Back	CBs	Eng /u/ and Fr /u/ height	Eng /u/ and Fr /u/ Back
Bob	F/u/<E/u/	F/u/<E/u/	Beth	F/u/>E/u/	F/u/>E/u/
Damon	F/u/<E/u/	F/u/>E/u/	Cole	F/u/>E/u/	F/u/<E/u/
Ella	F/u/≤E/u/	F/u/<E/u/	Curt	F/u/>E/u/	F/u/<E/u/
Émilie	F/u/<E/u/	F/u/>E/u/	Jenn	F/u/=E/u/	F/u/>E/u/
Fred	F/u/>E/u/	F/u/>E/u/	Lily	F/u/>E/u/	F/u/<E/u/
Marlo	F/u/>E/u/	F/u/>E/u/	Sarah	F/u/<E/u/	F/u/>E/u/

As anticipated, significant difference was produced between English and French lax vowels (see Tables 8 and 9). French [ɪ] was produced significantly higher (F1: SB $p = .005$, CB $p = .0006$) and less centralized or less further back than English /ɪ/ (F2 SB $p = .009$, CB $p < .0001$), which is supported by MacLeod et al.'s (2009) results. In both front and back lax phones, the CBs produced a more significant difference across both languages than SBs. The difference was more pronounced in high front lax vowels than high back lax vowels.

Table 8. Pairwise comparison of English /ɪ/ and French [ɪ]

SBs	Eng /ɪ/ and Fr [ɪ] height	Eng /ɪ/ and Fr [ɪ] back	CBs	Eng /ɪ/ and Fr [ɪ] height	Eng /ɪ/ and Fr [ɪ] Back
Bob	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/	Beth	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/
Damon	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/	Cole	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/
Ella	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/	Curt	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/
Émilie	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/	Jenn	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/
Fred	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/	Lily	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/
Marlo	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/	Sarah	F[ɪ]>E/ɪ/	F[ɪ]<E/ɪ/

As predicted, French [ʊ] was produced significantly higher than English /ʊ/ (F1: SB, CB $p = .01$) but F2 was not significantly different across English and French productions (F2: SB $p = .25$, CB $p = .34$). MacLeod et al.'s (2009) results display a similar pattern. Linear regressions did not yield interesting results between English and French lax vowels in terms of age of acquisition of French or years of exposure to French.

Table 9. Pairwise comparison of English /ʊ/ and French [ʊ]

SBs	Eng /ʊ/ and Fr [ʊ]		CBs	Eng /ʊ/ and Fr [ʊ]	
	Height	Back		height	Back
Bob	F[ʊ]>E/ʊ/	F[ʊ]≤E/ʊ/	Beth	F[ʊ]>E/ʊ/	F[ʊ]<E/ʊ/
Damon	F[ʊ]>E/ʊ/	F[ʊ]≥E/ʊ/	Cole	F[ʊ]>E/ʊ/	F[ʊ]≥E/ʊ/
Ella	F[ʊ]>E/ʊ/	F[ʊ]<E/ʊ/	Curt	F[ʊ]>E/ʊ/	F[ʊ]≤E/ʊ/
Émilie	F[ʊ]>E/ʊ/	F[ʊ]≤E/ʊ/	Jenn	F[ʊ]>E/ʊ/	F[ʊ]<E/ʊ/
Fred	F[ʊ]>E/ʊ/	F[ʊ]<E/ʊ/	Lily	F[ʊ]>E/ʊ/	F[ʊ]<E/ʊ/
Marlo	F[ʊ]≥E/ʊ/	F[ʊ]≤E/ʊ/	Sarah	F[ʊ]>E/ʊ/	F[ʊ]<E/ʊ/

3.1.3 French Front Rounded Vowels

French front rounded vowels were compared to French front unrounded and back rounded vowels with similar featural specifications (see Tables 10 through 13). All predictions, based on the adult configuration of vowels in MacLeod et al. (2009), Martin (2002) and Flege (1987), were validated; there was good separation between pairs. CBs produced more significant spread between front rounded vowels /y/ and [ʏ] and front unrounded vowels /i/ and [ɪ]. SBs produced more significant spread between front rounded vowels /y/ and [ʏ] and back rounded vowels /u/ and [ʊ], as is particularly evident in the tense pairs, shown in the linear regressions in Figure 10 and 11.

There was a significant difference between French high front rounded vowels and French high front unrounded vowels along the backness (F2) dimension for CBs, but SBs missed significance for /y/ and /i/ (F2: */y/ & /i/*, SB $p = .09$, CB $p = .0004$; *[ʏ] & [ɪ]*, SB $p = .007$, CB $p = .003$; */y/ & /u/*, SB $p < .0001$, CB $p = .002$); *[ʏ] & [ʊ]*, SB $p < .0001$, CB $p = .001$). The difference in height (F1) was not significant for any pair (F1: */y/ & /i/*, SB $p = .32$, CB $p = .31$; *[ʏ] & [ɪ]*, SB $p = .2$, CB $p = .13$; */y/ & /u/*, SB $p = .21$, CB $p = .6$; *[ʏ] & [ʊ]*, SB $p = .6$, CB $p = .7$). This is again similar to Martin's (2002) findings.

Table 10. Pairwise comparison of French /y/ and French /i/

Sbs	Fr /y/ and Fr /i/		CBs	Fr /y/ and Fr /i/	
	height	back		height	Back
Bob	/y/</i/	/y/>/i/	Beth	/y/</i/	/y/>/i/
Damon	/y/</i/	/y/>/i/	Cole	/y/>/i/	/y/>/i/
Ella	/y/≤/i/	/y/>/i/	Curt	/y/>/i/	/y/>/i/
Émilie	/y/≥/i/	/y/>/i/	Jenn	/y/</i/	/y/>/i/
Fred	/y/</i/	/y/>/i/	Lily	/y/>/i/	/y/>/i/
Marlo	/y/>/i/	/y/>/i/	Sarah	/y/</i/	/y/>/i/

Table 11. Pairwise comparison of French [ʏ] and French [ɪ]

SBs	Fr [ʏ] and Fr [ɪ]		CBs	Fr [ʏ] and Fr [ɪ]	
	height	back		height	Back
Bob	[ʏ]<[ɪ]	[ʏ]>[ɪ]	Beth	[ʏ]<[ɪ]	[ʏ]>[ɪ]
Damon	[ʏ]<[ɪ]	[ʏ]>[ɪ]	Cole	[ʏ]<[ɪ]	[ʏ]>[ɪ]
Ella	[ʏ]<[ɪ]	[ʏ]>[ɪ]	Curt	[ʏ]<[ɪ]	[ʏ]>[ɪ]
Émilie	[ʏ]≤[ɪ]	[ʏ]>[ɪ]	Jenn	[ʏ]<[ɪ]	[ʏ]>[ɪ]
Fred	[ʏ]≤ [ɪ]	[ʏ]>[ɪ]	Lily	[ʏ]<[ɪ]	[ʏ]>[ɪ]
Marlo	[ʏ]<[ɪ]	[ʏ]>[ɪ]	Sarah	[ʏ]<[ɪ]	[ʏ]>[ɪ]

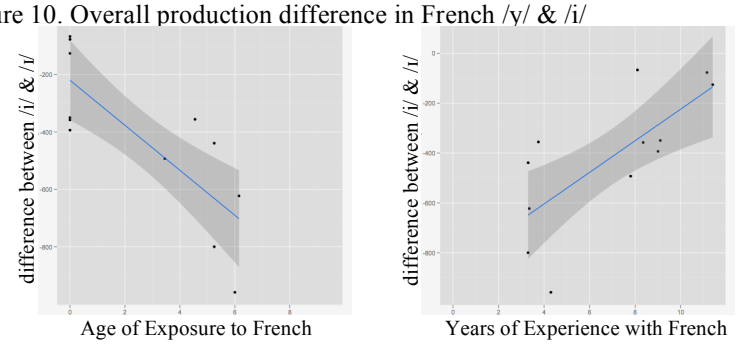
Table 12. Pairwise comparison of French /y/ and French /u/

SBs	Fr /y/ and Fr /u/		CBs	Fr /y/ and Fr /u/	
	height	back		Height	Back
Bob	/y/</u/	/y/</u/	Beth	/y/</u/	/y/</u/
Damon	/y/</u/	/y/</u/	Cole	/y/>/u/	/y/</u/
Ella	/y/>/u/	/y/</u/	Curt	/y/</u/	/y/</u/
Émilie	/y/</u/	/y/</u/	Jenn	/y/>/u/	/y/</u/
Fred	/y/</u/	/y/</u/	Lily	/y/>/u/	/y/</u/
Marlo	/y/</u/	/y/</u/	Sarah	/y/</u/	/y/</u/

Table 13. Pairwise comparison of French [ʏ] and French [ʊ]

SBs	Fr [ʏ] and Fr [ʊ]		CBs	Fr [ʏ] and Fr [ʊ]	
	height	back		height	Back
Bob	[ʏ]≥[ʊ]	[ʏ]<[ʊ]	Beth	[ʏ]>[ʊ]	[ʏ]<[ʊ]
Damon	[ʏ]<[ʊ]	[ʏ]<[ʊ]	Cole	[ʏ]≤[ʊ]	[ʏ]<[ʊ]
Ella	[ʏ]<[ʊ]	[ʏ]<[ʊ]	Curt	[ʏ]≤[ʊ]	[ʏ]<[ʊ]
Émilie	[ʏ]>[ʊ]	[ʏ]<[ʊ]	Jenn	[ʏ]≤[ʊ]	[ʏ]<[ʊ]
Fred	[ʏ]≤[ʊ]	[ʏ]<[ʊ]	Lily	[ʏ]≥[ʊ]	[ʏ]<[ʊ]
Marlo	[ʏ]<[ʊ]	[ʏ]<[ʊ]	Sarah	[ʏ]>[ʊ]	[ʏ]<[ʊ]

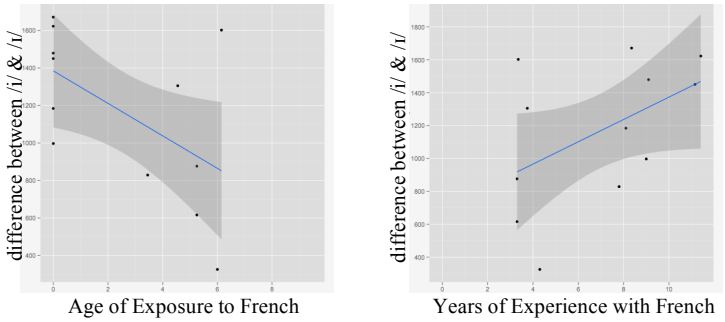
Figure 10. Overall production difference in French /y/ & /i/



The linear regressions in Figure 10 suggest that participants with a later age of exposure to French, and those with fewer years of experience with French produced French /y/ significantly distinct from /i/ (*Age* rˆ = .585,

$p = .002$, *Years* $r^2 = .475$, $p = .008$). The linear regressions in Figure 11 suggest that participants with a later age of exposure to French, and those with fewer years of experience with French produced less difference between /y/ and French /u/ (*Age* $r^2 = .229$, $p = .07$, *Years* $r^2 = .16$, $p = .11$). Therefore, as Flege (1987) found, more experience with French enables bilinguals to create a front rounded category for /y/ that is further forward, closer to monolingual French /y/ category. It is interesting to note that acquiring the front or back /y/ category does not appear to have caused these SBs or CBs respectively to produce French /u/ significantly further back, as research in experienced early bilingual adults and monolingual French speakers has shown (Flege 1987; MacLeod et al. 2009; Martin 2002).

Figure 11. Overall production difference in French /y/ & /u/



The results represent an emerging system approaching adult patterns, already quite similar to those reported by MacLeod et al. (2009) Martin (2002), but not fully developed.

The first of the three specific questions I asked, whether differences in production would be found between each group, was confirmed. SBs followed the adult patterns for both languages more closely than CBs, and CBs strayed from adult patterns, most notably in two manners. First, CBs produced tense round /y/ as further back in general, and specifically further back than lax round [ʏ]. Second, CBs produced English tense back /u/ further back than French /u/. Both groups deviated from adult productions in their production of English tense front /i/ as further back than French /i/.

Among the SBs the difference between English tense-lax pairs was smaller than for the CBs or the English monolinguals. I interpreted this as an effect of earlier acquisition of French. The greater difference between French tense-lax pairs as produced by CBs can be interpreted as an effect of L1 English. As in adult productions, these children produce overlap in similar tense categories across both languages and they captured the difference between English and French lax vowels attested in MacLeod et al. (2009) and Martin (2002). Furthermore, in terms of differences, CBs have not fully established French /u/ as more peripheral than English /u/. Both groups had established categories for the "different" front rounded vowels /y/ and [ʏ] found in only French, but CBs category for /y/ was further back, and SBs'

further forward. These results are suggestive of a bidirectional influence on lax vowels and were stronger among the participants who were exposed to French at a younger age and those who had more years of continued exposure to French.

The second and third questions, whether there is an effect of age of exposure to French, and whether there was an effect of experience on production, were both validated. Summary linear regressions suggest an effect of age of exposure to French and years of experience with French. Both effects were linked to a bidirectional effect observed in both groups. All participants had established separate categories for French front rounded allophones, but participants with a younger age of exposure to French and those who had had more years of experience with French category was produced further forward yet distinct from front unrounded allophones, resembling an adult French monolingual production pattern. They also produced less difference between English tense and lax vowels, and produced French front tense-lax pairs in the expected adult configuration. Participants with a later age of exposure to French and those who had had fewer years of experience with French produced further back yet distinct from back rounded allophones.

To address the main question addressed in this study, what is the nature of the Canadian English and Canadian French bilingual child's phonemic inventory in the lexicon: are simultaneous and consecutive bilinguals' phonological system(s) autonomous or interdependent? The bidirectional effect found in the lax vowels suggests two seemingly autonomous but interdependent phonological systems, with more established monolingual-like categories in both languages for SBs, and more established English categories for CBs. However more research is needed to gain a firmer understanding of the development of these categories.

4. Conclusion

The results of this study were examined as individual profiles, which attest to the heterogeneity of the bilingual experience. As in Guion (2003), group membership was not consistently a predictor of individual production. In some pairwise comparisons the behaviour of one or two individuals deviated from the rest of the group. Crucially, these eight to twelve year-old CBs do not appear to be at an irrecoverable or unintelligible advantage disadvantage. Overall, they have established distinct categories and produce quite similar patterns of production to SBs despite having acquired French later.

Despite its modest size, this study makes a unique contribution to the study of bilingual development because it investigates the evolving phonological inventories of two types of child bilinguals, and because bilinguals were tested in both of their languages and compared to productions of adult bilinguals and monolinguals.

This is a topic worthy of further investigation, specifically a cross-sectional or longitudinal study of English-French simultaneous and consecutive bilinguals to document the acquisition process and development of phonological categories for both languages over time.

References

Best, Catherine T. 1994. The emergence of native language phonological influences in infants: A perceptual assimilation model. In *The development of speech perception: The transition from speech sounds to spoken words*, eds. Judith C. Goodman and Howard C. Nusbaum, 167-224. Cambridge, MA: MIT Press.

Boersma, Paul and Weenink, David. 2009. Praat: doing phonetics by computer [Computer program]. Version 5.1.18, retrieved October 8 2008 from http://www.praat.org/ Upgraded January 9 2009.

Cebrian, Juli. 1996. Voicing in Final Obstruents and the Transfer of Phonological Rules in Catalan-English Interlanguage. Master's thesis, University of Toronto.

Côté, M. H. 2005. Phonologie française. Ms., University of Ottawa.

Flege, James E. 1987. The production of "new" and "similar" phones in a foreign language: evidence for the effect of equivalence classification. *Journal of Phonetics* 15:47-65.

Flege, James E. 1995. Second language speech learning: Theory, findings and problems. In *Speech perception and linguistic experience: Issues in cross-language research*, ed. Winifred Strange, 233-277. Baltimore: York Press.

Guion, Susan G. 2003. The Vowel Systems of Quichua-Spanish Bilinguals: Age of Acquisition Effects on the Mutual Influence of the First and Second Languages. *Phonetica*, 60:98-128.

Hagiwara, R. (2006). Vowel production in Winnipeg. *Canadian Journal of Linguistics, 51*(2/3), 127-141.

Ladefoged, Peter. 2001. Vowels and Consonants: An introduction to the sounds of languages. Malden, MA: Blackwell Publishers Ltd.

MacLeod, Andrea A. N. 2006. Production and perception of VOT and high vowels by bilingual and monolingual speakers of Canadian English and Canadian French. Doctoral dissertation, University of Washington. *Dissertation Abstracts International*, 67(07), 2554.

MacLeod, Andrea A.N., Stoel-Gammon, Carol, and Wassink, Alicia B. 2009. Production of high vowels in Canadian English and Canadian French: A comparison of early bilingual and monolingual speakers. *Journal of Phonetics*, 37:374-387.

Martin, Pierre. 2002. La système vocalique du français du Québec de l'acoustique à la phonologie. [The vowel system of Québec French from acoustics to phonology.] *La Linguistique*, 38:71-88.

Smith, Anne and Zelaznik, Howard N. 2004. Development of Functional Synergies for Speech Motor Coordination in Childhood and Adolescence. *Developmental Psychobiology*, 45(1):22–33.

Walker, Douglas C. 1984. *The Pronunciation of Canadian French*. [Online edition]. Ottawa, ON: University of Ottawa Press. Retrieved December 4, 2008 from the University of Calgary, Department of Linguistics Web Site: http://www.ucalgary.ca/~dcwalker/PronCF.pdf