English Coronal Consonants Produced by L2 French Learners - An Articulatory and Acoustic Study

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Abstract

This work concentrates on acoustic and articulatory properties of coronal consonants /t, d, n/ produced by French learners in English. Articulatory data are collected using static palatography. The study thus relates to L2 acquisition at a phonemic (phonetic) level. The advanced learners in English (AL) will show a shift in production between French and English sounds, whereas the beginners (BE) will articulate L1 and L2 sounds similarly.

1 Introduction

There are well-established differences in how /t, d, n/ are produced in English and French. These consonants tend to be lamino-dental in French as opposed to apico-alveolar in English (Dart [1]), i.e. both the active articulator (tongue blade vs. tip) and the place of articulation (dental vs. alveolar) differ between the two languages. However, variations can appear for a given language, Dart [1] showed about 30% of French productions realized with alveolar gestures by natives. Few articulatory studies have been conducted as of yet, partly because articulatory data in the production of speech are particularly complex to collect and analyse.

2 Issues addressed

The issue addressed in this work is whether French learners will show an articulatory shift towards an apico-alveolar configuration in the production of these consonants. Flege's Speech Learning Model [2] considers that "similar phones", i.e. phones that belong to the same phonemic category in L1 and L2 but that differ in their phonetic realization (like English and French /t/, /d/

or /n/), will, due to the proximity of the sounds of both languages, result in a difficult learning of a new articulatory pattern for the L2 sound, necessary to its correct production. We will see if AL will be able to produce English phonemes accurately, despite this great difficulty mentioned in this theoretical framework.

We predict that a French BE will produce these English consonants /t, d, n/ as dentals, and that AL will have a tendency to produce them as alveolars, but not systematically however, keeping in mind the difficulty mentioned in Flege's model, and also the variations observed by Dart.

Acoustically, these differences in place of articulation will be associated with a lower onset F2 frequency in the post-consonantal vowel (consistent with a more dental articulation) [3], for consonants produced by BE compared with AL.

3 Method

Two groups of French university students (and teachers) in English were tested. Group 1 was composed of five BE, having entered university one month and a half before the recordings, and having never travelled in an English speaking country, and Group 2 of five AL (English phonetics teachers at university, or Ph.D. students in English phonetics). All the speakers learned English at school (from the age of about 10), none have English relatives, nor the opportunity to speak English on a daily basis (except for their studies).

The material was made up of a series of six phonetically-similar pairs of monosyllabic English (on the left) and French (on the right) words or pseudo-words: damn /dæm/-dame/dam/ ; nap /næp/-nappe /nap/ ; dab /dæb/-dab /dab/ ; nib /nɪb/-nib /nib/ ; deb/deb/-deb /dɛb/ ; nip /nɪp/-nippe /nip/

For the acoustic recordings, each word was spoken within a carrier sentence (creating a phonetic context), with five repetitions for each sentence:

Il reprend … encore (French words)

Put up a … above all (English words)

We then carried out an articulatory study with the same speakers using static palatography. A mixture of dessert cream and medicinal charcoal was applied on the subject's tongue prior to her/his producing each word in isolation. A digital photography of the palate's image, as reflected by a purpose-built mirror, was taken immediately afterwards and transferred onto a computer for further processing.

The pairs tap/tape, damn/dame and nap/nappe have been chosen for analysis (as the initial consonant is followed by an open vowel and thus restricting undesired tongue/palate contacts), with two repetitions for each (the productions of /t/ are missing for one AL).

4 Results

4.1 Acoustic results

We focused our work on the frequency of the second formant, as it is a good indication of the consonant locus. We based our study on Sussman & al. [4], i.e. one measure was taken at the onset of the vowel following the consonant chosen for analysis, and another measure was taken at a more stable point of that vowel, at its mid-point. We focused on the structure of the transition from the onset of the vowel to a more stable point of it, as looking only at the vowel onset could falsify the data due to the intrinsic relation between F2 onset and F2 stable frequencies [3]. We wanted to see if there were differences in the structures of the transitions depending on the language spoken and the group of speakers.

We conducted statistical analyses in a linear mixed-effects model, with "onset F2 frequency" as dependent variable, "F2 stable frequency" (onset measures analysed for an F2 mid-point frequency of 1900 Hz), "Group" (AL, BE), and "Language" (French, English) as fixed factors, and "Subjects" and "Consonant" (/d/, /n/) as random factors.
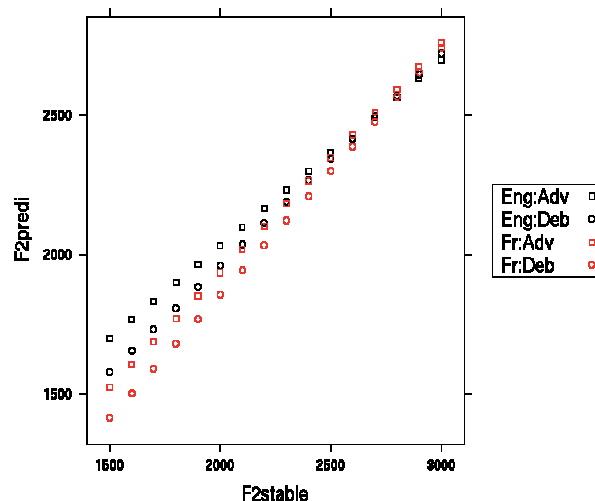

Figure 1: *Linear regressions ("F2 onset frequency" (on the "y" axis), and "F2 stable frequency" (on the "x" axis) variables) of English and French consonants produced by AL and BE.*

The first observation is the existing link between the frequency values of F2 at the vowel onset and at the vowel mid-point, which proves significant ($t(574) = 30.6$, $p < 0.001$). We also observed a statistically significant difference between French and English F2 onset values on linear regression lines (measures centred at 1900 Hz on F2 stable), French intercepts being 113 Hz lower than English ones ($t(574) = -10.063$, $p < 0.01$), what we expected. Also, the results concerning the "Group" factor proved statistically significant ($t(8) = -3.453$, $p < 0.01$), the onset F2 frequency at the intercept of F2 stable centred at 1900 Hz happen to be higher for AL (1967 Hz) than for BE (1889 Hz), as expected. Looking at the interaction Group*Language, no statistical significance was observed (ANOVA : $F(1,574) = 0.47$, $p = 0.49$) meaning that the difference between French and English onset F2 values is roughly the same between BE and AL.

4.2 Palatographic results

A classification of the photographs in three groups was made : dental (when the whole back of the incisors was touched by the tongue), dento-alveolar (when only part of the back of the incisors was touched), and alveolar (productions which did not touch the incisors at all).

Figure 2: *Articulatory classification in 3 categories: dental (left), dento-alveolar (middle), and alveolar (right).*

English consonants were produced, as expected and for the majority, as alveolars by AL (69%), and never as dentals. However, but as expected also, most of these consonants are articulated as dentals (60%) when produced by BE, i.e. correspond to the French consonants properties (cf. table 1).

Table 1. *Articulation of English /t, d, n/ by AL (left) and BE (right).*

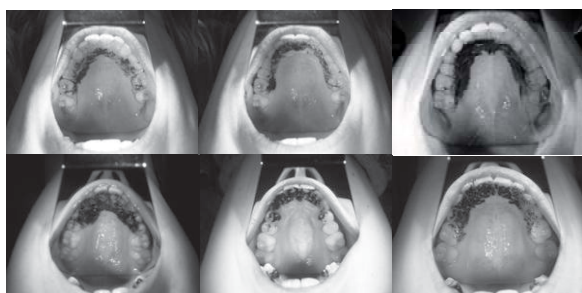|	dental:	dento-alveolar:	alveolar:
Total	0% | **60%**	31% | 33%	**69%** | 7%
/t/	0% | **50%**	25% | **50%**	**75%** | 0%
/d/	0% | **70%**	44% | 20%	**56%** | 10%
/n/	0% | **60%**	22% | 30%	**78%** | 10%

Figure 3: *Samples of correct productions of English /t, d, n/ (tap, damn, nap) (from left to right) by AL (top) and BE (bottom).*

French consonants are generally produced as dento-alveolars by AL as well as BE (42% and 40% respectively), but the productions also appear to be sometimes dental (BE's productions are actually divided between dental and dento-alveolar when looking closer at it). More surprisingly, some of these consonants are produced as alveolar for both groups of speakers (cf. table 2).

Table 2. *Articulation of French /t, d, n/ by AL (left) and BE (right).*

	dental:	dento-alveolar:	alveolar:
Total	31% | **37%**	**42%** | **40%**	27% | 23%
/t/	**50%** | 40%	25% | **50%**	25% | 10%
/d/	22% | **50%**	**56%** | 20%	22% | 30%
/n/	22% | 20%	**45%** | **50%**	33% | 30%

Table 3. *Articulation of English and French /t, d, n/ by each AL (A1 to A5) and each BE (B1 to B5).*

	den	d-alv	alv		den	d-alv	alv	
B1	5|2	1|1	-|3	**A1**	-|-	1|2	1|-	**En | Fr**
B2	3|-	2|3	1|3	**A2**	-|3	1|2	5|1	**En | Fr**
B3	5|4	1|2	-|-	**A3**	-|1	3|5	3|-	**En | Fr**
B4	4|3	2|2	-|1	**A4**	-|-	2|1	4|5	**En | Fr**
B5	1|2	4|4	1|-	**A5**	-|4	1|1	5|1	**En | Fr**

Each speaker's results (cf. table 3) show that only two BE (B1 and B2) produced English and French consonants differently (mostly dental in English and alveolar in French), but opposite to the general patterns observed in the literature. The other BE produced English and French consonants globally at the same place, i.e. mainly as dentals for B3 and B4, and as dento-alveolars for B5. Only 2 words out of 30 were produced "properly" by BE (B2 and B5), i.e. as alveolars.

AL A2 and A5 produced a majority of French consonants as dentals, and of English consonants as alveolars. A3 also articulated French and English phonemes differently, with English ones divided between dento-alveolar and alveolar gestures, and French ones mostly with dento-alveolar gestures. Only A4 produced both languages' consonants globally at the same place, i.e. as alveolars.

5 Discussion

We saw that F2 frequencies at vowel onset and mid-point are closely related, the results having thus to be treated with care. This means that F2 frequency at vowel onset depends on the colour of that vowel. We can suppose that BE produced English and French vowels identically, and also produced the consonants of both languages similarly. So the difference between French and English results concerning BE are quite unexplainable.

The palatographic data concerning English consonants reveal that AL actually shifted the place of articulation from one language to another, in order to reach a native-like way of producing their L2 consonants, which is not true for BE. French consonants were for the majority articulated as dento-alveolars, for both groups of speakers, whereas they are generally considered as being dental in the literature. These differences observed, as compared with the general patterns admitted in the literature, must be regarded as natural, since variations from these general patterns are not considered as inaccurate productions (Dart [1], cf. our introduction).

Our acoustic and palatographic data seem to converge as regards French consonants. F2 linear regressions (figure 1) appeared to be lower for BE than for AL, which is explainable with the palatographic study, where BE produced French consonants more often as dental than AL.

There seems to be a discrepancy in the acoustic and palatographic results concerning BE, the acoustic analyses showing a different articulatory pattern in the production of the Consonant-Vowel transitional structure between French and English, and the palatographic ones proving clearly that English consonants were produced in a French manner. This can be explained by considering what is precisely observed in each analysis, the acoustic study focussing on the articulatory temporal adjustments during the transitional sequence Consonant-Vowel, and the palatographic one on the exact moment when the tongue touched the palate during the production of the consonant. Although F2 frequency at the vowel (following the consonant studied) onset is generally considered as being a good indicator of the consonant locus, the measures do not correspond to the exact moment of the tongue/palate contact showed through palatographic analysis. This apparent contradiction between the acoustic and palatographic results could also reside in tongue shape differences being made which are affecting F2 but not having any palate contact correlates.

6 Conclusion

This study concentrating on the production of English /t, d, n/ by French native learners shows that experienced speakers are able to produce accurate L2 sounds, contrary to the beginners in English. This is particularly interesting concerning the age of acquisition, as it is generally argued that L2 phonemes have to be acquired very early to become native-like.

The accurate production of speech sounds in L2 needs a different coordination of supra-laryngeal articulators, as compared to native sounds. From this study, we can argue that AL are sensitive to the articulatory differences between L1 and L2 phonemes despite the fact that these differences are sub-phonemic. From these results, it can be said that Flege's Speech Learning Model predictions (cf. issues addressed) are confirmed, a great experience of the L2 being necessary to produce L2 phones having an easily identifiable counterpart in the L1 accurately.

7 Acknowledgements

8 References

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