MONOLINGUAL AND PLURILINGUAL STRATEGIES IN THE ARTICULATION OF FRENCH R: A CASE STUDY

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ABSTRACT

This case study describes lingual articulatory strategies for French [ʁ] as it pertains to a monolingual, native speaker of French, and two English-Spanish bilinguals, learners of French as their third language (L3). We tracked movements of the tongue using electromagnetic articulography (EMA) in order to investigate inter-speaker differences involving rhotic production in word-initial and final positions. Curve trajectories were compared using generalized additive models (GAMs). Findings indicate active involvement of tongue tip in rhotic articulation, native speaker included. Raising of tongue dorsum in language learners points towards a velar constriction, not uvular. Varying articulation strategies by language learners are interpreted as an indication of language interference. Duration differences and curve complexity as indices of native-like degree of coarticulation were closely linked to the learner's amount of exposure to the target language.

Keywords: EMA, language learner, rhotics, French, coarticulation.

1. INTRODUCTION

Literature on articulatory descriptions of uvular fricatives has been relatively scarce. Moreover, only a few works have attempted to describe the French uvular rhotic [1, 2]. As a result, gestural configurations of these sounds are still poorly understood. The uvular fricative [χ, ʁ] is characterised by the coordination of a tongue body raising gesture and tongue root retraction toward the pharyngeal cavity [3]. Data also suggests that the raising of the tongue body only accounts for 58 percent of uvular constriction. According to Gick et al. [4], velar lowering makes up for the remaining 42 percent. In comparison, tongue tip movements in the articulation of uvular fricatives are minimally described and thus considered to have a minimal role. Nevertheless, ultrasound recordings of uvular fricatives in Upper Sorbian [3] documented less raised tip/blade in /a/ environments. The goal of this study is to describe lingual articulatory strategies for French [ʁ] as it pertains to a monolingual, native speaker of French, and two English-Spanish bilinguals, learners of French as an L3 with varying times of exposure to the target language.

The Spanish phonological inventory has two rhotic phonemes used contrastively in the intervocalic position only: a tap and a trill [5]. Tongue root retraction has been observed for both tap and trill [2, 6]. The level of retraction appears to be more prominent for [ɾ] than for [r] [7]. Since [ɾ] is the only rhotic sound that appears in word-final position in Spanish, a Spanish-dominant bilingual would be expected to retract more in word-final position. The tongue tip place of articulation is described as alveolar but height can vary due to vocalic context. In /a/ environments, the tongue tip is slightly lower but canonically alveolar as opposed to other closed vowels where tongue-tip position is higher and slightly more posterior [7].

The American English /ɹ/ has been studied extensively due to the idiosyncratic nature of its articulatory configurations and a complexity that lies in the coordination of three independent gestures [8-11]. Production of the English rhotic involves retraction of the tongue root towards the pharyngeal wall, raising of the tongue tip/body toward the alveolar ridge/palate (retroflex/bunched), and rounding of the lips. Campbell et al. [12] found that the magnitude of constriction for the tongue root/blade varied according to syllabic position with reduction in tongue body retraction in word-final position and emphasis of tongue root retraction in word-initial position. Thus, an English-dominant bilingual would show less retraction in word-final position.

French /ʁ/ occupies the same phonological category as its Spanish and American English counterparts but articulatory gestures vary depending on the language. A study [13] found that bilinguals, perceived as native speakers in both languages, employed distinct language-specific articulatory settings. In order for that to happen, late learners would have to correctly identify allophones of the same category phonologically and phonetically [14]. A couple of previous studies have concentrated on coarticulation differences in native vs. non-native speakers [15, 16]. Both studies concluded that more experienced learners developed more native-like degrees of coarticulation than less experienced learners did. Moreover, high frequency words tend to have shorter durations and fewer segments [17, 18]. Words chosen for this case study are considered high-frequency thus resulting in smoother curves, an indication of native-like coarticulation degrees. We expect late learners in this case study to employ French articulatory gestural strategies and coarticulation degrees according to their level of exposure. [19] posits that the quantity and quality of L2 input that learners receive influence the long-term learning of L2 speech, or L3 in this case.

2. METHODOLOGY

Three speakers participated in this case study. One female 52 y.o. native speaker of French from the Paris region with very little exposure to English or Spanish (FR), one male 34 y.o. native speaker of Spanish, exposed to American English before the age of 5 (SP), and one female 30 y.o. native speaker of American English, exposed to Spanish after the age of 10 (EN). The language learners were first exposed to French in a formal setting after the age of 13 but differ in times of naturalistic exposure to the target language. SP has been living in France for six years while EN has only been in France for six months. Language levels were not formally evaluated but it's worth nothing that SP was at a C1 level upon entering the country. EN was less fluent, but still able to carry out a conversation in French.

Participants were asked to repeat the words '*rat*' and '*par*' three times. Words were placed in the carrier sentence '*Ils disent* ___ *sept fois*' ('They said ___ seven times'). These are two relatively high-frequency words in French with a rhotic consonant in word-initial and word-final position.

Articulatory data was recorded using electromagnetic articulography (EMA; AG 501). Displacement measurements in millimetres were recorded along the horizontal (front-back) and vertical (high-low) axis with four captors placed along the midsagittal plane of the tongue as follows: one captor as far back as possible on the tongue dorsum (TD), two middle captors 1 cm apart, one near the back (TB) and one near the front (TF), one last captor on the tip of the tongue (TT). Two captors were placed on the mastoid processes for spatial reference and in order to correct for deviations in head position during the post-processing stage of the data [20].

Displacement trajectories were visualized and extracted using EMA2WAV [21]. Annotations were done manually on Praat and included gesture offset for the first alveolar consonant preceding the target word and gesture onset for the second alveolar consonant following the target word. Trajectory curves were drawn from measurements taken at 100 points at regular intervals within the target word. The mgcv package [22] was used to analyse for significance amongst speakers. A generalized additive model (GAM) model with a random effect was fit using the formula *captor ~ speaker + s(normalized time, by = speaker) + s(speaker, bs = "re")*. The smooth components are centred around zero with a varying intercept along interpolated normalized times [23, 24]. Variability is shown by overlaying counter plots.

3. RESULTS

Curves were compared by fitting GAMs and partial effects are plotted independently as component effects of the smooth (time) and linear terms (speakers) in the model. This also allowed us to accurately portray rhotic segment trajectories (column 1) and rhotic gesture durations (dotted lines) for each of the speakers based on individual averages. Column 4 shows comparisons between speakers with significant differences marked in red (column 4). Lines correspond to the captors used to measure displacement. Standard errors show 95 percent interval for the mean shape of the effect.

3.1. R in word-initial position

As shown in Fig. 1, TT gesture onset for SP is higher than FR and EN. FR and SP show similar articulatory strategies by lowering both the back (TD and TB) and the front of the tongue (TF and TT). EN shows a different strategy by raising the back of the tongue and then gradually lowering it for the vowel gesture. TF and TT are lowered by all speakers.

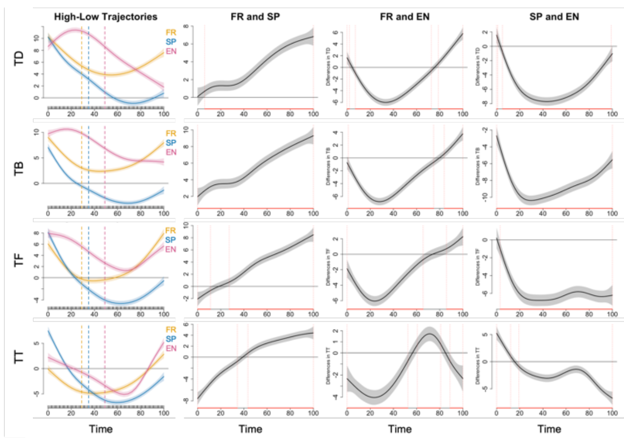

Figure 1: Column 1 shows high-low displacement in mm for the word 'rat'. Dotted lines: start of rhotic gestures per speaker. Columns 2 – 4: significant differences between speakers (in red). Drops in trajectory correspond to tongue lowering.

The lowest point in the curve for TD and TB corresponds to the low vowel gesture at maximum constriction. TD and TB curves for FR show the least amount of change. SP shows the lowest dip amongst the speakers. Curve trajectories appear more complex for EN than for FR and SP.

ANOVA revealed significant values for the effect of speaker on the smooth of the spline for TD, TB, TF, and TT (mean edf = 7.361, p<2e-16). Partial significance between speakers was found at gesture onset for TD. Analysis also showed partial significance for TF differences between FR and SP. TD, TB, and TF rhotic gestures are higher for EN than for FR and SP. Vowel gestures are lower for SP than for FR and EN. There is less of a difference between FR and SP's rhotic gestures as it concerns TD, TB, and TF. See fig 1 column 2.

Front-back displacement for the word 'rat' is plotted in Fig 2. SP and FR show similar articulatory strategies (see curve trajectories for TF and TT). Tongue retraction is present in both SP and FR but gesture transitions are less noticeable for FR. SP advances TD slightly for the vowel gesture. EN's articulation of the rhotic segment differs from the other speakers: the speaker advances the tongue instead of retracting it.

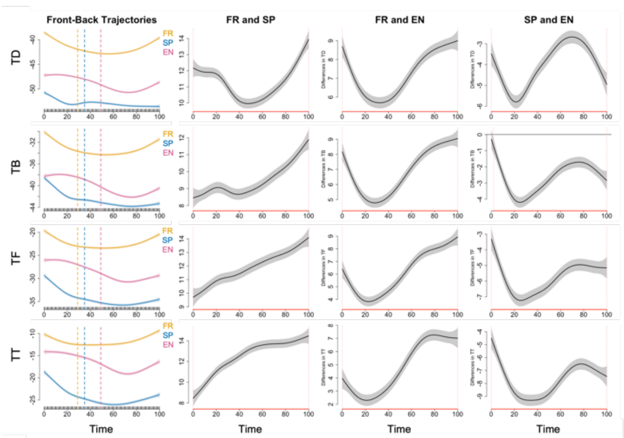

Figure 2: Column 1 shows front-back displacement in mm for the word 'rat'. Dotted lines: end of rhotic gestures per speaker. Columns 2 – 4: significant differences between speakers (in red). Drops in the trajectory correspond to tongue retraction.

Significant effects on the smooth found across speakers for all captors (mean edf = 7.084, p<2e-16). When compared to the other speakers, EN shows significant advancement of the tongue towards the end of the rhotic gesture. SP retracts the tongue further back than EN and FR. The overall tongue position for FR is more advanced than it is for the other two speakers (see column 1 of Fig. 2). Smooth values closest to 0 intercept for FR and EN where TF and TT are concerned. Differences amongst all speakers were more pronounced for the front-back dimension as interpreted from partial significance and values approaching 0 intercept for rhotic gestures in the high-low dimension. SP had the longest average duration for the word "rat" at 343 ms (σ: 32), followed by EN at 307 ms (σ: 21), and FR at 234 ms (σ: 20).

3.2. R in word-final position

An ANOVA revealed significant values for the effect of speaker on the smooth of the spline for TD, TB, TF, and TT (mean edf of 7.361, p<2e-16). Displacement for the rhotic in *'par'* plotted in Fig. 3 coincides with rhotic articulatory configurations for EN and FR in the word 'rat'. EN presents noticeable raising of TD, TB, and TF, followed by a slight fall at gesture offset. FR raises the entirety of the tongue during the rhotic gesture with what seems like a steeper slope for TF and TT.

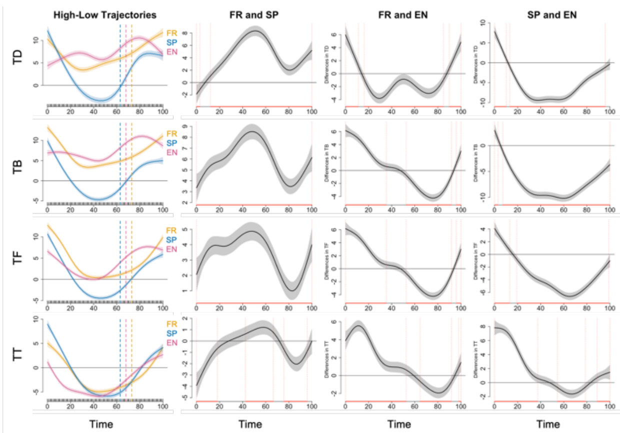

Figure 3: Column 1 shows high-low displacement in mm for the word 'par'. Dotted lines: start of rhotic gestures per speaker. Columns 2 – 4: significant differences between speakers (in red). Drops in trajectory correspond to tongue lowering.

SP raises TD after the vowel gesture and slightly lowers it at the end of the rhotic gesture. TB is also raised but does not appear to fall at gesture offset, it plateaus instead. TF, and TT are all raised and continue to rise until the end. Partial significance for TT was found in all speakers with similar trajectories in column 1. Partial significance at gesture offset was found for TD, TB, and TF between FR and EN.

Front-back displacement in Fig. 4 shows tongue advancement during rhotic articulation for FR and EN. SP shows slight advancement for all four captors but TD and TB undergo a slight fall at gesture offset. Significant differences were found across speakers for the effects of the smooth on the spline (mean edf = 7.091, p<2e-16) for all captors. FR rhotic articulatory gestures are significantly more anterior than gestures for EN and SP. Tongue gestures are consistently more posterior for SP than for FR and EN for both vowel and rhotic articulation. TB rhotic gestures approach 0 intercept for SP and EN making differences only partially significant. Overall differences between speakers were more prominent where front-back trajectories were concerned. EN had the longest mean duration for the word “par” at 611 ms (σ: 81), followed by SP at 480 ms (σ: 54), and FR at 372 ms (σ: 40).

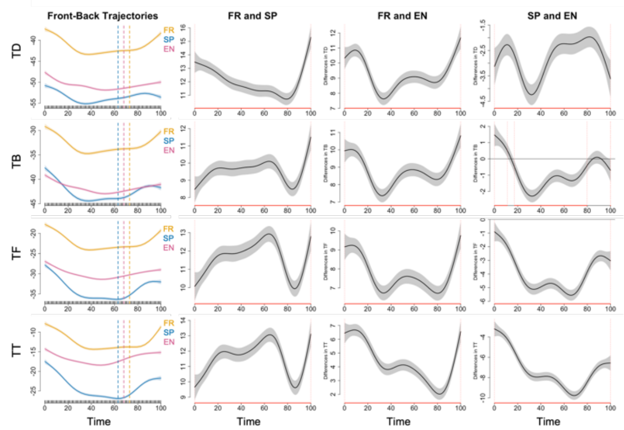

Figure 4: Column 1 shows front-back displacement in mm for the word ‘par’. Dotted lines: the start of rhotic gestures per speaker. Columns 2 – 4: significant differences between speakers (in red). Falls in the trajectory correspond to the posteriorization of captor.

4. DISCUSSION

Tongue tip lowering for all speakers suggests an active involvement of the front part of the tongue for rhotic articulation in French but only in initial position. Articulatory studies that describe lingual configurations for [ʁ] either omit tongue tip movement altogether or simply describe it as unsolicited during uvular rhotic production [3]. This lowering could be due to an all-encompassing lowering of the tongue for the vowel gesture. Future studies will describe rhotic production in multiple contexts and in a larger number of participants. Westbury’s EMA study [10] did not find any significant links between tongue shape and oral cavity size, or gender, for American /ɹ/. However, no known studies have tested the same effects on French /ʁ/, or uvular rhotics in general. Influence of physiological factors remains inconclusive. Articulatory strategies varied significantly across speakers. EN raised tongue dorsum and body for word-initial and final positions suggesting a lower point of constriction for the alveolar consonant at both ends of the word. SP shows a higher point of articulation in relation to the alveolar boundary but only in word-final position. American English [ɹ] is produced by lowering the tongue dorsum toward the pharynx [25]. Children with [ɹ] distortions raise the back of the tongue toward the velum [26-28]. [29] describe productions of [ɹ] with high tongue body as mergers of oral and pharyngeal constrictions resulting in singular velar constrictions. As per [19], lower time of exposure could mean higher degrees of language interference. This could explain the velarization seen in both EN and SP. EN and SP may have identified the French rhotic as [DORSAL] but, phonetically, it was produced as velar and not uvular. SP only velarized the rhotic gesture in final position. This could be explained by a higher time of exposure to the target language.

SP was expected to retract more in word-final position [7] while EN was thought to retract more in word-initial position [12]. This was not the case. While both SP and EN do in fact articulate gestures further back than FR overall, SP’s gestures were less posterior in word-final than in word-initial. Similarly, EN showed less tongue retraction in word-initial than in word-final position. Last but not least, FR produced shorter words and rhotic gestures with qualitatively smoother curves. This suggests a certain level of efficiency when it comes to articulatory effort and, consequently, a certain level of undershoot when it comes to articulatory targets. SP showed similar curve patterns to FR and EN showed the most complex curves by far. Longer durations in word-initial position for SP and word-final position for EN could be interpreted as signs of hyper articulation. Our findings support [15, 16, 30] whereby the learning of L2 coarticulation patterns is defined as a gradual process linked to the amount of exposure to the target language.

5. CONCLUSION

This case study analysed articulatory strategies for French rhotics produced by a native speaker of French and two learners of French as an L3. Lower times of exposure seemed to correlate with higher degrees of language interference as attested by the velarization of French [ʁ] and lower degrees of coarticulation for SP and EN.

Our findings are in line with [14] and go on to highlight the importance of phonetic and phonological relations between the learner’s mother tongue and the target language not only when identifying, but equally as important when producing allophones of the same category. This leads us to believe that articulatory strategies in language learners are both phonologically and phonetically driven.

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