AFFRICATION PATTERNS AND PERCEPTUAL TENDENCIES IN CANADIAN AND EUROPEAN FRENCH*

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1. Introduction

Psycholinguistic research has shown that an individual's perception of speech sounds is fundamentally shaped by the phonology of the language (or languages) that they have acquired. One way that a language's phonology influences perception is through its phonotactics. Listeners are biased against perceiving sequences of sounds that are phonotactically impossible in their language—when they encounter such phonotactic violations, they frequently repair them illusorily. This has been shown by Massaro and Cohen (1983) for licit and illicit English consonant clusters, and by Dupoux et al. (1999) for licit and illicit syllable structures in Japanese. Another way that an individual's perception is affected by the phonology of their language is through its system of contrast. Work on categorical perception has shown that listeners experience a much sharper perceptual boundary between sounds that are contrastive in their language than sounds that are not, which has been shown by MacKain et al. (1981) on an /r/ - /l/ continuum with English speakers (who exhibited a sharp identification boundary) and monolingual Japanese speakers (who perceived the continuum much more gradually).

In this paper we present the results from a pilot study designed to test two additional hypotheses regarding the perceptual effects of phonotactics and contrast. Our first hypothesis is that in addition to being biased against sound sequences that are phonotactically impossible in their language, listeners are biased against perceiving sound sequences that are phonotactically possible but rare. Our second hypothesis is that in cases of "partial allophony", where whether two sounds contrast or not depends on the environment, there will be a sharper perceptual boundary between the two sounds in the contrastive environment than the non-contrastive environment. We use the affrication patterns in Canadian French to test these two hypotheses.

In most dialects of Canadian French, coronal stops undergo affrication (/t, d/ → [t͡s, d͡z]) before high front vowels and glides (/i, y/ and /j, ɥ/). For example, *Canadien* 'Canadian' is pronounced [kanad͡zjɛ̃] (as opposed to [kanadjɛ̃]). Non-derived affricates also exist and they are not limited to occurring before high front vowels, but they are rare. They include the reduced form *tsé* [t͡se] (from *tu sais* 'you know') and loan words (*tsar* [d͡zaʁ] 'tsar' / 'czar'). The presence of both derived and non-derived affricates gives us two key phenomena in Canadian French. The first is a state of phonotactic rareness:

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vowels other than high front vowels are possible after affricates, but rare. The second is a state of partial allophony (or "partial contrast"). In most environments, stops and affricates are contrastive (e.g. the minimal pair [t͡se] 'y'know' and [te] 'tea'). But before high front vowels, they are allophones (dialectal variants of the same phoneme).[1] This means that their contrastiveness depends on the environment.

Our first experiment tests the hypothesis that listeners are biased against perceiving sound sequences that are rare but possible. It involves a 10-step vowel continuum from [e] to [i], played in a French pseudo-word after either a stop or an affricate. If our hypothesis is correct, encountering an affricate should bias listeners against perceiving an [e]. Our second experiment tests the hypothesis that the sharpness of a perceptual boundary between two sounds can vary between environments, if the sounds are partial allophones that contrast in one environment and not in another. It involves a 10-step consonant continuum from [t͡s] to [t] (and [d͡z] to [d]), played before either a high front [i] or a mid front [e]. If our hypothesis is correct, the affricate-stop continuum should be perceived more sharply before [e] (where the two sounds contrast) but more gradually before [i] (where they do not).

This pilot study was run on a preliminary sample of 13 speakers of Canadian French, 6 speakers of European French living in Quebec (to gain insight into the effect of dialect experience, because Sumner and Samuel (2009) found with speakers of New York English that dialect exposure can potentiate priming effects), and 6 speakers of Canadian English, as a control group. Both French groups showed the expected effect in Experiment 1 of hearing an affricate and being biased towards perceiving the following vowel as high front. However, unexpectedly, the English group also showed that effect, which questions whether the effect for the French group was a result of their language-specific factors (specifically the pattern of phonotactic rareness), as was hypothesized. In Experiment 2, the Canadian French speakers had the hypothesized effect of perceiving the affricate-stop continuum more sharply in the environment where those sounds contrast. Neither the European French speakers nor the Canadian English speakers showed such an effect. This is evidence that stops and affricates are neither fully contrastive nor fully allophonic in Canadian French. More broadly, this supports the notion of contrast as gradient rather than binary (see e.g. Hall et al. 2015).

1.1 Affrication in French

Affrication of coronal stops is one of the characteristic traits of Canadian French phonology, alongside vowel laxing in closed syllables and diphthongization (Brasseur 2009, Friesner 2010, Remysen 2014). Affrication and vowel laxing (as well as laxing harmony) can be seen in the pronunciation of *tigre* 'tiger' and *difficile* 'difficult' as [t͡sɪgʁ]

[1] Because at least one French word (*tsigane*) has a non-derived affricate before a high front vowel, it is more accurate to say that stops and affricates are almost always non-contrastive before high front vowels (rather than just that they are non-contrastive in that environment). In other environments, however, they are unambiguously contrastive.

and [d͡zɪfɪsɪl] (as opposed to the characteristically European pronunciations [tigʁ] and [difisil]). Affrication is not socially marked (Brasseur 2009) or associated with any negative social stigma (Dumas 1987).

Affrication is not quite universal in Canadian French, although most dialects (and most speakers) have it. In most areas of Quebec, affrication is obligatory and consistently applied inside words, with a handful of lexical exceptions, all English loanwords like 'building' and 'meeting' (Friesner 2010, Côté 2012). Ontario French is historically related to Quebec French (both fall under the label of Laurentian French: Cichocki 2012, Côté 2012), and as a result it also has affrication, although less consistently (Durand 1993). The phenomenon is also present in Manitoba French (Bérubé et al. 2015). The exception with regard to affrication in Canada is Acadian French, which is historically distinct from the French found in Quebec and as a result it largely lacks the same affrication process (King 2000, Cichocki 2012).

Affrication of coronal stops can be found in European French, but it is of a different nature than the affrication in Canadian French. Rather than a consistent part of the grammar, affrication in European French is a highly variable, purely phonetic phenomenon, which generally results in the postalveolar affricates [t͡ʃ, d͡ʒ] rather than the alveolar affricates [t͡s, d͡z] (Berns 2013). Candea et al. (2013) study a corpus of newscaster speech in France and find that rates of /t, d/ → [t͡ʃ, d͡ʒ] before /i, y, j, ɥ/ range from 1% to 8%.

There are a handful of European French varieties that have affrication as a phonological process, namely certain non-standard varieties in the south of Belgium and in working class communities in France (Corneau 2000, Fagyal et al. 2006, Armstrong and Pooley 2010). As with the more widespread (but much less consistent) phonetic phenomenon, the result is generally postalveolar instead of alveolar.

The examples of affrication so far have been affricates derived from stops through productive rules or processes of affrication that only occur in particular environments (generally before high front vowels). Non-derived affricates, both postalveolar and alveolar, are possible in French. They are not limited to a particular dialect or a particular environment, but they are uncommon. Examples for postalveolar affricates include the English loan-words *tchatcher* [t͡ʃat͡ʃe] 'to blabber', *jeans* [d͡ʒins] 'jeans', and *jet* [d͡ʒɛt] 'airplane' (Fagyal et al. 2006).

Examples of alveolar affricates, which are more relevant for this study, include loan words like *tsigane* 'Roma/Romani person' (sometimes considered offensive, like *gypsy* in English), *mouche tsé-tsé* 'tse-tse fly', and *tsar* 'tsar' / 'czar' (pronounced with an affricate, unlike in English). Other examples of affricates include the reduced form *tsé* ("y'know" from *tu sais*[2]), and *tsoin-tsoin* [t͡swɛ̃ t͡swɛ̃] (an onomatopoeia).

Is there a difference between the derived and non-derived alveolar affricates? Phonologically the answer is clearly yes—derived affricates are positional allophones of /t/ and /d/ that only occur before high front vowels, while non-derived affricates appear in a wide

[2]Native speakers we have consulted with have expressed the strong intuition that *tsé* is a set word rather than an on-the-fly reduction in fast speech.

range of environments (even if infrequently) and are presumably /t/ + /s/ and /d/ + /z/. Phonetically, however, they seem to be indistinguishable. If non-derived affricates were stop-fricative sequences phonetically then we would expect them to have a longer overall duration (Berns 2013), but this was not the case in our recordings.[3] In addition, non-derived affricates patterned with derived affricates in having a shorter closure duration than stops.

2. Experiment 1: Vowel Continuum

2.1 Rationale

The goal of this experiment is to test the hypothesis that listeners are biased against perceiving sound sequences that are phonotactically possible but rare.

2.2 Methods

2.2.1 Participants

Thirteen speakers of Canadian French (mean age = 38, sd = 12.1), 6 speakers of European French (mean age = 24, sd = 5.4, range of time living in Quebec = 1-4 years), and 6 speakers of Canadian English (mean age = 26, sd = 10.6) took part in this experiment. Seven additional participants were run in the Canadian English group, but they were excluded due to being non-native speakers or self-rating their French ability higher than 3/7. Participants were either paid $15 or received course credit. They provided written informed consent prior to partaking in the experiment. All of the European French speakers and most of the Canadian French speakers participated in Montreal, while all of the Canadian English speakers and some of the Canadian French speakers participated in Toronto.

2.2.2 Stimuli

The stimuli for this experiment were created from recordings of a male native speaker of French from Quebec reading a list of the following 8 pseudo-words in French orthography ("é" is the orthographic form for /e/): "nati", "naté", "nadi", "nadé", "foti", "foté", "fodi", and "fodé". Recordings were done at a sampling rate of 48kHz.

The speaker was instructed to read the words clearly and naturally according to his dialect, meaning that the words ending in "i" were produced with affrication on the preceeding coronal stop. A token for the vowel [e] and one for [i] (selected for clear sound and formant values) were extracted from these recordings and the first three formants were measured from the steady-state portion of the vowel for each. The [e] token's formant values (F1 to F3) were 400Hz, 1890Hz, and 2490Hz, while the [i] token's values

[3] We measured the overall duration of the affricate (which includes closure duration, burst, and frication) for six tokens from each set (derived and non-derived). The mean overall duration was 213ms (sd = 14.96ms) for derived affricates and 215ms (sd = 7.63ms) for non-derived affricates.

were 308Hz, 2073Hz, and 2924Hz. The differences in formant frequencies were therefore -92Hz, +184Hz, and +434Hz. To create the vowel continuum, the [e] token was downsampled to 16kHz and then run through a formant-editing script making use of linear predictive coding (LPC) and FormantGrid in Praat (Boersma and Weenick 2015). This script created 10 files starting with step 1 on the vowel continuum (the pure [e]), which was only minimally modified from the input [e]. Each additional step from 2 to 10 was modified to have incrementally more [i]-like formant values, with step 10 (the target [i]) having the same formant values as those originally measured from the [i] token that was extracted from the recordings.[4]

One token for each of the eight pseudo-words (with the final vowel cut off, giving [nat͡s], [nat], [nad͡z], [nad], [fot͡s], [fot], [fod͡z], and [fod]) was extracted and downsampled to 16kHz. These segments were then spliced (at zero crossings) onto the 10 vowel continuum segments to give 80 total stimulus items, which were normalized to an average root mean square intensity of 70dB Sound Pressure Level (SPL).

2.2.3 Procedure

This experiment was designed and run in the OpenSesame experiment builder software (Mathôt et al. 2012). Participants were tested individually in a quiet room. They were asked to listen to the stimuli through headphones and identify whether the sound they heard at the end of the word was "é" or "i" by pressing "e" or "i" (respectively) on the keyboard (the English speakers were given different instructions, which explained the intended vowels using the English words 'bay' and 'bee'; they indicated their choices using "f" and "j" on the keyboard to avoid confusion with French orthography). Participants were given eight practice trials. After completing the practice trials, each of the 80 stimulus items was presented 5 times, for a total of 400 randomly presented trials in this experiment with a 500ms inter-trial interval (ITI). Abstracting away from the variation in frame ([na] vs [fo]) and voicing of the consonant, each participant heard each step in the vowel continuum 20 times in the stop condition and 20 times in the affricate condition.

Because the same participants were used for both the first and the second experiment in this study, the order of the experiments was counterbalanced across participants. Each experiment took 15-20 minutes to complete, for a total session length of approximately 40 minutes. Participants were given the option to take a break before beginning the second experiment.

2.3 Results

The proportion of "é" responses of the Canadian French participants in each step and condition is provided in Figure 1. For outlier removal, we removed all responses whose reaction time was more than 2.5 standard deviations away from the mean reaction time

[4]The formant values for [e] and [i] were measured from the steady-state portion of the vowel, but the numerical formant modifications were applied uniformly to the entire vowel. For example, the 92Hz reduction in F1 to make step 10 (the target [i]) was applied to the beginning, middle, and end of the base [e].

of the individual participant (amounting to 2.5% of the trials from this group). We then performed a repeated measures ANOVA with response (“é” or “i”) as the dependent variable. The within-subjects independent variables were type of preceeding consonant (affricate or stop), voicing of preceeding consonant (voiced or voiceless), and step on the vowel continuum (1-10).

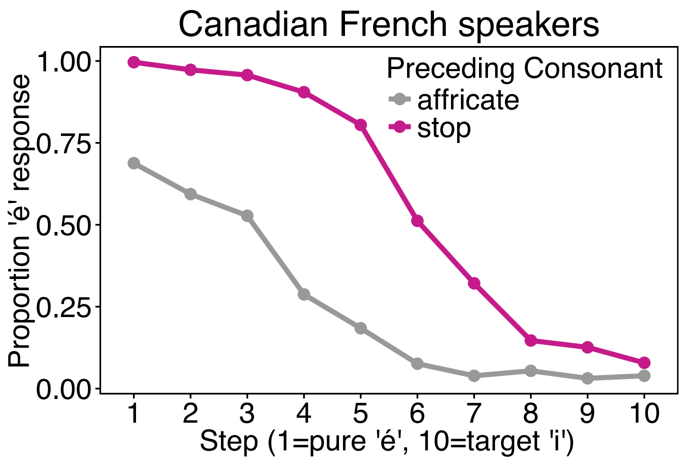

Figure 1: Canadian French speakers (Exp. 1)

The effect of continuum step was highly significant ($F(1,12) = 172.42$, $p < 0.001$). The effect of the type preceeding consonant was also highly significant ($F(1,12) = 51.28$, $p < 0.001$)—the Canadian French speakers were much less likely to identify hearing an “é” after an affricate than after a stop (25.06% compared to 58.41%, across all steps). The interaction between continuum step and consonant was also significant ($F(1,12) = 11.21$, $p = 0.006$). Post-hoc comparisons using a repeated measures ANOVA on steps 1, 5, and 10 individually found no significant difference for type of preceeding consonant at step 10 ($F(1,12) = 0.70$, $p = 0.42$), but a significant difference at step 1 ($F(1,12) = 11.83$, $p = 0.005$) and an even larger significant difference at step 5 ($F(1,12) = 71.11$, $p < 0.001$).

As for the European French participants, their proportion of “é” responses in each step and condition is provided in Figure 2. Outlier removal discarded 3.1% of the trials. Although the sample of European French speakers is not large enough for inferential statistics, a visual inspection of the data shows that these speakers responded similarly to the Canadian French group in being less likely to identify hearing “é” after an affricate than after a stop (20.29% compared to 75.55%, across all steps).

Finally, the proportion of “é” responses in each step and condition for the Canadian English speakers is provided in Figure 3. Outlier removal discarded 2.0% of the trials. Again the sample size is not large enough for inferential statistics, but a visual inspection of the data also shows a similar effect to the two French-speaking groups. The Canadian English speakers were less likely to identify hearing “é” after an affricate than after a stop (33.42% compared to 50.00%, across all steps).

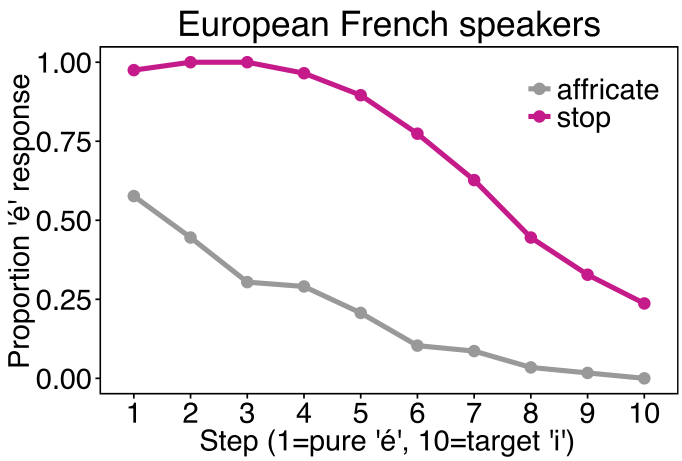

Figure 2: European French speakers (Exp. 1)

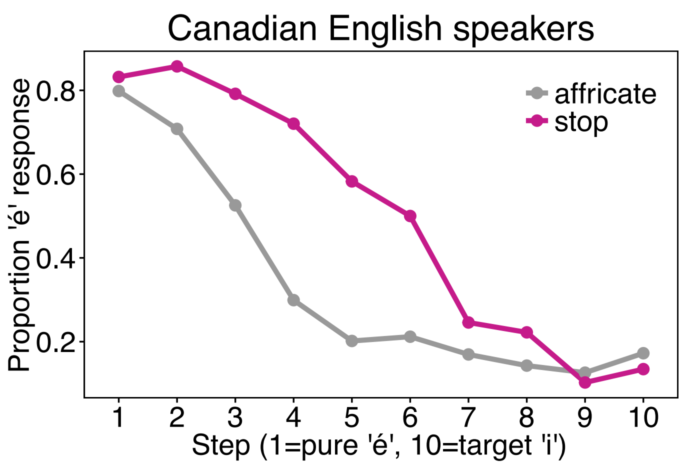

Figure 3: Canadian English speakers (Exp. 1)

2.4 Discussion

Our preliminary results suggest that all three groups—Canadian French speakers, European French speakers living in Quebec, and Canadian English speakers with minimal French knowledge—exhibit a bias towards perceiving the vowel following an affricate as high front. This effect was hypothesized for the Canadian French speakers on account of the phonotactic rareness pattern in their dialect, and it also makes sense for the European French speakers on account of their exposure to Canadian French. However, this effect is unexpected for the Canadian English speakers and their results put into question whether the two French-speaking groups had the effect for the expected reasons.

There are at least three possibilities for why this unexpected effect was found for the Canadian English speakers. First, although they were selected for low self-rated proficiency in French (3/7 or lower), it is possible that even a low level of French ability could have induced an effect. Second, there could have been a confound in the stimuli, namely residual acoustic cues that could have led participants (regardless of language background) to cue into the pre-modified stimulus. And third, it is also possible that there were cross-linguistic biases at play. There is evidence of a cross-linguistic association between affricates or frication and high front vowels, as shown in epenthetic vowels in loan words. For example, the epenthetic vowel in Japanese is usually [ɯ], but it is [i] after English [t͡ʃ, d͡ʒ] (e.g. *match* [mætʃ] as [mattɕi]). Shoji and Shoji (2013) suggest articulatory factors for this association. In Sesotho (Bantu) the epenthetic vowel is [ɪ] after [s]—Rose and Demuth (2006) suggest phonetic/perceptual factors for this association.

3. Experiment 2: Consonant Continuum

3.1 Rationale

The goal of this experiment is to test the hypothesis that in cases of partial allophony (where whether two sounds contrast or not depends on the environment) there will be a sharper perceptual boundary between the two sounds in the contrastive environment than the non-contrastive environment.

3.2 Methods

3.2.1 Participants

The same 13 speakers of Canadian French, 6 speakers of European French, and 6 speakers of Canadian English participated in this experiment.

3.2.2 Stimuli

The stimuli for this experiment were created from the same 48kHz recordings of the following pseudo-words as those used for Experiment 1: “nati”, “naté”, “nadi”, “nadé”, “foti”, “foté”, “fodi”, and “fodé”. The consonant continuum was created by modifying a token of [t͡s] and a token of [d͡z] from the pseudo-words ending in “i”. The affricates were played in their entirety for step 1 of the continuum. For each additional step, part of the frication was cut away from the middle of the frication region until at step 10 none remained.[5] The portion of frication eliminated for each step was proportional to the overall frication duration, which was shorter for the voiced affricate (87ms compared to 114ms). In addition to stops and affricates being distinguished by the presence or absence of frication, there was also a difference between stops and affricates in closure duration in our recordings (approximately 60ms for affricates, and 100ms for stops), so the closure

[5]The voiceless stops of our speaker have weak (30ms) aspiration. It was not practical to incorporate this into the consonant continuum, because that would involve steps 2-9 having both aspiration and frication. The lack of aspiration does not affect the design of the experiment, however. Even if a listener requires the weak aspiration to preceive the stop as voiceless and thus hears the voiceless unaspirated stop as voiced, the task involved choosing between stop and affricate, not between voiced and voiceless segments.

duration was incrementally increased over the course of the consonant continuum until step 10, the target stop, had the most stop-like closure duration.

From the pseudo-word recordings there were two additional sets of segments extracted, one to be spliced before the consonant continuum and one to be spliced after it in the final stimuli. The frames [na] and [fo] were extracted, with two versions: a [na] and [fo] leading into a voiceless consonant (taken from e.g. "naté" and "foté"), and a [na] and [fo] leading into a voiced consonant (taken from e.g. "nadé" and "fodé"). An [e] token and an [i] token were also extracted. The 10 voiceless consonant continuum tokens ([t͡s] ... [t]) were then spliced (at zero crossings) between [na] or [fo] at the beginning (the [na] and [fo] taken from pseudo-words leading into voiceless consonants) and [i] or [e] at the end, to give 40 total stimulus items. The other 40 stimulus items came from performing the same splicing with the 10 voiced consonant continuum tokens ([d͡z] ... [d]), which used the [na] and [fo] originally recorded leading into voiced consonants. The 80 total stimulus items were downsampled to 16kHz to match the sampling rate of the stimuli from the first experiment, and they were normalized to an average root mean square intensity of 70dB SPL.

3.2.3 Procedure

Experiment 2 was also designed and run in OpenSesame. Participants were tested individually in a quiet room. They were asked to listen to the stimuli through headphones and identify whether the sound they heard before the last vowel was a "t"/"d" sound or a "ts"/"dz" sound by pressing "f" or "j" (respectively) on the keyboard. Participants were given eight practice trials. After that, each of the 80 stimulus items was presented 5 times, for a total of 400 (randomly presented) trials in this experiment with a 500ms ITI. Abstracting away from the variation in frame ([na] vs [fo]) and voicing of the consonant, each participant heard each step in the consonant continuum 20 times before [i] and 20 times before [e].

3.3 Results

The proportion of "ts"/"dz" responses of the Canadian French speakers in each step and condition is provided in Figure 4. Outlier removal, which was done in the same manner as the first experiment, removed 2.8% of the trials. We then performed a repeated measures ANOVA with response ("ts"/"dz" or "t"/"d") as the dependent variable. The within subject independent variables were type of following vowel (high front or mid front), voicing of consonant (voiced or voiceless), and step on the consonant continuum (1-10).

The effect of continuum step was highly significant ($F(1,12) = 614.66$, $p < 0.001$). The effect of the following vowel on identification of the consonant was not significant ($F(1,12) = 0.002$, $p = 0.97$)—the Canadian French speakers were not any more or less likely to identify hearing "ts"/"dz" before a high front vowel (47.96% for [i] compared compared to 47.88% for [e], across all steps). There was, however, an interaction between continuum and vowel ($F(1,12) = 20.63$, $p < 0.001$), caused by a steeper slope of the curve

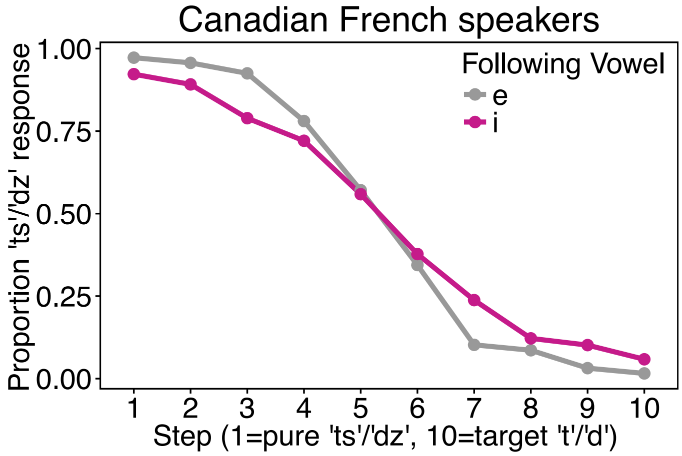

Figure 4: Canadian French speakers (Exp. 2)

for the consonants before [e], suggesting a more categorical perception of the continuum (as opposed to a more gradual or continuous perception before [i]). Post-hoc comparisons using a repeated measures ANOVA on steps 3 and 7 individually found a significant difference for type of following vowel at both step 3 ($F(1,12) = 11.63$, $p = 0.005$) and step 7 ($F(1,12) = 8.07$, $p = 0.014$).

The European French speakers' proportion of "ts"/"dz" responses in each step and condition is provided in Figure 5. Outlier removal discarded 2.8% of the trials. Although the sample of European French speakers is not large enough for inferential statistics, a visual inspection of the data does not suggest that the continuum was perceived with a sharper boundary before [e] than before [i].

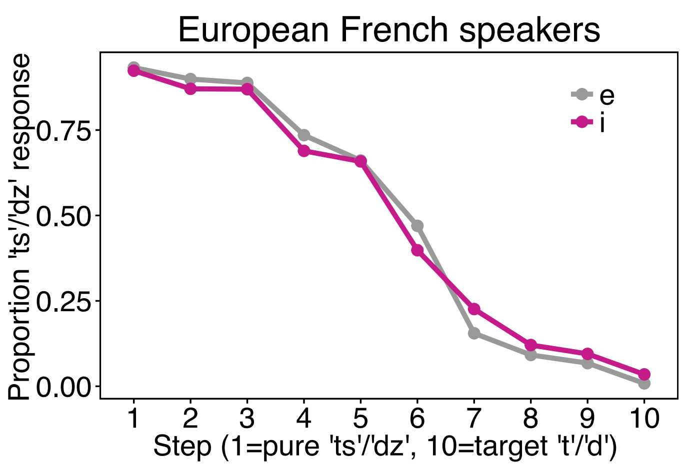

Figure 5: European French speakers (Exp. 2)

Lastly, the proportion of "é" responses in each step and condition for the Canadian English speakers is provided in Figure 6. Outlier removal discarded 2.2% of the trials. A visual inspection of the data also does not suggest a sharper perceptual boundary before [e] than before [i].

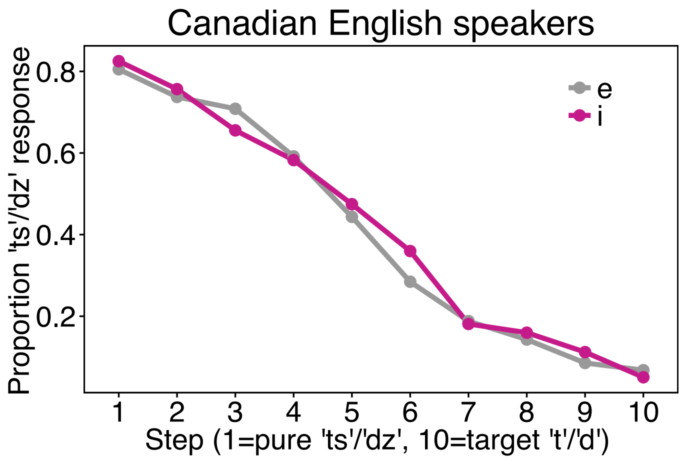

Figure 6: Canadian English speakers (Exp. 2)

3.4 Discussion

Our preliminary results suggest that only Canadian French speakers (and not European French speakers or Canadian English speakers) are sensitive to the environment and contrastive status when perceiving an affricate-stop continuum in French. This is expected for the Canadian French speakers and the Canadian English speakers due to the former but not the latter speaking Canadian French and having this environmental distinction in their own speech. On the other hand, the European French speakers (all of whom have spent time in Canadian French speaking locations) might be expected to exhibit the effect due to their exposure to Canadian French, but that was not found.

4. General Discussion

Taking into account only the two French-speaking groups, Experiment 1 initially provided evidence that (1) listeners are biased against perceiving sound sequences that are phonotactically possible but rare, and that (2) this applies even for non-native dialects with dialect exposure. This would expand on findings by Massaro and Cohen (1983) and by Dupoux et al. (1999) that speakers are biased against perceiving sound sequences that are phonotactically impossible in their language, and it would support Sumner and Samuel (2009) on the effect of dialect exposure.

However, the English-speaking control group also exhibited the same effect as the French-speaking groups in this experiment. These unexpected results from the control group put into question the reason for the French-speaking groups having the effect. On one hand it might be the case that the English speakers have low levels of exposure to

French and this is enough to cause the effect, which would not challenge the perceptual effects of phonotactic rareness or of dialect exposure. On the other hand, if the English speakers exhibited the effect due to a confound in the stimuli or because of a cross-linguistic perceptual association between frication and high front vowels, then the stimuli issues or cross-linguistic factors would also be at play for the two French-speaking groups and there would be less of a need for language-specific factors (the phonotactic rareness pattern, and exposure to it) to explain their results.

The results from Experiment 2 were clearer. With the Canadian French speakers, evidence was found that in cases of partial allophony (where whether two sounds contrast or not depends on the environment) there was a sharper perceptual boundary between the two sounds in the contrastive environment than the non-contrastive environment. Neither European French nor Canadian English speakers exhibited this effect. This is in line with work like MacKain et al. (1981), which has found outside of cases of partial allophony that contrastiveness is associated with a sharper perceptual boundary. Our finding here supports the notion of contrast as gradient rather than binary (see e.g. Hall et al. 2015), because a factor associated with contrastiveness (sharpness of the perceptual boundary) varied by environment. The results from the European French speakers do not suggest an effect of dialect exposure.

5. Conclusion

In this paper we presented the preliminary results from two psycholinguistic studies on the perception of affrication in Canadian French, with three groups of participants: Canadian French speakers, European French speakers who live in Quebec, and Canadian English speakers with minimal knowledge of French. Our two experiments were designed to test two main hypotheses, one involving phonotactic rareness (listeners are biased against perceiving sound sequences that are possible but rare) and one involving partial allophony (when the contrastive status of two sounds depends on the environment, the contrastive environment will give rise to a sharper perceptual boundary between those two sounds). We also hypothesized that exposure to these phenomena (phonotactic rareness and partial allophony) in a non-native dialect would be enough to induce the effects. To summarize, the perceptual effects of phonotactic rareness and dialect exposure are still undetermined, while the perceptual effects of partial allophony were more clearly supported—with the understanding that these results are still preliminary due to having the sample size of a pilot study.

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