Investigating the Phonological Representations of Canadian Raising: Experimental Evidence from Gating and Cross-Splicing Studies

Maggie Baird (University of Massachusetts, Amherst)

Background The experiments presented here test the phonological representations of the sounds involved in the seemingly opaque interaction between Canadian Raising and flapping. In most dialects of Canadian English (Joos 1942) as well as several dialects of American English, the diphthongs /aɪ/ and /aʊ/ raise to [ʌɪ] and [ʌʊ], respectively, when preceding voiceless obstruents. Raising (e.g. 'ride' [ɹaɪd] and 'write' [ɹʌɪt]) interacts opaquely with flapping, e.g., 'rider' [ɹaɪɾəɹ] vs. 'writer' [ɹʌɪɾəɹ]. One way to analyze this is through opacity, where the flapping process occurs before the raising, leading to surface contrast. Another possible analysis is that the diphthongs have an underlying contrast, and this isn't a case of opacity at all. Farris-Trimble and Tessier (2019) tested these two accounts psycholinguistically using eye-tracking. They assume that each phonological process in a word must be undone in processing, which takes time. They show that words with raising and flapping were slower to be recognized than words with only raising, which were slower than words without any phonological processes. Because more phonological processes (flapping + raising) led to slower recognition, they conclude that these vowels appear to be allophonic and the process is opaque.

Current Study This work presents gating and sub-categorical mismatch experiments based on a different linking hypothesis than phonological inference. If raised [ʌɪ] is an allophone, it predicts that a voiceless sound follows, whereas unraised [aɪ] does not similarly predict the voicing of the following sound because its environment is less constrained. Under an underlying contrast representation, neither vowel would make a strong prediction of the upcoming sound based on its phonological status – they would both be phonemes unconstrained in distribution. This study validated the prediction linking hypothesis by comparing the Canadian Raising stimuli to nasal-[t, d] stimuli. In English, the nasal in [Vnt] sequences is deleted, whereas the nasal in [Vnd] sequences is not. Because nasal deletion is demonstrably allophonic and not phonetic (Cohn 1993), finding that listeners respond in the same way to the Canadian Raising stimuli as the nasal deletion stimuli would show that the former process is also allophonic.

Methods/Results Experiment 1 is a gating study (see Smits et al. 2003). Participants hear a stimulus followed by a high-pitched beep and are tasked with responding what they think the last sound in the word is. There are 4 gates for each word (1) at 1/3 of the way through the nucleus vowel, (2) 2/3 of the way through the nucleus vowel, (3) the end of the nucleus vowel, and (4) the end of the word. The stimuli were monosyllabic English words ending in /t, d, s, z, f, v, p, b/ and each was recorded with both voicings of the final consonant, yielding 8 total versions of each word. The nasal stimuli were also monosyllabic, but only ended in /t, d/. The interval of the V(n) was used as the nucleus for measuring the gates. There was a mix of stimuli where both voicings made a licit word as well as where only one voicing made a licit word.

Results are visualized in Figure 1 and were analyzed using a mixed effects logistic regression model (*lme4* package, Bates et al. 2015).

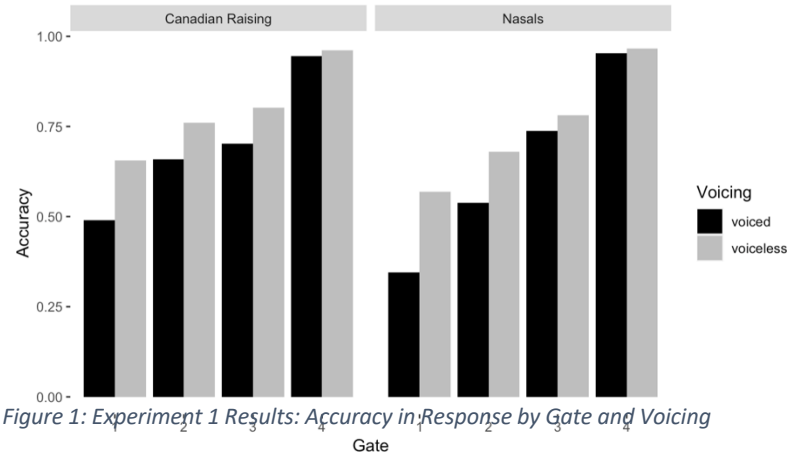

Figure 1: Experiment 1 Results: Accuracy in Response by Gate and Voicing

Accuracy increases with progressive gates ($p < .0001$), there is higher accuracy for voiceless consonants ($p < .0001$), and there is a significant interaction between gate and voicing ($p = .014$). There is also a significant difference between the nasal stimuli and the Canadian Raising stimuli. The higher accuracy for voiceless consonants, particularly at earlier gates does suggest that the raised vowel is providing a stronger prediction to the listener than the unraised vowel, which aligns with an allophonic representation.

Experiment 2 was a cross-splicing study. Cross-splicing involves presenting listeners with stimuli where the final consonant has been spliced on to a vocalic context. It has been used to show that speakers are sensitive to fine-grained phonetic detail cueing upcoming material, such as place of articulation (McQueen et al. 1999). The words for this study were drawn from the same set as the gating stimuli. There were 4 versions of each word (unraised/raised V + voiced/voiceless C) for the Canadian Raising stimuli as well as nasal (nasalized vowel/vowel nasal sequence + voiced/voiceless C). Participants were tasked with responding with the sound they heard at the end of the word and were asked to respond as quickly as possible. Figure 2 shows results in terms of reaction time, which was measured from the offset of the stimulus. The colors represent the actual voicing of the consonant, and the two columns for each condition are the vocalic context (raised = voiceless predicted, etc.).

Results were analyzed using the *lmertest* package in R (Kuznetsova et al. 2017) and show a significant interaction between voicing and prediction ($p < .0001$), with voiceless predicted and voiceless consonants leading to faster RT. There is also an effect of voicing ($p < .0001$), with voiceless having a faster RT, and an effect of condition ($p = .0011$) with the nasals being faster as well. The significant interaction between voicing and predicted consonant suggests an allophonic account: participants are fastest at recognizing the final consonant when they hear a vowel which strongly predicts the final consonant and that prediction is correct. They are slowest when they hear a strongly predictive vowel and the incorrect consonant. Under a contrastive representation, we would not expect a significant interaction and we would expect the results from Canadian Raising to look different from the nasals, which they do not.

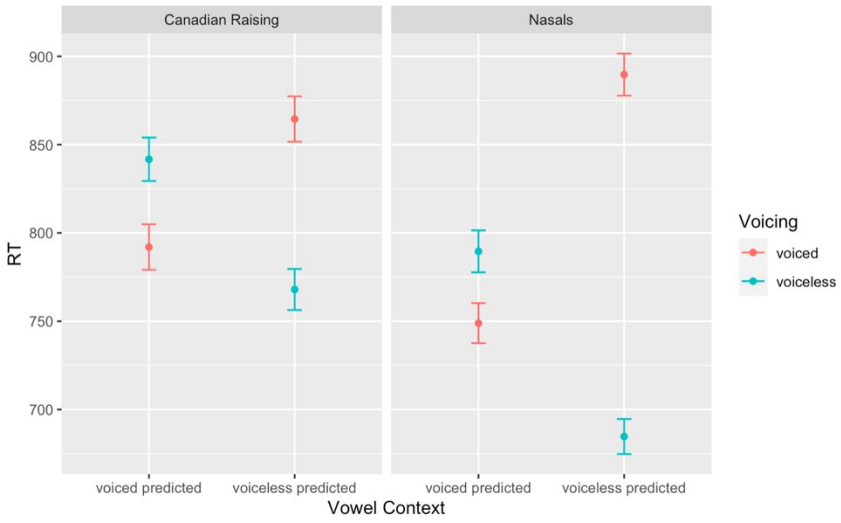

Figure 2: Experiment 2 Results: RT by Condition, Vowel Context and Consonant Voicing

Conclusions In two experiments, we have shown that participants make a stronger prediction about upcoming consonants from the raised diphthong [ʌɪ] than from the unraised [aɪ]. This evidence is in line with the other experimental results in the literature (Farris-Trimble and Tessier 2019) and provides psycholinguistic evidence to support phonological analyses of Canadian Raising as opaque, as opposed to an analysis which has an underlying contrast.