CANADIAN ENGLISH IN THE PACIFIC NORTHWEST: A PHONETIC COMPARISON OF VANCOUVER, BC AND SEATTLE, WA*

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The *Atlas of North American English* (henceforth ANAE) calls attention to the difficult task of differentiating the dialect regions entitled "the West" and "Canada" and surmises that the dialects can be differentiated on the basis of their degree of participation in the same sound changes (Labov et al. 2006). In other words, the difference is a quantitative one, not a qualitative one. This paper argues that this assessment may be due, in part, to the methodological approach taken. Despite the geographic proximity and cultural similarities of Vancouver, BC and Seattle, WA, few studies have directly compared their speech (see Sadlier-Brown 2012 for one exception). With 29,372 tokens collected via a word list reading task from 20 Seattle and 19 Vancouver speakers and a sociocultural identity survey, the full study analyzes and compares speakers' participation in five key dialectal features of Pacific Northwest English and Canadian English: pre-velar /æ/ raising, pre-nasal /æ/ raising, /æ/ retraction, and the "Canadian" raising of diphthongs /aɪ/ and /aʊ/. Formant measurements for these phonemes were extracted at five duration-proportional points and comparisons of formant trajectories were included in the mixed-effects linear regression models for each dialect feature. Including this dynamic information makes evident that there are qualitative differences between Seattle and Vancouver with respect to pre-nasal /æ/, in particular. Findings from this work also affirm the overlapping, coexisting identities of the region's inhabitants and highlight the simultaneous ideologies of solidarity and differentiation exhibited by speakers on either side of the national border.

1. Background

1.1 Convergence of Canadian English with Standard American English?

Canadian linguists have regularly posited a loss of distinctive Canadianisms in favor of American norms (Scargill 1957, 1974; Warkentyne 1971; Chambers 1990; Nylvek 1992; Zeller 1993; Woods 1993). In particular, during the 1990s, this fear of convergence or assimilation with U.S. dialects of English seemed particularly strong. Chambers and Hardwick (1986) identify a possible weakening in the Canadian Raising of /aʊ/ and /aɪ/

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among younger speakers. Looking at speakers ranging from Toronto to Milwaukee, Zeller (1993) found asymmetrical relationships in the awareness Canadian speakers had of American lexical items and vice versa. Her study focused on lexical pairs in which there was variation between Canadian and American speakers and considered self-reported pronunciations, but did not provide any acoustic measures. Research since their writing has increasingly documented regional variation across Canada and across the U.S. – Canadian border. (Labov et al. 2006, Boberg 2008, Boberg 2010, Walker 2015). Additionally, Walker (2015) observes that evidence for convergence tends to be more lexical than phonological in nature.

1.2 Differentiation of the West and Canada as dialect regions

One particular region surrounding the U.S.-Canadian border remains underexplored. The relationship of "the West" as a dialect region to neighboring "Canadian English" remains unclear and lacking in empirical investigation. The Atlas of North American English states that "The differentiation of the West from Canada is a more difficult question, involving the degree of activity of similar sound changes" (Labov et al. 2006: 137). The authors look to Canadian Raising and retraction of /æ/ as differentiators for Canada from the West. Prior to this writing, Boberg (2000: 15) reports that "the phonological systems of western Canada and the northwestern United States are identical and their phonetics very similar." To this point, no large-scale studies comparing the West and Canadian English have been carried out, leaving aside the issue of how expansive each of the geographic regions are. Prior research in BC has focused on the region's participation in features of the Canadian Shift such as /æ/ retraction and its questionable participation in raising of /aɪ/ and /aʊ/ (Chambers 1973, Esling and Warkentyne 1993, Sadlier-Brown and Tamminga 2008, Boberg 2008, Pappas and Jeffrey 2014). In Seattle, research primarily documents pre-velar raising of /æ/ before /g/ (Wassink et al. 2009, Freeman 2013, Riebold 2015). No large-scale studies have compared these specific features between Vancouver and Seattle. To make matters less clear, the phonetic studies conducted North and South of the border have employed different methods, making comparisons even more difficult.

1.3 Pre-nasal raising

In particular, Labov (1994) states that pre-nasal /æ/ raising is a hallmark of American English, and the ANAE makes further discussion of this as a dialect differentiator. The West and Midland dialects are described as having a split /æ/ system in which /æ/ is tense and raised before nasals, but relatively lower and backer before all other consonants. In looking at the issue of /æn/ raising, the ANAE relies on data from a relatively small number of speakers (four Seattle speakers; four Vancouver speakers) with relatively few repetitions of target allophones (at most 10 per allophone) as produced randomly in spontaneous speech. Boberg (2008 and 2010) elucidates to some extent the regional variation in Canadian dialects for /æ/ allophones. He reports stronger /æn/ raising in the eastern provinces and generally higher /æg/ than /æn/ raising in the Western provinces, though he also notes large standard deviations for /æg/ raising in BC. His findings are based on a single measurement point taken from the vowel's point of inflection. The ANAE also describes the "impracticality" of using vowel formant trajectories for the speakers, stating that they would impede over-arching generalizations about dialect regions and would not lend themselves to statistical analysis (Labov et al. 2006: 36). Subsequent to their writing, innovative methods have since made dynamic analyses more commonplace, and the current paper shows that relying on single point measurement can obscure a potentially salient difference between the dialects.

The articulatory gesture of lowering the velum for a following nasal segment is expected to lower F1 values of a neighboring vowel (Ladefoged 2001, Baker et al. 2008). While pre-nasal raising is a coarticulatorily motivated process, this does not necessarily result in a monolithic, universal effect across speakers, dialects, or populations. A central issue in studies of sound change and dialectology is how *some* phonetic universals become exaggerated beyond what can be considered a coarticulatory effect resulting from anatomical or physiological factors. More recent research makes clear that a raised pre-nasal system is not monolithic and emphasizes that pre-nasal raising, like other phonetic or allophonic processes, follows a life-cycle (Dinkin 2011). This life-cycle, and therefore, the status of any particular dialect region with respect to the life-cycle, may be obscured by using single-point measurements rather than dynamic formant measurements. That is, Labov et al.'s (2006) observation about the degree of participation in similar sound changes can be better thought of in terms of the dialect's position in the life-cycle, and this necessitates a dynamic view of the vowels in question.

1.4 Research questions

Some bigger questions emerge in response to these previous findings:

1. How do the phonological/phonetic systems of Seattle and Vancouver speakers compare? Namely, what is the status of /æn/ in each of these cities?
2. How do the sociocultural identities of these speakers relate to their phonetic behavior?
3. What do these findings indicate about the way we analyze and implement dialect "differentiators" for regions like Canada and the West?
4. Is there evidence for convergence or divergence at the national border?

The current paper will be limited to a discussion of /æn/ raising with some brief comments about sociocultural identities and the convergence/divergence issue. The reader is referred to Swan (2016) for a more complete presentation.

2. Methods

2.1 Subject recruitment

The study recruited 20 adult speakers in Seattle and 19 adult speakers in Vancouver who had lived in their respective city since the age of 7 or before and who self-identified as native speakers of English. The subjects were balanced for age and sex. Group 1 included speakers from age 18-25; Group 2 included speakers from age 26-36. The two age groupings described above were defined *emically* on the basis of shared life experience (Eckert 1998).

	Age Group I (18-25)	Age Group II (26-35)
Male	5	5*
Female	5	5

Table 1. Number of subjects of Vancouver and Seattle *For Age Group II in Vancouver, four male speakers were interviewed.

2.2 Word-list reading task

Questions (1) and (3) were addressed using a word list elicitation task to obtain pronunciations from 20 Seattle speakers and 19 Vancouver speakers, which were recorded in person by the researcher using a Zoom4H handheld digital recorder. The word list contains a total of 220 tokens and speakers were asked to repeat the word list three times yielding 660 total tokens per speaker. The word list was comprised of real word tokens for each of the phonemes: /aʊ/, /aɪ/, /æ/, /ɛ/, and /e/. Five tokens of each phoneme were elicited for each of six environments: _[+lab], _[+cor], _[+vel], [+lat], [+nas], [+cont] in both [+vce] and [-vce] environments (as phonological inventory allows). No tokens of [ŋ] were included in the [+nas] class. Pre-lateral and pre-nasal tokens are only available for the pre-voiced condition.

2.3 Sociocultural survey

Question (2) was addressed via a socio-cultural survey. Subjects were asked to respond verbally to a set of questions about their city, their involvement in municipal and regionally-based activities. They were also asked about their impressions of the other city and their attitudes towards language in their city and the neighboring one. These interviews were transcribed by the researcher and were both quantitatively and qualitatively analyzed. The sociolinguistic questions were interspersed with the repetitions of the word list reading task such that there were three stretches of sociocultural identity questions of about six to eight minutes, depending on the respondent. These were transcribed and stored in separate text files for each speaker. The numeric responses to the Likert scale questions were stored in a Microsoft Excel spreadsheet along with basic demographic information for each respondent. Descriptive statistics (means and standard deviations) were computed for these questions using R. Participants ratings were normalized prior to inclusion in the regression models described below. Emergent coding was used to analyze the qualitative responses by considering each free-response question one at a time. Responses to the sociocultural survey that acted as statistically significant predictors of linguistic behavior were identified separately for each question using linear regression models.

2.4 Extraction of vowel formant data

The sound files from the word list reading task were analyzed in PRAAT (Boersma and Weenik 2014) and aligned using the University of Pennsylvania FAVE-align forced aligner (Rosenfelder et al. 2011). Each stressed vowel in the TextGrid was hand checked for accuracy. The hand correction process was facilitated by a PRAAT script (Riebold 2013) that moves from one stressed token to the next with a zoom set to display phonetic detail. The boundaries for each vowel token were adjusted so as to avoid the transitions associated with the flanking consonants. FAVE-extract produces an extensive set of information about the vowel segments including time-scaled formant measurements for F1 and F2 at 20%, 35% 50%, 65% and 80% of the vowel's duration as well as the information about the phonetic environments preceding and following the extracted segment. FAVE-extract was used to extract the information for all stressed target vowels in the word-list reading task, aside from the carrier phrase words *say* and *again*. Several commonly mispronounced words were removed from the data set for all speakers: *Bethesda, dessert,* and *lead*.

2.5 Normalization

Following the findings of these previous studies, the current project employed Lobanov (1971) normalization, a z-score transformation for each formant and each talker (Adank, Smits, and Van Hout 2004, Clopper 2009). The Lobanov (1971) method found to be the best at reducing anatomical variation while preserving sociolinguistic variation in the signal.

2.6 Time-proportional analysis

The current analysis relies on data from five time-proportional points across the vowel's duration. DiPaolo et al. (2011) recommend that multiple measurements be used for all vowel analyses, even those traditionally considered to be steady monophthongs (like /æ/). They suggest the proportional distance approach, which adjusts its multiple measurements according to the duration each vowel token (e.g. at 20%, 35%, 50%, 65%, and 80% of the vowel's duration). This has the advantage of comparing different tokens at similar points along their trajectories allowing for a more dynamic view of vowel articulation. Another advantage of this approach is that it is not biased by an a priori assumption of where in the vowel's duration the articulatory goal is realized. Per these best practices, the study uses an ordered factor created from the five time points to make comparisons of the trajectories of vowels in different allophonic contexts and by different sub-groups of speakers. As an ordered factor, vowel trajectory is included in the mixed-effects linear regression models as a possible predictor. This allows modeling and comparison of basic trajectory shape, including linear, quadratic, and cubic shapes similar to the approach in Functional Data Analysis where polynomials are fit to the curves. Such a comparison requires relatively few time points allowing for an efficient modeling of the basic shape of vowel trajectories and provides a simple computation using R. This approach is particularly useful to sociolinguists who tend to work with larger data sets from more talkers. Because the five time points are sufficient for illustrating the basic shape of a trajectory, the amount of data required is manageable and efficient.

2.7 Hierarchical linear regression modeling

This study uses mixed-effects linear regression models to conduct inferential statistics in response to the aforementioned research questions (Gorman 2009). Thirty separate mixed-effects models were constructed in R using the lme4 package (Bates et al. 2015) to provide an analysis of the five different types of variables and environments considered. Cities were examined first in isolation, and models were constructed for both F1 and F2, followed by a model for both F1 and F2 that spans both cities. This modeling process was repeated for pre-velar /æ/, pre-nasal /æ/, environments of /æ/ retraction, /aʊ/ raising and /aɪ/ raising. Only the results from pre-nasal /æ/ will be presented here.

3. Findings

Findings from the current study reveal a significant dialectal difference between Seattle and Vancouver speakers with regard to /æn/ raising and make clearer the potential pitfalls of dialect classification on the basis of mid-point data alone. The findings argue strongly for the importance of dynamic analyses of vowel data and likewise support the inclusion allophonic behavior in dialect studies. Taken at mid-point value and undifferentiated for allophonic environment, the data appear to confirm the similarity of the vowel systems between Seattle and Vancouver speakers as discussed in Boberg (2000) and again in Labov et al. (2006). Upon closer inspection, however, the findings reveal significant differences in the vowel formant trajectories of allophones in the two dialects, which without the benefit of a time-proportional, multi-point analysis might appear to be participating in "the same" allophonic process. Production studies have identified significant differences in the formant trajectories of speakers across ethnicities, dialects, and generations, and perceptual data confirms that listeners make use of these fine-grained differences in formant trajectory patterns to draw social conclusions (Koops 2010; Jacewicz and Fox 2012, 2013; Risdal and Kohn 2014). This suggests that our studies of phonological variation would be better aligned with both acoustic/phonetic realities and listener perception in dialect classification if they also took into account vowel formant trajectories. Of the five dialectal features considered, the case of pre-nasal raising in Seattle and Vancouver makes this point especially clear.

3.1 Overview of the vowel system

The vowel plot below compares the vowel systems of Seattle and Vancouver speakers based on the average of F1 and F2 measurements at the time-proportional 50% mark for the vowel across all phonetic environments.

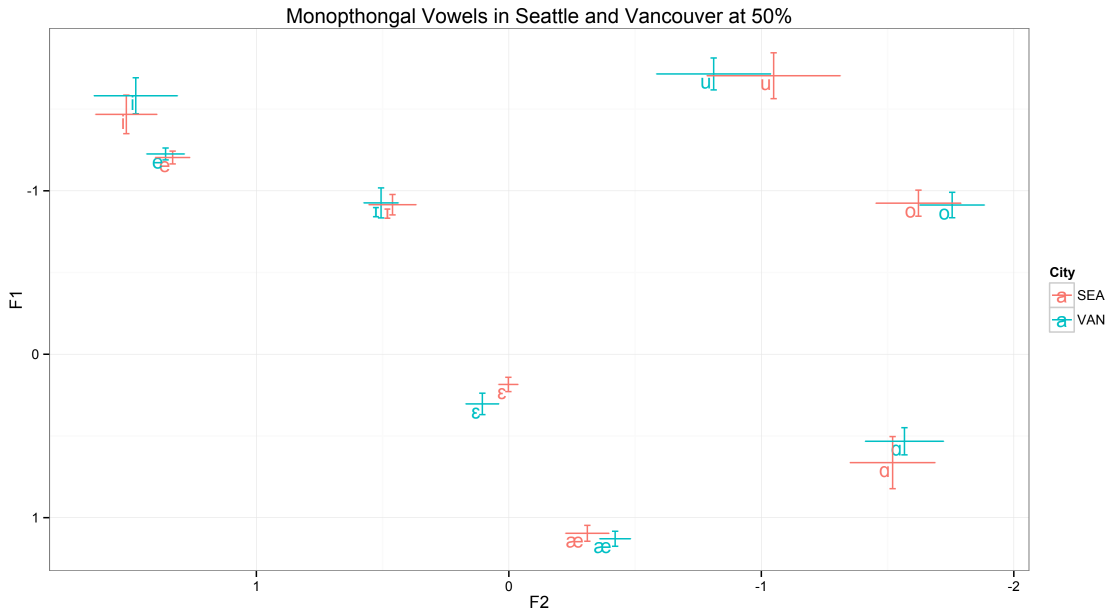

Figure 1. Lobanov normalized vowel space for Seattle and Vancouver: Lobanov normalized vowel space for both cities at 50% time-proportional vowel duration (inverted F2 on x-axis; inverted F1 on y-axis) with confidence intervals indicating the variation across speakers

At first glance, the general shape of the vowel spaces look quite similar for Vancouver and Seattle speakers. The larger horizontal error bars for the back vowels seem to suggest more variation on the F2 dimension for the back vowels (most especially, /u/) than for the front vowels. In this visual, /æ/ appears to be slightly lower and more back for Vancouver speakers than for Seattle speakers, but this provides no indication of statistical significance, nor of phonetic context or the vowel's dynamic properties.

3.2 Overview of five diagnostic allophones

The chart below summarizes the results of the mixed-effects linear regression models for the five dialect features compared across the two cities. These mixed-effects models were constructed to compare allophonic environments and include information about the shape of the formant trajectory. The columns labeled "Seattle" and "Vancouver" represent the analyses conducted within that city alone to detect significant differences between the allophone and its most articulatorily proximate sound. For the first row, for instance, /æg/ raising examines all tokens of /æg/ as compared to /æk/, first for Seattle alone, then Vancouver, and finally, across both cities. For the city-internal columns, a "*" indicates that significant differences were found for the allophonic environments (e.g. /æk/ versus /æg/) on the dimension specified (F1 or F2). A blank cell indicates no significant difference between the allophones listed in that row. For the comparison column, a "+" indicates that Vancouver speakers generally showed greater allophonic difference (greater participation in this allophonic distinction) than Seattle speakers. A "-" suggests the opposite; Vancouver speakers generally show less participation in this allophonic process or a lesser degree of allophonic differentiation than Seattle speakers. A blank cell indicates that no significant difference was found between the cities.

	Seattle		Vancouver		Comparison (VAN to SEA)	
	F1	F2	F1	F2	F1	F2
/æg/ Raising	*	*	*	*	+	+
/æn/ Raising	*	*	*	*	-	-
/æ/ Retraction Before Fricatives				*		+
/æ/ Retraction Before Laterals		*		*		+
Pre-vcls /aʊ/ Raising	*	*	*	*	+	+
Pre-vcls /aɪ/ Raising	*	*	*	*	+	+

Table 2. Summary of significant effects for Seattle and Vancouver for five dialectal features

To summarize, both Seattle and Vancouver speakers are raising of /æ/ before /g/, but Vancouver speakers show a comparatively greater degree of raising for /æg/ (relative to /æk/) than Seattle speakers. The same is true for the raising of diphthongs /aɪ/ and /aʊ/ before voiceless consonants. Seattle speakers show /æ/ retraction before laterals, but Vancouver speakers retract /æ/ before both laterals and fricatives, as compared to stops. The analyses for /æn/ raising also show significant differences with Vancouver speakers raising /æn/ to a lesser extent than Seattle speakers. When allophonic environment and formant trajectory are taken into account, Seattle and Vancouver speakers show significant differences on both the F1 and F2 dimensions for nearly all of the dialectal variables examined.

3.3 /æn/ raising

Because z-scores resulting from Lobanov normalization can be unintuitive and difficult to compare with Hertz means as provided in previous studies, raw formant measurements along with standard deviations are provided below. Results are included for /æ/ before all consonants, before /n/ specifically, and /eyC/ is also included to give perspective on the height of /æn/ raising. It is important to note that these data average the F1 or F2 values across the five time points measured for each token, making them an average from onset to offset rather than a mid-point value.

	F1 (Hz)	SD F1 (Hz)	F2 (Hz)	SD F2 (Hz)	Dur (Ms)	SD Dur (Ms)	Lob. Norm F1	Lob. Norm F2
SEATTLE								
æC	814	142	1700	212	156	56	1.076	-0.375
æN	642	145	1993	365	196	54	0.046	0.363
eyC	434	78	2328	331	171	63	-1.182	1.216
VANCOUVER								
æC	831	118	1645	228	149	46	1.075	-0.480
æN	730	93	1867	224	177	42	0.467	0.064
eyC	453	84	2353	332	157	52	-1.218	1.243

Table 3. /æ/ before /n/ and and /C/ for Seattle and Vancouver. Mean of unnormalized F1/F2 values and duration, standard deviations of unnormalized F1/F2 values and duration, plus Lobanov normalized z-scores across all five time-proportional points.

The unnormalized means show lower F1 and higher F2 values for Seattle as compared to Vancouver, suggesting that Seattle participates in /æn/ raising to a greater extent than Vancouver. When presented with an average of the five points across the segments, however, it is not possible to say at what time-proportional point in the segment the differences occur. This, in turn, relates to the so-called life-cycle of the allophonic process. If Seattle were more advanced in this life-cycle, the fronting and raising of /æn/ tokens would be expected to affect the earlier part of the segment as much as the coarticulatory effect at offset. The dynamic formant trajectories and regression models presented below make clear this difference between Seattle and Vancouver.

3.3.1 Mixed-effects regression models

A total of 6,680 tokens of /æn/ and /æd/ were included in the mixed-effects linear regression models comparing F1 and F2 across the two cities; 3,330 for Seattle and 3,350 for Vancouver, respectively.

Following Phone	**Age Group 1**		**Age Group 2**		**Total**
	Female	Male	Female	Male	
æd	515	480	595	520	2,110
æN	295	290	345	290	1,220
GRAND TOTAL	n=3,330				

Table 4. Number of observations (by age and sex) included in mixed-effects linear regressions of /æd/ ~ /æn/ among Seattle speakers

Following Phone	Age Group 1		Age Group 2		Total
	Female	Male	Female	Male	
æd	560	600	600	480	2,240
æN	280	295	300	235	1,110
GRAND TOTAL	n=3,350				

Table 5. Number of observations (by age and sex) included in mixed-effects linear regression models of /æd/ ~ /æn/ among Vancouver speakers

3.3.2 Model for F1

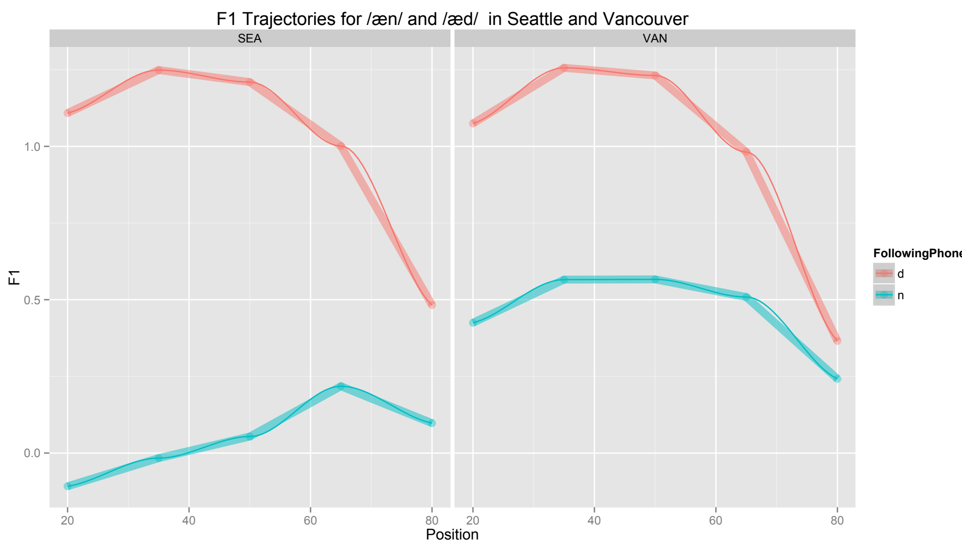

Figure 2. F1 trajectories for /æ/ before /d/ and /n/ in Seattle (left panel) and Vancouver (right panel) with time-proportional duration point on x-axis; Lobanov normalized F1 on y-axis across five time-proportional points

In plotting the formant trajectories for F1 of /æ/ before /d/ and /n/, the trajectories appear nearly identical for Seattle and Vancouver speakers before /d/. The trajectories before /n/ are quite different: for Seattle speakers F1 is rising over the course of the vowel, while for Vancouver speakers it is falling. This suggests that for Seattle speakers, pre-nasal /æ/ begins very high in the vowel space and actually lowers across its duration. Among Vancouver speakers, on the other hand, /æn/ is less raised at onset rises slightly in the vowel space over its duration, as evidenced by gently dropping F1 values. The F1 trajectory of /æ/ before /n/ in Vancouver looks like a roughly symmetrical, wide parabola. For Seattle, the trajectory is more linear with a steep drop only from 75% of the time-proportional duration through offset. The mixed-effects analysis reveals that this effect of City is statistically significant. Across all five time points, Vancouver speakers have overall higher F1 values for /æn/ than Seattle speakers, indicating a lower vowel and less raising (t-value = 5.37, $p < .0001$). The interaction of City, Following Phone and Linear trajectory shape reveals an even larger effect where Vancouver has a negative slope for F1 in /æn/ tokens and Seattle has a positive slope (t-value = -6.45, $p < .0001$). There are additional interactions of Sex and Age Group across Seattle and Vancouver. While an analysis of mid-point values would discover lower F1 values (more raising) in Seattle, it would not capture these formant dynamics over the course of the segment.

```
F1.lmerH <- lmer(normF1 ~ FollowingPhone*Position.ord*normdurms*City +
City*as.factor(AgeGroup)*Sex*FollowingPhone + normNationalPride + (1 +
Position.ord | Name) + (1|Word), data=ae2)
```

Equation 1. Mixed-effects linear regression model comparing F1 of /æ/ in Seattle and Vancouver

	Est.	Std. Er.	t value	p
(Intercept)	0.683	0.14	4.83	< 1e-04
FollowingPhonen	-0.816	0.21	-3.94	< 1e-04
Position.ord.L	-0.533	0.04	-14.57	< 1e-04
Position.ord.Q	-0.387	0.03	-14.73	< 1e-04
CityVAN	0.184	0.07	2.58	0.010
as.factor(AgeGroup)2	0.196	0.07	2.84	0.005
SexM	0.158	0.07	2.13	0.033
normNationalPride	0.052	0.02	2.22	0.026
FollowingPhonen:Position.ord.L	0.743	0.04	21.14	< 1e-04
FollowingPhonen:Position.ord.Q	0.289	0.04	8.23	< 1e-04
FollowingPhonen:normdurms	0.068	0.02	3.30	0.001
Position.ord.L:normdurms	0.066	0.02	3.42	0.001
Position.ord.C:normdurms	-0.044	0.02	-2.31	0.021
FollowingPhonen:CityVAN	0.244	0.05	5.37	< 1e-04
Position.ord.Q:CityVAN	-0.097	0.04	-2.62	0.009
CityVAN:as.factor(AgeGroup)2	-0.274	0.10	-2.70	0.007
CityVAN:SexM	-0.305	0.10	-2.96	0.003
as.factor(AgeGroup)2:SexM	-0.217	0.10	-2.20	0.028
FollowingPhonen:SexM	0.103	0.05	2.26	0.024
FollowingPhonen:Position.ord.L:CityVAN	-0.324	0.05	-6.45	< 1e-04
FollowingPhonen:normdurms:CityVAN	-0.106	0.03	-3.74	0.000
CityVAN:as.factor(AgeGroup)2:SexM	0.292	0.14	2.04	0.042
FollowingPhonen:CityVAN:SexM	0.338	0.06	5.30	< 1e-04
FollowingPhonen:CityVAN:as.factor(AgeGroup)2:SexM	-0.247	0.09	-2.74	0.006

Table 6. Statistically significant fixed effects for linear mixed-effects regression model of F1 for /æd/ ~ /æn/ across both Seattle and Vancouver

3.3.3 Model for F2

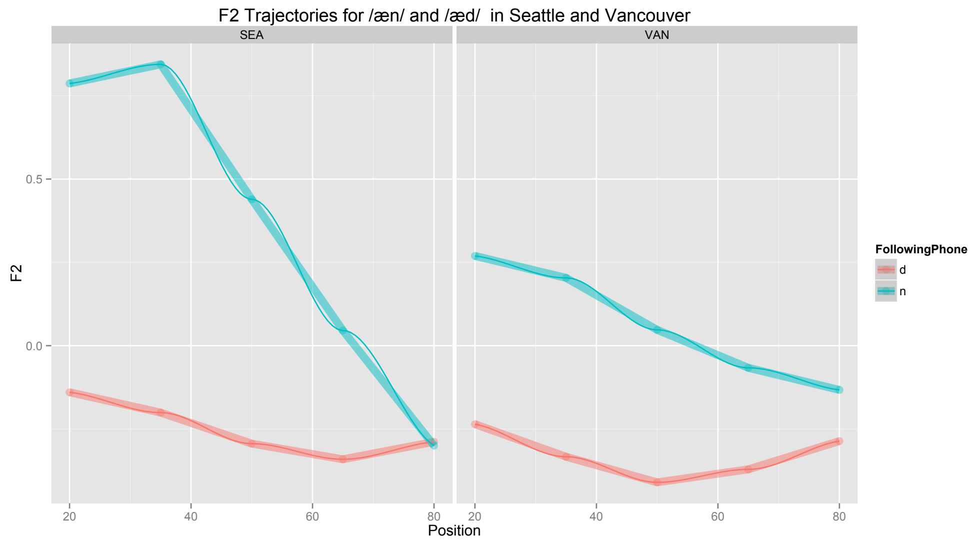

Figure 3. F1 trajectories for /æ/ before /d/ and /n/ in Seattle (left panel) and Vancouver (right panel) with time-proportional duration point on x-axis; Lobanov normalized F1 on y-axis across five time-proportional points

Trajectory shapes for /æ/ between Seattle and Vancouver emerge as important differences on the F2 dimension as well. Again, note the apparent similarity of F2 trajectories in the baseline /æd/ condition. Pre-nasal F2 trajectories, on the other hand, are strikingly different. While both Seattle and Vancouver have falling F2 trajectories for /æn/, the slope is much more sharply dropping for Seattle than for Vancouver. This reveals that, for Seattle speakers, /æn/ tokens start much more front and back dramatically over the course of the segment's duration. Vancouver speakers' tokens are much less front at onset and back more gradually over the course of the segment. Notably, City was not found to be a statistically significant predictor of F2 values when F2 values were pooled across all five time points. The linear and quadratic shapes of the trajectories were significantly different for Vancouver and Seattle speakers, and these were among the largest effects in the model (t-value = 10.02, $p < .0001$ for comparing linear shape of /æn/ versus /æd/ across Vancouver and Seattle). There are additional interaction effects of Age Group and Sex.

```
F2.lmerW <- lmer(normF2 ~ Position.ord*City*FollowingPhone +
City*as.factor(AgeGroup)*Sex*FollowingPhone + normdurms + normFollowSports + (1
+ Position.ord | Name) + (1|Word), data=ae2)
```

Equation 2. Mixed-effects linear regression model comparing F2 of /æ/ in Seattle and Vancouver

	Est.	Std. Er.	t value	p
(Intercept)	-0.389	0.08	-4.62	< 1e-04
Position.ord.L	-0.113	0.04	-2.93	0.003
Position.ord.Q	0.059	0.03	2.10	0.036
FollowingPhonen	0.535	0.11	4.98	< 1e-04
SexM	0.401	0.08	4.84	< 1e-04
normdurms	0.021	0.01	2.91	0.004
normFollowSports	0.052	0.02	2.34	0.019
Position.ord.L:FollowingPhonen	-0.835	0.04	-22.04	< 1e-04
Position.ord.Q:FollowingPhonen	-0.274	0.04	-7.23	< 1e-04
Position.ord.C:FollowingPhonen	0.129	0.04	3.41	0.001
CityVAN:SexM	-0.237	0.12	-2.00	0.046
FollowingPhonen:as.factor(AgeGroup)2	0.143	0.05	3.05	0.002
FollowingPhonen:SexM	-0.128	0.05	-2.61	0.009
Position.ord.L:CityVAN:FollowingPhonen	0.542	0.05	10.02	< 1e-04
Position.ord.Q:CityVAN:FollowingPhonen	0.177	0.05	3.27	0.001
CityVAN:FollowingPhonen:as.factor(AgeGroup)2	-0.352	0.07	-5.24	< 1e-04
CityVAN:FollowingPhonen:as.factor(AgeGroup)2:SexM	0.349	0.10	3.59	0.000

Table 7. Statistically significant fixed effects for linear mixed-effects regression model of F2 for /æd/ ~ /æn/ across both Seattle and Vancouver

3.3.4 Summary of /æn/ raising in Seattle and Vancouver

Seattle and Vancouver speakers manifest pre-nasal /æ/ tokens differently than /æ/ before a non-nasal alveolar like /d/, but the cities have qualitatively different patterns when it comes to pre-nasal "raising." For speakers in both cities, /æ/ is higher and fronter at onset than before a following /n/ than before /d/. For Seattle speakers, the allophonic difference is much more extreme and more advanced in terms of its phonologization. The term "raising" belies what is actually lowering and backing of /æn/ in the vowel space across its duration. Vancouver speakers, in contrast, have lower /æn/ tokens at onset that rise slightly and back gently in the vowel space over its duration. These crucial differences would be obscured by a single-point analysis of pre-nasal raising. The varied pre-nasal "raising" phenomena exhibit different degrees of phonologization versus co-articulatory effects and a qualitative difference between the two cities with greater advancement of phonologized raising in Seattle than in Vancouver.

4. Conclusions

The results of this work more broadly suggest that Vancouver speakers are participating in processes identified as part of the Canadian Shift and are also participating in patterns characteristic of Pacific Northwest English. The variation within the Vancouver sample and metalinguistic commentary suggests that both traits characteristic of the Canadian Shift and those characteristic of the Pacific Northwest are positively socially evaluated and being increasingly adopted by groups commonly thought to lead linguistic changes: younger adult speakers and women. Rather than pitting Canadian patterns against American ones, these findings suggest that the linguistic and socio-cultural identity of Vancouver residents nests a regional identity shared with Seattle within Canadian national identity and effectively integrates elements of both with pride. While Vancouver and Seattle speakers participate in many of the same allophonic processes, there remain significant and substantial differences in the extent of their participation in these processes, the qualitative nature of the processes, not to mention different variation by speaker age and sex sub-group. The results do not support arguments for wholesale convergence or divergence. Instead, this research sheds light on the variation within a dialect region divided by a national border and offers a realistically complex view of the simultaneous solidarity and differentiation of identity embodied by its inhabitants.

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