Bag, Beg, Bagel: Prevelar Raising and Merger in Pacific Northwest English*

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Abstract. This paper describes the raising of the low front vowels /ɛ, æ/ and the lowering of the mid front /e/ before the voiced velar /ɡ/ in Pacific Northwest English (PNWE). This prevelar system appears to have two parts with differing social patterns. In the most advanced part, /ɛɡ/ and /eɡ/ are homophonous upgliding diphthongs merged at a point between non-prevelar /ɛ/ and /e/ for all 20 Caucasian Seattle speakers examined. In contrast, raising of /æɡ/ is more variable between speakers and shows signs of social differentiation: men and older speakers are more raised, with middle-aged men showing near-complete three-way merger with /ɛɡ-eɡ/. Previous work has described both /æɡ/- and /ɛɡ/-raising, but with varying degrees of raising and incomplete data, it has been difficult to determine whether either is truly involved in merger. This study specifically included /eɡ/ in order to provide solid evidence that merger or near-merger is present between /ɛɡ/ and /eɡ/, and that the target for raising /æɡ/ may be merger with these two, not with the higher non-prevelar /e/. However, although /ɛɡ/ and /eɡ/ overlap significantly in F1xF2 space throughout their trajectories, /ɛɡ/ remains shorter in duration, which may be sufficient to differentiate it from other prevelars.

Keywords: prevelar raising, merger, Pacific Northwest English.

1 Introduction

The focus of this paper is the raising of low front vowels /ɛ, æ/ before voiced velar /ɡ/ in Pacific Northwest English (PNWE), the Seattle area in particular. This raising of these BAG- and BEG-class words was first observed by Reed (1952, 1961) but then went without comment until patterns were noticed during the course of an ongoing project that aims to provide descriptions of Pacific Northwest English comparable to those of more well-known American English dialect regions (cf. Wassink et al. 2009). As such, initial data collection did not target prevelar classes specifically, resulting in small numbers of relevant tokens. The current study addresses this problem with targeted collection of prevelar environments for the purpose of more fully describing prevelar raising in PNWE. Furthermore, this paper provides evidence that the target for raised /ɛɡ/ and /æɡ/ is lower than /e/, overlapping with a lowered prevelar /eɡ/. Since initial PNWE data yielded very few examples of underlying /eɡ/ words (e.g., *bagel*), it was impossible to determine the behavior of this tiny word class, and the positions of /ɛɡ/ and /æɡ/ were necessarily described in relation to non-prevelar /e/. Thus, the primary goal of this paper is to describe the relative positions of prevelars in

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two generations of Seattle Caucasians in order to provide evidence relevant to the discussion of whether prevelar raising in PNWE can be interpreted as merger.

Section 2 outlines previous work on prevelar raising and Pacific Northwest English. Section 3 states hypotheses and predictions for the phonetic and social conditioning factors affecting prevelar raising in PNWE. Section 4 describes the methods of data collection and analysis, Section 5 presents results, and Section 6 provides a summary, discussion, and conclusion.

2 Background

2.1 Regional distributions of prevelar raising

The Pacific Northwest, including Washington, Oregon, and Idaho, has only been settled by English-speakers for about 200 years and is thus considered a relatively young dialect region. As such, it has not been extensively studied separately from the larger Western dialect region, which is often defined by the absence of features found in Northern and Southern regions (cf. Labov et al. 2006). One early exception is Reed's work on a Linguistic Atlas of the Pacific Northwest (1952, 1961, and others), akin to auditory descriptions of other North American dialect regions being compiled at the time. Relevant to the current study of prevelar raising, Reed provided three observations: /æ/ before the prevelar nasal in *hang* was raised to [e] (1952), /æ/ before /g/ in *bag* was canonically [æ] in about half of speakers and diphthongal but without a raised nucleus [æɪ] in the other half, and prevelar /ɛ/ in *egg* and *keg* was often diphthongal, usually with the low [ɛ] or [ɛɪ] but occasionally the higher [e] or [eɪ] (1961). Aside from these early observations, there is no further mention of prevelar raising in the Northwest (or much formal work on the dialect region in general) until recent years, when Wassink and colleagues noticed patterns while collecting data for the general purpose of describing Pacific Northwest English (PNWE), to be described more fully below.

In contrast, raising of /æ/ before velars has been described in regions ranging from the Upper Midwest to the Pacific Northwest and throughout Canada. Zeller (1997) first described /æg/-raising in Wisconsin, showing that /æ/ before voiced velars, both oral and nasal, merges with /e/ at increasing rates over subsequent generations. Labov et al. (2006) found that /æg/ raises toward /e/ in areas across the American North and into Canada, to the extent of merger with /eg/ in the Wisconsin-Minnesota area. Boberg (2008) further investigated the pattern in Canada, finding that while /æg/-raising occurs in most regions, it is most extensive in western Canada, the regions just north of those where /æg/-raising was found in the U.S. by Labov et al. (2006).

The results of more detailed phonetic studies of /æg/-raising in Wisconsin by Bauer and Parker (2008) and Benson et al. (2011) challenge the assumption that raised /æg/ is merged with /ɛ/ or /e/. Both studies included duration and formant measures at multiple time points, finding that the formant distributions of /æg/ often overlapped those of /ɛ/ or even /e/ at some points but not throughout its duration. Prevelar /æg/ variously began as low as /æ/ or as high as /ɛ/, raising toward /e/ over its duration (with the F1 of its offset reaching at most the F1 onset of /e/ for Bauer and Parker). In contrast, the formants of non-prevelar /æ/ and /ɛ/ changed less over time, often lowering or backing slightly rather than raising. Benson et al. concluded that because all their age and gender groups raised /æg/ above /ɛ/, this is not a change in progress but a firmly established pattern. Bauer and Parker also investigated a few /eg/-class words, which patterned with /æg/ but not any non-prevelar vowel; they interpreted this as evidence that this tiny word class has been reanalyzed by speakers as belonging to the larger (and now raised) /æg/ class.

2.2 Phonetic and phonological motivations

Zeller (1997), Baker et al. (2008), Purnell (2008), and Wassink and Riebold (2013) describe velar pinch – the simultaneous raising of F2 and lowering of F3 going into (or out of) a velar constriction – as the articulatory mechanism that may encourage the raising and fronting of /æ/ before voiced velars. As the tongue dorsum raises to meet the velum, F2 rises and F3 lowers, creating the appearance of "pinching" on a spectrogram. At the same time, F1 also lowers, a movement involved in upgliding, along with a rising F2. Before the velar nasal, velar pinch is elongated due to the anticipatory lowering of the velum as the dorsum raises (Baker et al. 2008); this could contribute to the implicational scale proposed by Baker et al. whereby the less common raising before /ɡ/ does not occur without raising before /ŋ/. With the addition of these glide-like articulations before either voiced velar, the phonemic monophthong /æ/ (and presumably also /ɛ/) may be perceived as diphthongal and subsequently reanalyzed as the nearest phonemic diphthong in its path, /e/, which then reinforces the raised and diphthongal production (Bauer and Parker 2008, following Ohala's (2003) perception-based model of sound change), potentially leading to phonological merger.

Merger violates the preference of phonological systems to maintain distinctions (Labov 1994), but there are actually few distinctions between the prevelar word classes. /eɡ/ is an extremely tiny class (referred to in this paper as the BAGEL class). It contains only a handful of words (e.g., *bagel, vague, plague, pagan, flagrant, vagrant*), none of which form minimal pairs with words in either the BEG or BAG class, and a few proper names (*the Hague, Sprague*, *Hegel*). BEG has larger membership but is also small and forms few minimal pairs with the much larger BAG class. Even fewer BAG-BEG pairs exist in which both members have high lexical frequency and are confusable in context (e.g., *bag-beg, lag-leg*). (The same holds for the prevelar nasal set, but it was not examined for this paper.) In short, the need to maintain distinction is absent, and while this does not necessarily motivate merger (Zeller 1997), it does not impede it, either. Thus, language-internal forces promoting merger, such as the number and closeness of phonetic and perceptual features in common (Labov 1994), may take precedence.

2.3 Current work on prevelar raising in the Pacific Northwest

The current study is part of a larger project which aims to provide descriptions of Pacific Northwest English comparable to those of more well-known American English dialect regions (cf. Wassink et al. 2009). In the first phase (supported by National Science Foundation grant BCS-0643374 awarded to PI Alicia Wassink), 35 Seattleites participated in face-to-face interviews that included conversation, dialect survey questions, a reading passage, and a word list. Of the 35, 26 were Caucasian, the majority ethnic group in the area and the focus of the current study. Only 6 of these were male, distributed across three age groups (one from Generation 1, born before 1950; three from Gen. 2, born 1951-1976; two from Gen. 3, born after 1977). Of the 20 females, seven were from Gen. 1, nine from Gen. 2, and three from Gen. 3. Although prevelar environments were not specifically targeted in the original elicitation materials, enough tokens of /æɡ/ and /ɛɡ/ were collected to outline the patterns now under investigation. Squizzero (2009) and Wassink et al. (2009) found that many PNWE speakers raised /ɛɡ/ toward /e/, and some also raised /æɡ/ to overlap with /ɛɡ/ or /e/. Patterns of gender differentiation suggested that women might be more advanced in /ɛɡ/-raising, while men may be more advanced in /æɡ/-raising, especially in casual styles. In a closer examination of females' data, Wassink and Riebold (2013) also found differences between age groups and in lexical frequency such that *egg* was raised most frequently, followed by *leg* and then *peg*, consistent with phonetically-motivated sound change in progress (cf. Phillips 1984).

These patterns were surprising for two reasons. First, although anecdotal mentions of /ɛɡ/-raising exist for various geographic regions,[1] little scholarly work has described its occurrence in any dialect, and second, to the author's knowledge, no other dialect region has been formally

[1] For example, comments on online discussion forums (e.g., Kirk and Rom 2005; Kirk and Andre 2006; Marvin 2006; O Choco and Derek 2013) mention hearing raised /ɛɡ/ in the Upper Midwest, western Canada, California, and Pennsylvania, and Stephen Colbert, from South Carolina, can be observed consistently pronouncing /ɛɡ/ words like *eggs* and *legs* with a raised, auditorily diphthongal [eɪ] on his show *The Colbert Report*.

described as having both /æɡ/ and /ɛɡ/-raising. If both /æɡ/ and /ɛɡ/ are produced and perceived as similar to /e/, there is potential for a three-way merger with /eɡ/. While the variation in degrees of raising found in the PNWE project may not provide clear evidence of a completed merger, it is consistent with ongoing change.

2.4 Gender differentiation and change in progress

Gender differentiation has been an important aspect of many studies of changes in progress. Labov's well-known Principles I, Ia, and II summarized the repeated observations of women being both conservative and innovative: "For stable sociolinguistic variables, men use a higher frequency of nonstandard forms than women… In change from above, women favor the incoming prestige form more than men," but "in change from below, women are most often the innovators" (1990: 210, 213, 215). In Labov's terms, "above" and "below" refer to both the level of conscious awareness and the social class where changes originate (1994). Changes from above generally begin in socially dominant classes, society is consciously aware of them, and the new variants are seen as prestigious. Changes from below often originate in lower classes and proceed upward without conscious awareness. Labov explains the apparent paradox of women's behavior in terms of prestige and stigma: it is more important for women to use forms that carry prestige in the wider community and avoid those with stigma. This easily explains their preferences for both recognized and new prestige forms but also allows them to be innovators of forms with no established social value or those with local prestige, provided the wider community has not attached a stigma to them. This mirrors Trudgill's (1974) earlier conclusion that women tend to be conservative in a change in progress if it has stigma attached to it from a larger marketplace (i.e., it does not have overt prestige), while men tend to lead in change that has local, covert prestige.

Underlying much of this is the alignment of prestige with mainstream culture and nonstandard linguistic use with vernacular subculture (Labov 1966), which may or may not divide genders uniformly. Many studies have found that gender interacts with other social groupings, often with the result that there is more variation within a gender than between genders. For example, Cheshire (1982) found that boys who identified with and participated in a vernacular subculture with a tough "troublemaker" image had greater usage of the linguistic variants associated with that vernacular than did boys who participated less in the subculture. Similarly, Eckert (1989) found more variation among suburban teen girls than boys based on their affiliation with opposing social categories. Both boy and girl "jocks" oriented toward academic life and had middle-class goals like going to college and getting white-collar jobs, while both boy and girl "burnouts" oriented toward urban subculture and blue-collar work. Burnouts had more contact and desire to affiliate with urban Detroiters, who were more advanced in the Northern Cities Chain Shift (NCS); burnout girls used these new NCS features far more than jock girls, who had little contact with urban culture and whose image of "good" girls did not fit with the urban image of toughness. In contrast, boys varied less between the social groups. In explaining the greater variation between girls, Eckert expands on Trudgill (1974): while men are afforded status based on what they do – their occupations and accomplishments, women are judged based on what kind of person they are, appear to be, or affiliate with – and language use is one way they can express their image. Eckert asserted that women have little power in society and therefore must rely on symbolic capital and group affiliation to gain status.

Other studies have appealed to explanations of occupation-related mobility for interactions between gender and age in relation to language use. Nichols (1983) found gender differentiation to be greater between older speakers than younger in their use of receding Gullah creole features. This was related to differing occupational contacts and needs: older women in one community were more confined to local jobs and used more Gullah features than their male counterparts, who had more contact with standard-English-speaking outsiders. However, in the younger generation, both men and women worked in contact with standard speakers and therefore both genders used more standard features than the older group. In another community, the gender pattern was reversed for the younger group, but for the same reasons: young women worked outside the community and therefore needed to use standard English more, but young men had less contact with outsiders and used more Gullah.

As with any of these and many other examples, gender differentiation in prevelar raising is likely to interact with complex social roles, but the scope of the current paper does not allow for a detailed investigation of social structure in the Seattle speech community. However, even with simple divisions of age and gender, variation found between or within groups might hint at relevant social groupings for future investigation. If patterns of gender differentiation mirror those found in other communities, a similar social structure may be relevant. For example, if women are more advanced in /ɛg/-raising, as suggested by patterns in Squizzero (2009) and Wassink et al. (2009), this may be a sign of change from below. This would be consistent with the lack of comment on /ɛg/-raising (i.e., the lack of social awareness and stigma from outsiders). If men are more advanced in /æg/-raising, this could be a sign that this part of prevelar raising has some stigma attached to it or is otherwise incongruent with the image women want to project. Less gender differentiation in the younger generation than in the older might point to changing social opportunities across genders or increasing contact and orientation with supra-local norms. If wide variation is found only among one age/gender group, they may be more sensitive to some other social affiliation, like the jock and burnout girls in Eckert (1989) or the troublemaker boys in Cheshire (1982).

Although patterns within age and gender groupings will be presented here, most discussion of theoretical frameworks, social motivations, and the progression of sound change will be left to future work. Instead, the main goal of this paper is to provide a more complete description of prevelar behavior in one group of Pacific Northwesterners, Seattle Caucasians. This work is part of the ongoing second phase of the PNWE project (supported by NSF grant BCS-1147678 awarded to PI Alicia Wassink), which has expanded to cover more regions of Washington (centered around Spokane in Eastern Washington and the Yakima Valley in South-Central Washington) and greater representation of minority ethnic groups (African Americans, Mexican Americans, Japanese Americans, and members of the Yakama Nation, all of which have long histories of settlement in the area). Important for this study, the PNWE project now includes elicitation materials that specifically target prevelar environments.

3 Hypotheses

With the primary goal of a fuller description of prevelar behavior, several hypotheses are proposed for the relevant phonetic characteristics, followed by those regarding social differentiation.

H1. /ɛg/ and /eg/ overlap at a point between /ɛ/ and /e/; i.e., /ɛg/ is raised from /ɛ/, /eg/ is lowered from /e/, and the two prevelars overlap substantially. If supported, this provides a new contribution to the description of PNWE prevelars. Wassink et al. (2009) and Squizzero (2009) found evidence of /ɛg/ raising to overlap partially with /e/, but since the PNWE project did not notice the extent of raising before designing interview materials, the very small /eg/ word class was not targeted, making it impossible to examine its behavior. However, a pilot study of Seattle children conducted as part of coursework did target this class and found evidence suggesting that /eg/ lowers to overlap with the raised /ɛg/. Thus, the current study tests this by eliciting /eg/ words specifically for comparison with /e/, /ɛg/, and /ɛ/.

H2. /æg/ raises to overlap with /ɛg/ and/or /eg/. Based on the previous studies of PNWE, Wisconsin and western Canada described above, /æg/ is expected to raise, but the “target” location of this raising is less predictable. As previous studies found so-called merged /æg/ to variously overlap or fail to reach the height of /e/, the inclusion of /eɡ/ provides an alternative target for raising that may differ from the location of /e/. If H1 is supported and /eɡ/ is lowered, the raising of /æɡ/ to overlap /ɛɡ/ and /eɡ/ between /ɛ/ and /e/ would suggest a three-way prevelar merger while remaining consistent with previous findings that /æɡ/ does not raise as high as /e/.

H3. All three prevelars are upgliding diphthongs; that is, prevelars raise and front substantially throughout their durations. Most of the previous work described above found /æɡ/ to be diphthongal and rising, and Reed (1961) and Wassink and Riebold (2013) also described /ɛɡ/ as having a rising glide. All three prevelars appeared to have upglides in the pilot study of Seattle children, as well. Ingle et al. (2005), Wassink et al. (2009), and Wassink (2011) found /e/ in PNWE to be fairly monophthongal, having a short or absent glide, so the trajectories of plain vowels are also reviewed in this data set and compared to those of the prevelars. Prevelars may show greater change in F1 and/or F2 than plain vowels, suggesting they are comparatively more diphthongal.

H4. Prevelar raising affects vowel duration. This could manifest as prevelars being longer than their plain counterparts, similar to the hypothesis that they are more diphthongal than the plain vowels. If prevelars are fully merged, they should be indistinguishable in duration as well as F1xF2 space. This may be particularly relevant for prevelar /ɛ/, which is typically shorter than /e/ or /æ/ and would therefore need to lengthen substantially to attain full merger.

H5. Age affects prevelar raising/merger. If prevelar raising or merger is a change in progress, older speakers may exhibit older states of the change, following the apparent-time hypothesis that sound systems are stabilized during adolescence (cf. e.g., Labov 1963). If both parts of the potential merger (/ɛɡ-eɡ/ merger and /æɡ/-raising) have been advancing over time toward full three-way merger, we might expect younger speakers to be more advanced in both parts and older speakers to show less separation between prevelars from their plain counterparts.

H6. Gender affects prevelar raising/merger. Men and women may show different rates of /æɡ/- vs. /ɛɡ/-raising. Wassink et al. (2009) and Squizzero (2009) found women to be more advanced in /ɛɡ/-raising but men more advanced in /æɡ/-raising. As discussed above, this may indicate differing social values placed on the two types of raising. If H5 is also supported, age and gender may interact such that one age-by-gender group is most advanced in one part of the merger while less advanced in the other. Since many combinations are possible, no specific predictions are made here, only that social differentiation is expected.

4 Methods

4.1 Subjects

In previous interviews for the PNWE project, many speakers showed patterns of raising of /ɛɡ/ and /æɡ/, but since these patterns were not expected before the project began, very few prevelar tokens were targeted for elicitation, yielding a small and incomplete data set. This study re-interviewed previous subjects to add to their data with more prevelar tokens and comparison environments. However, only five subjects were available for new interviews, so new speakers were also interviewed to reach a larger sample with speakers of both genders in two age groups.

Table 1: Number of subjects by age and gender

Generation	Males	Females
Gen 2 (age 37-62)	5	5
Gen 3 (age 18-36)	5	5

The sample consisted of 20 Caucasian speakers who had spent most or all of their childhoods in the Seattle metropolitan area, divided evenly by gender and age group, as shown in Table 1. In the larger PNWE project, speakers were divided into three generations; this study focuses on the younger two: Generation 2, speakers born 1951-1976 (age 37-62 at time of interview), and Generation 3, born 1977-1995 (age 18-36). Of this total, five had been interviewed for the PNWE project about five years previously (two Gen. 2 females, one Gen. 2 male, and two Gen. 3 males).

4.2 Elicitation procedures and materials

Following the original PNWE interview procedures, subjects were recorded with another eligible friend or family member whenever possible. Two in the current sample had no partner and were recorded alone, nine were recorded in groups of three or four family members, and four did part of the interview in a pair and part separately due to scheduling constraints. Return subjects were recorded alone, since they had already completed the group portions of the interview, which were not altered for this study. Before recording, all subjects completed a current PNWE consent form. Interview sessions lasted about an hour for return subjects and two or three hours for new subjects; all were compensated $15 for their participation.

Interviews were conducted in subjects' homes or study rooms in public libraries or community centers. Recordings were made using a Samson H4Zoom HandyCorder set on a table-top stand facing subjects. Both built-in microphones were used, creating 32-bit stereo recordings with 44.1 kHz sampling rates. For the individual-speaker tasks, channels were split in *Praat* (version 5.3, Boersma and Weenink 2013) prior to acoustic analysis.

Interviews began with two informal tasks: a group conversation and demographic questionnaire that elicited stories about family history and growing up in the Seattle area. Next, subjects were recorded individually for three formal tasks: an oral linguistic questionnaire, a reading passage (see Appendix), and three repetitions of a word list using the carrier phrase "Write ____ today." Together, these tasks elicited minimal pairs involved in various American English mergers and a wide range of phonemic/phonetic environments that have been found useful in differentiating social and regional dialects, plus additions for the prevelar environments under investigation here. Return subjects only completed the new portions of the formal tasks, to add to their original data.

Table 2: Target words measured. These 27 base words were targeted from the reading passage (Appendix) and word list (embedded in the carrier phrase "Write ____ today"), yielding 1-5 repetitions of each target from each speaker.

Following Environment	**/æ/**	**/e/**	**/ɛ/**
C (plain)	bad dad hatch	bait pace	bed dead test
/g/	bag brag drag dragon lag magnet nag zag	bagel pagan plague vague	beg egg leg leggings negative peg regular

A subset of target words from the reading passage and word list was selected for analysis. Target words included all measurable utterances (tokens) of a set of monosyllabic words selected to represent each non-high front vowel in a fairly neutral consonantal context, such as /b__d/, to avoid the coarticulatory effects of consonants which have large effects on neighboring vowel articulation, such as nasals and liquids. In addition, all measurable tokens of a set of words with each front vowel before /g/ were selected. Due to the sparsity of words in the /eg/ class, it was necessary to include polysyllabic words (e.g., *bagel, pagan*) and those with liquids before the vowel (e.g., *plague*). For better comparison, similar post-liquid environments were added to the other prevelar vowels (e.g., *lag, leg, drag, dragon*). All target words selected for measurement from the word list and reading passage are listed in Table 2.

4.3 Analysis procedures

Vowel boundaries

Transcripts of each speaker's reading passage and word list were force-aligned using the Penn Phonetics Lab Forced Aligner (*P2FA,* Yuan and Liberman 2008) to create phone-level *Praat* TextGrids. The automatically-generated phone boundaries in target words were hand-corrected in *Praat* with the help of a *Praat* script that located the target words in the grids. Vowel boundaries were hand-corrected in *Praat* for all target tokens (utterances of each target word) using the following guidelines.

The onsets of vowels after stops were marked just after the consonant release burst, as indicated by a short period of increased amplitude in the waveform. Vowels following voiceless stops were also marked this way so that vowel duration included aspiration. This method reflects articulatory gestures whereby the vowel begins directly after consonant release, regardless of the duration of voicing onset time (VOT). It has the advantage that all tokens are comparable for durational measures (i.e., all vowels are measured for duration the same way, beginning directly after the preceding consonant), but it has the drawback that the first portion of the vowel contains aspiration, often making formant measures inaccurate or impossible. In many study designs, vowels after aspirated consonants can be avoided, but because *pagan*, one of the four /eg/ class words chosen for this study, begins with an aspirate, it was deemed appropriate to include post-aspirates from other word classes, especially since duration is predicted to be a component differentiating prevelars from their plain counterparts.

The offsets of vowels before stops were marked at the consonant closure, as indicated by the loss of energy of F2 and/or a drop in waveform amplitude. Vowels neighboring fricatives were marked up to but excluding frication, as indicated by energy in high frequencies and a dense waveform. Boundaries of vowels adjacent to liquids were determined by changes in waveform shape and amplitude, in combination with changes in F3 (a dip for the rhotic /ɹ/ or a rise for the lateral /l/). For the analysis presented here, no target vowels were flanked by nasals, glides, or other vowels.

Vowel measurements

Vowel onset, offset, and duration were recorded, and formants (F1, F2, F3) and pitch (f_0) were measured at onset, midpoint, and offset (20%, 50%, 80% of vowel duration) using a *Praat* script that automatically located and measured all tokens of target words with primary stress. The formant range was set to 0-5500 Hz with a window length of 25 ms and dynamic range of 30 dB. The pitch range was initially set to 75-300 Hz, but some tokens fell below this range, so later measures were taken with the lower bound at 55 Hz. The number of formants was set per speaker based on the best fit of the LPC formant tracker to the majority of target tokens, as observed visually during hand-correction of phone boundaries. For most speakers, the fit was best with 5 formants; for a few, 6 formants, and for one, 4 formants. Measurements were discarded for tokens that had been marked during boundary correction as unmeasurable because they were mispronounced, self-corrected, obscured by laughing or background noise, etc.

About one quarter of these automatic measurements were verified or corrected by hand. To identify potential outliers, raw formant values were plotted for each speaker (F1xF2, Hz) using *NORM* (Thomas and Kendall 2007). Vowel measures at midpoint and at 20-80% points were plotted separately by following environment: pre-/g/ and "plain" (vowels before "neutral" consonants). Potential outliers were marked when they fell farther than two standard deviations away from the F1xF2 mean. These were then viewed individually in *Praat* for verification or correction. If the formant trace showed a poor fit to the spectrogram, the number of formants was adjusted to 4 or 6 for remeasurement; if a nasal formant was traced (replacing F2), measurements were shifted to ignore this. If the formant trace made an error only at the point of measurement, new measurements were taken at an adjacent glottal pulse; if the midpoint fell within the last 20 ms of aspiration (a rare occurrence), this point of measurement was moved to one glottal pulse inside of voicing. For 89 vowels after aspirated stops (/p, t, k/), the 20% point fell within aspiration, making the formant measures unreliable; for this reason, these post-aspirates were excluded from analysis involving the 20% point.

Normalization (*NORM*)

Since individual speakers have differing formant ranges, pooling of raw Hertz values can obscure meaningful differences (or similarities) between speakers. To be able to compare all speakers together, formant measures were first normalized using the Bark Difference Metric in the *NORM* Vowel Normalization Suite (version 1.1, Thomas and Kendall 2007). In this method, formant values are first converted from Hz to Bark z-scores, and then each F1 and F2 is subtracted from F3, with the difference between F3 and F1 modeling vowel height and the difference between F3 and F2 modeling the front-back dimension. This results in ranges (and axes on plots) that are reversed in direction from the raw Hz values so that the front-back values are the lowest, increasing from front to back, followed by higher height values, increasing from low vowels to high (i.e., low-front vowels have the lowest values on both dimensions). This method was chosen mainly because, as a vowel-intrinsic method, it does not require measurements from the whole vowel space; although vowels were elicited from the whole vowel space, only the non-high front vowels have been analyzed for this paper. An additional advantage is that the Bark scale relates to perceptual sensitivities so that differences between values in the lower frequencies, where perception is more sensitive, are greater than those in higher frequencies. Although perception is not discussed in this paper, these differing perceptual ranges are reflected in the SSANOVA plots used to examine vowel trajectories (described below).

Vowel overlap (*VOIS3D*)

Bark-normalized midpoint distributions were plotted with ellipses representing two standard deviations around the distributional means in F1xF2 space in *R* (version 2.15.1, R Development Core Team 2012) using the *phonR* package (McCloy 2012). Shading was added to some ellipses in Adobe Photoshop (version 7.0, Adobe Systems 2002) to highlight various comparisons, as discussed in the results section.

The overlap of vowel distributions was quantified using the Spectral Overlap Assessment Metric (SOAM) in the *VOIS3D* suite (version 0.98, Wassink 2006). For two-dimensional spectral data (F1xF2), SOAM estimates best-fit ellipses of two standard deviations around the means of two normalized vowel distributions and then calculates the percentage of the smaller distribution that is contained within the larger distribution. In addition, SOAM models three-dimensional ellipsoids by adding a term for z-score normalized duration and then calculating the volumetric overlap of the two ellipsoids. This 3D (F1 x F2 x duration) method adds important information for investigations of merger and near-merger – while two vowels may overlap substantially in 2D (F1 x F2), they may remain distinct in duration, showing less 3D overlap; conversely, two vowels that overlap substantially in 3D may be said to be fully merged. Wassink (2006) defines overlap fractions of 0-20% as indicative of separate distributions, 21-74% as partial overlap, and over 75% as complete overlap.

Trajectory modeling (SSANOVA)

Changes in formant values over time were examined via smoothing-spline analyses of variance (SSANOVA, cf. Davidson 2006) performed using an *R* script (Wassink and Koops 2013) that creates best-fit curves connecting the means of vowel formant measures at each time point (onset, midpoint, offset). This plotting method presents trajectory information more accurately than vector-based representations which connect measured time points with straight lines. The resulting plots resemble formant traces on a spectrogram with 95% confidence intervals around the best-fit mean curves. The confidence intervals are akin to the ellipses of two standard deviations seen in the midpoint F1xF2 plots and used by *VOIS3D* in the two-dimensional SOAM calculations, and similarly, if the confidence intervals of two vowels do not overlap, their distributions are considered separate. As mentioned previously, 89 of the total 2556 tokens were excluded from this analysis because their onset measurement point (at 20% of vowel duration) fell within the aspiration following an aspirated consonant (/p, t, k/).

5 Results

Evidence was found to support the first three hypotheses but not H4: /ɛg/ and /eg/ overlap at a spectral location between their plain counterparts (H1), /æg/ raises toward the higher prevelars (H2), and all three prevelars have rising upglides (H3), but prevelars do not differ in duration from their plain counterparts (H4). All speakers overlap /ɛg-eg/, but social differentiation is found for /æg/ (H5), with older males raising substantially more than the other groups. Following a description of the data set, results are detailed in three parts: midpoint data for /ɛg/ and /eg/, followed by /æg/, and then an examination of trajectory data. Evidence of social differentiation will be presented in each section with speakers separated by age and gender groups.

5.1 Data set

In total, 2556 tokens were measured, with 1-5 repetitions of each target word in Table 2 per speaker. Table 3 shows the distributions and mean formant values for each vowel context, for all speakers pooled (top panel) and for each age/gender group. Vowels are arranged roughly in order of increasing F1 (i.e., decreasing height) – note that the prevelars are higher than their plain counterparts except for /eg/, which is lower than /e/. In all, there were similar numbers of tokens of each vowel context with a roughly equal balance of contributions from each speaker group. (The lower total from Gen. 2 males is largely due to one speaker completing only one of the three repetitions of the word list.)

5.2 Formants at midpoint

/ɛg/ and /eg/

There is strong evidence to support H1, the overlap of /ɛg/ and /eg/ at a point between their plain counterparts. Figure 1 shows the non-high front F1xF2 vowel space for all speakers with ellipses of two standard deviations around each vowel's Bark-normalized mean at midpoint. All panels show the same distributions with different portions shaded to highlight relevant comparisons. As seen in

Figure 1a, with ellipses of two standard deviations, there is a fair amount of overlap among all vowels; however, their proportions can be compared visually and quantitatively via the overlap percentages calculated by *VOIS3D*, listed in Table 4.

Beginning with the plain vowels as seen in Figure 1a, /e/ and /ɛ/ (tan and light blue outlines) do not overlap at all (0%), while /æ/ (violet outline) overlaps /ɛ/ by 39% in 2D but only 23% in 3D, when duration is taken into account (/ɛ/ is shorter). Turning to the prevelars, Figure 1b highlights that /ɛg/ and /eg/ (blue and yellow shading) overlap almost completely (91% in 2D, 87% in 3D), centered directly between and overlapping almost equally (49-55%) with their plain counterparts (gray shading).

/æg/-raising

Figure 1c highlights how /æg/ (pink shading) has a visibly wider distribution that covers 95% of /ɛ/ (light blue outline). It is raised from /æ/ (gray shading) but still overlaps by 58% in 2D, 48% in 3D (with the prevelar shorter). Figure 1d highlights the overlap of /æg/ (pink shading) with /ɛg/ and /eg/ (blue and yellow shading) – over 60% of each (reduced by 6-14% in 3D, with /ɛg/ being shorter). However, with speakers separated by age and gender, shown in Figure 2 below, it is clearer that differing treatments of /æg/ contribute to its wider distribution.

Table 3: Mean midpoint formant values of each vowel environment

Speakers	Vowel	N	F1 (Hz)	F2 (Hz)
All speakers (N = 2556)	e	400	424	2283
	eg	297	514	2076
	ɛg	490	505	2043
	ɛ	339	601	1870
	æg	542	622	1901
	æ	488	743	1737

Speakers	Vowel	N	F1	F2
Gen. 2 Males (N = 589)	e	91	400	2143
	eg	64	486	1916
	ɛg	116	476	1918
	ɛ	81	562	1771
	æg	126	522	1887
	æ	111	689	1689
Gen. 3 Males (N = 645)	e	101	372	2065
	eg	75	439	1864
	ɛg	124	434	1856
	ɛ	82	501	1684
	æg	138	575	1692
	æ	125	680	1596

Speakers	Vowel	N	F1	F2
Gen. 2 Females (N = 671)	e	107	454	2396
	eg	78	532	2188
	ɛg	129	521	2145
	ɛ	86	603	1963
	æg	141	611	1996
	æ	130	729	1799
Gen. 3 Females (N = 651)	e	101	465	2506
	eg	80	590	2293
	ɛg	121	587	2246
	ɛ	90	727	2041
	æg	137	774	2026
	æ	122	870	1860

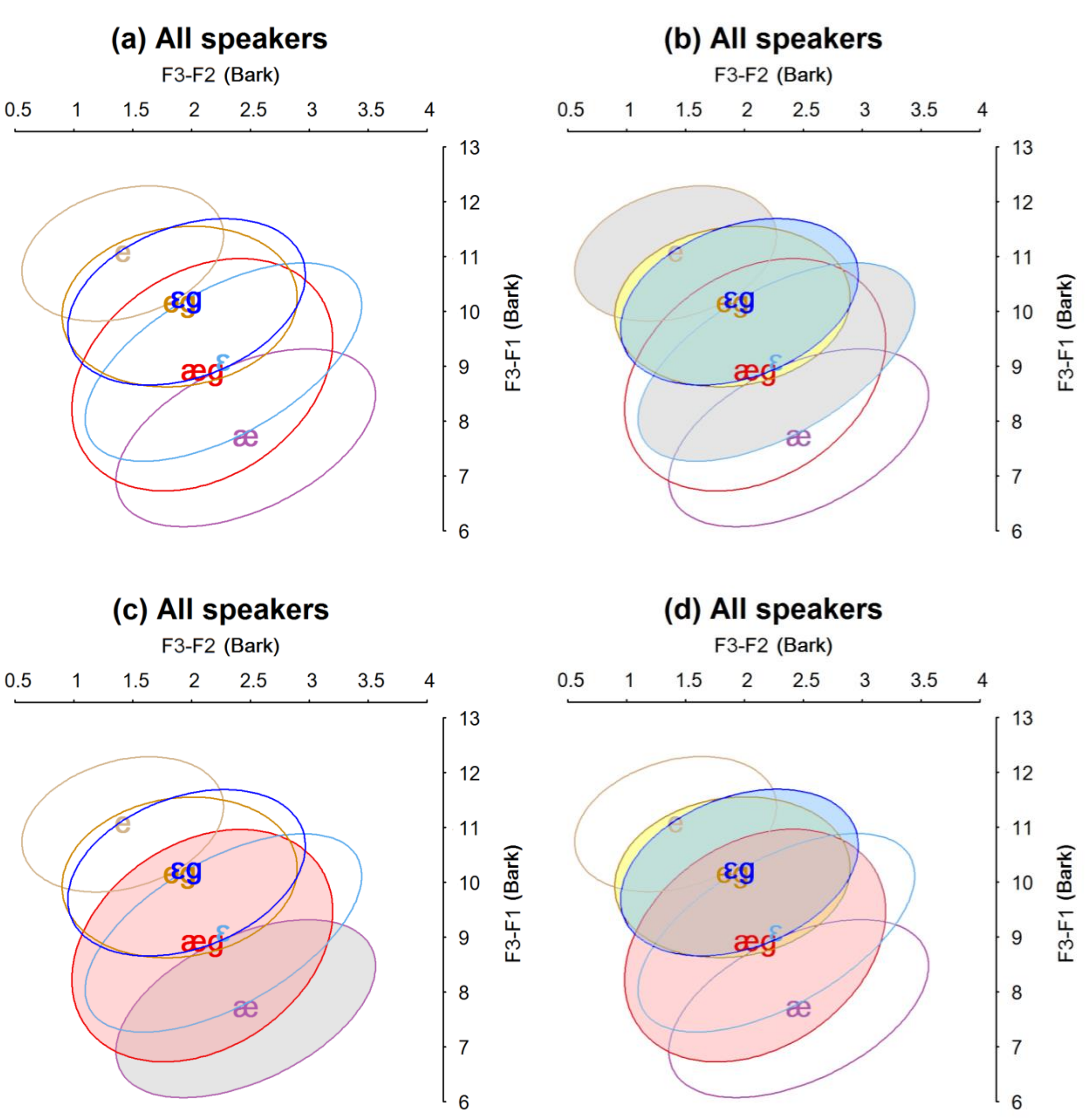

Figure 1: F1xF2 midpoint plot of all speakers pooled. All panels show the same distributions, the means for each vowel with ellipses of two standard deviations. Figure 1b highlights the positions of /eg/ and /ɛg/ (yellow, blue) compared to their plain counterparts (gray). Figure 1c highlights the position of /æg/ (pink) compared to /æ/ (gray). Figure 1d highlights all three prevelars.

Table 4: *VOIS3D* overlap percentages for all speakers pooled. Percentages in 2D include overlap of ellipses of two standard deviations in F1xF2 space; 3D includes a term for duration to represent volumetric overlap of three-dimensional ellipsoids. Following Wassink (2006), all pairs show partial overlap (21-74%) except /ɛg-eg/, which shows complete overlap (>75%), and /æg-e/, showing complete separation (<20%). Missing pairs (ɛ-e, æ-e, æ-eg, æ-ɛg) had less than 10% overlap.

Vowel Pairs	2D overlap	3D overlap
æ-ɛ	39%	23%
ɛg-eg	91%	87%
ɛg-ɛ	49%	40%
ɛg-e	49%	36%
eg-ɛ	52%	38%
eg-e	55%	44%
æg-ɛ	95%	91%
æg-æ	58%	48%
æg-eg	62%	56%
æg-ɛg	61%	47%
æg-e	9%	7%

Social differentiation

Figure 2 shows the non-high front Bark-normalized F1xF2 vowel space for each age/gender group with ellipses of two standard deviations around each vowel's mean at midpoint. As in the lower right panel in Figure 1, the prevelars are shaded to highlight the areas of overlap between them and to show their positions relative to their plain counterparts. For every speaker group, /ɛg/ and /eg/ (blue and yellow shading) have nearly identical distributions with high overlap percentages ranging from 79-96% (with the overlapping area appearing green). Their location is clearly centered between the plain /e/ and /ɛ/ (tan and light blue outlines), extending to overlap each plain vowel almost equally, regardless of the plain vowels' proximity to each other. All this is consistent with the pooled data that these two prevelars overlap entirely at midpoint between their plain counterparts.

In contrast, the position of /æg/ differs between the groups. In all groups, /æg/ (pink shading) is raised from /æ/ (violet outlines) to overlap substantially with /ɛ/ (light blue outlines), but its height and range differ between groups. The widest distribution for /æg/ is found for younger females (Gen. 3, bottom right), but most striking is its high degree of overlap with the distribution of /ɛg-eg/ for Gen. 2 males (top left) –99% of /eg/ and 89% of /ɛg/. This decreases to about half for Gen. 2 females (52% of /eg/, 49% of /ɛg/, top right), slightly lower for Gen. 3 males (46% of /eg/, 40% of /ɛg/, bottom left), and about 40% for Gen. 3 females (42% of /eg/, 41% of /ɛg/, bottom right). Similarly, the amount /æg/ is raised away from /æ/ (violet outlines) is greatest for older males, who show only 23% overlap, followed by 41% for older females, 52% for younger males, and 79% for younger females. In short, middle-aged males are clearly advanced in /æg/-raising, to the point of three-way merger with /ɛg-eg/. The other groups show much less raising, with /æg/ overlapping the higher prevelars by less than half and no group overlapping /æg/ with the plain /e/. Younger females are the most variable, and perhaps the least advanced, with the lower range of /æg/ overlapping much of /æ/, including its lowest height.

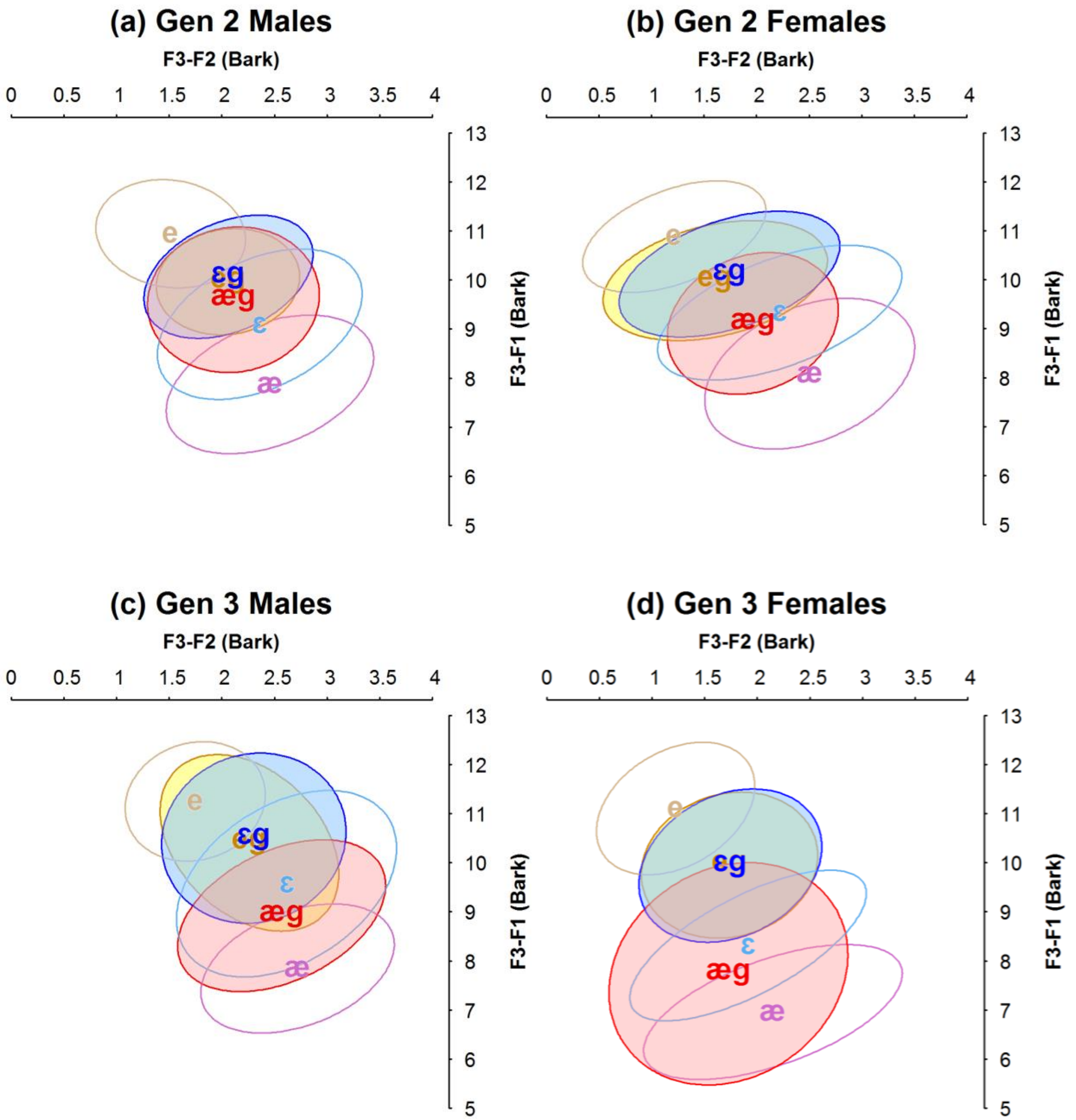

Figure 2: F1xF2 midpoint plots for each age/gender group. Older speakers (Gen 2) are on the top panels (a-b), younger (Gen 3) on the bottom (c-d); males on the left, females are on the right. Ellipses show two standard deviations around the mean of each vowel. The prevelar ellipses are shaded (/æg/ pink, /ɛg/ blue, /eg/ yellow), the plain vowels outlined (/æ/ violet, /ɛ/ light blue, /e/ tan). Note that with nearly identical means, the label for /eg/ is often obscured by that of /ɛg/.

5.3 Trajectory

Formants at onset and offset

Vowels with similar formant frequencies at midpoint may yet differ in duration or change in formants over time. Onsets and offsets are often visualized in an F1xF2 plot with arrows representing the direction of change. However, the arrows only roughly simulate the path of formant change over time by connecting the onset and offset with a straight line. To more closely model the path of change, smoothing spline analyses of variance (SSANOVA) were performed and the results plotted in Figures 3-4. These plots show mean formant values at all measured time points with a best-fit curve connecting them. With an appearance similar to that of formant traces on a spectrogram, formant measures (in Bark) are indicated on the vertical axis and time point across the horizontal (onset "0.2," midpoint "0.5," offset "0.8"). Confidence intervals of 95% around the means are represented by dashed lines that, in this data set, closely follow the thicker mean lines. By convention, if the confidence intervals around two means do not overlap, the distributions are significantly different. Because the Bark scale models frequency in relation to auditorily perceivable differences, the perceptibility of finer distinctions in height than backness is apparent as the differences between F1 values (shown by the lines in the bottom portion of each plot) appear greater than those between F2 values. With several overlapping F2 lines in Figure 3a, the y-axis is expanded in Figure 3b to zoom in on F2.

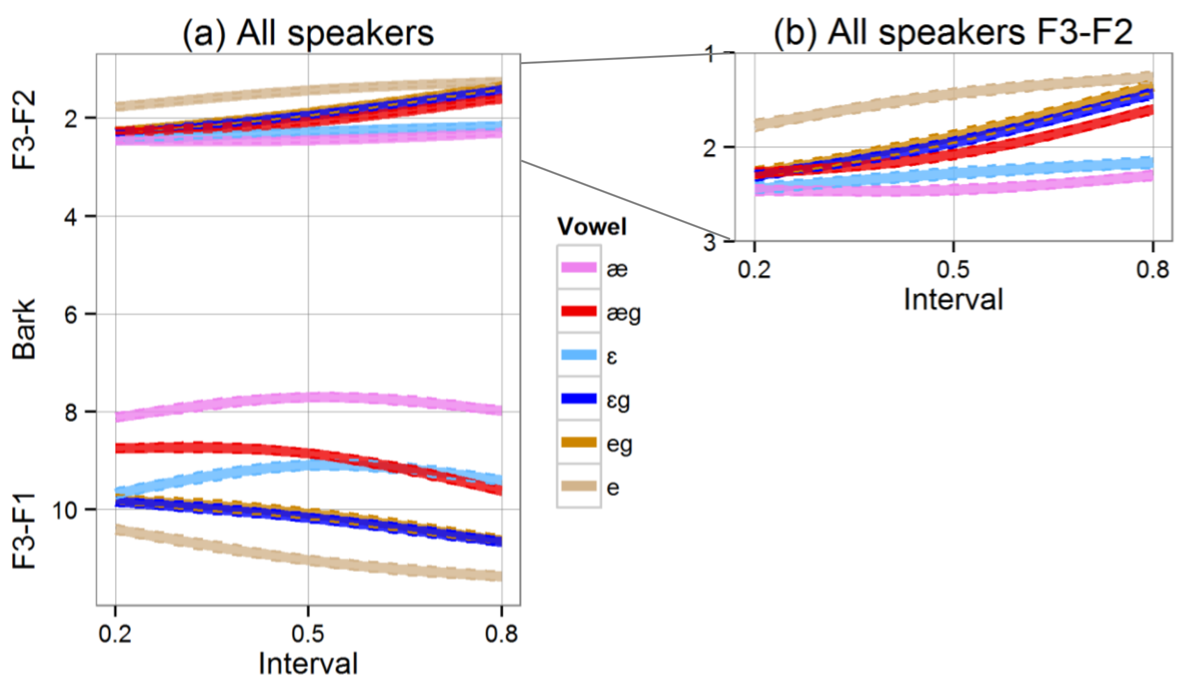

Figure 3: SSANOVA plots of formant change over time, all speakers pooled. Formant measures in Bark on the vertical axis, time points on the horizontal (onset at 0.2, midpoint 0.5, offset 0.8). F1 is represented by F3-F1 lines at the bottom of Figure 3a, F2 by F3-F2 at the top and in the zoomed-in view in Figure 3b. Dashed lines represent 95% confidence intervals around the means, shown as thick solid lines.

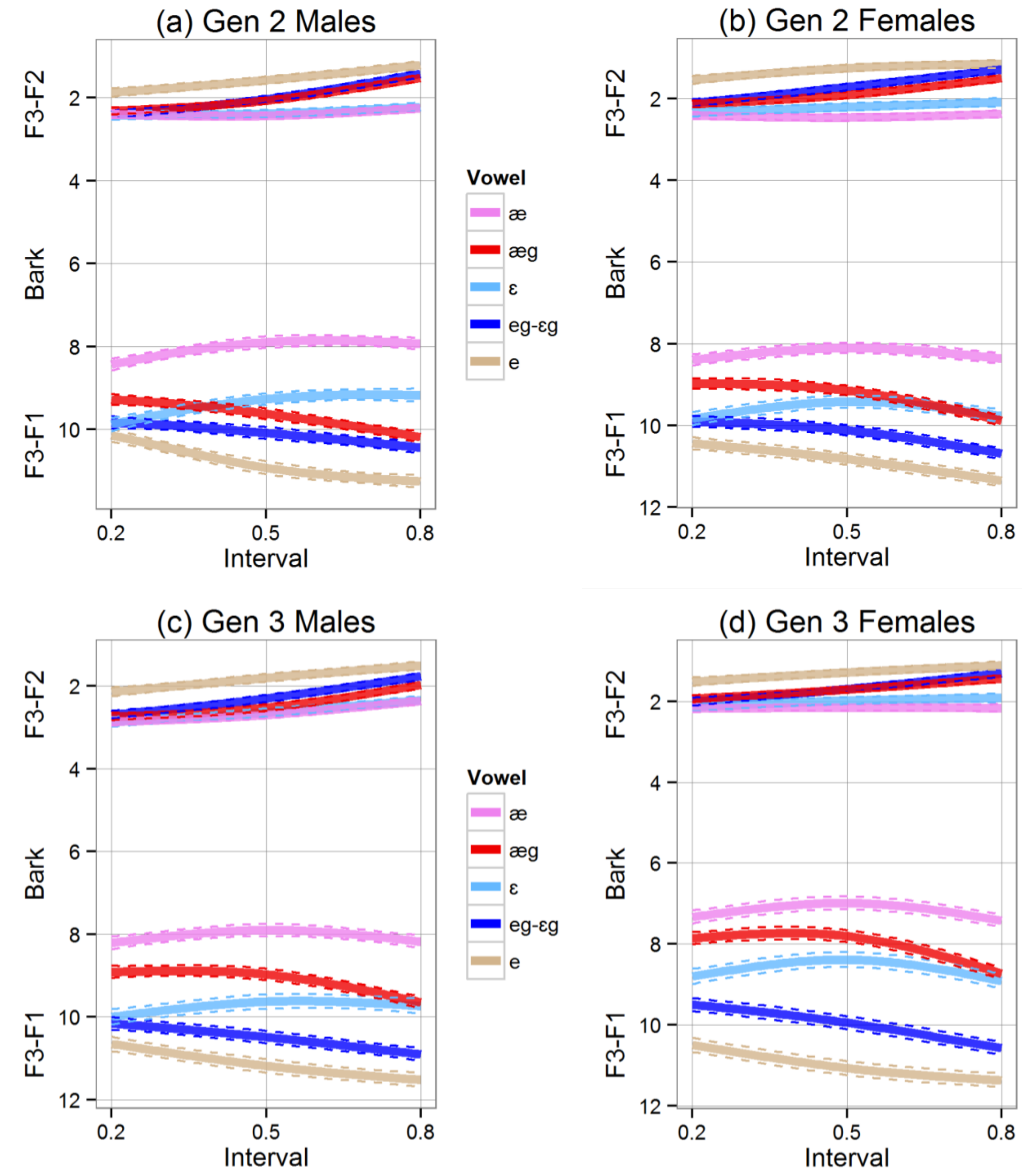

Figure 4: SSANOVA plots of formant change over time for each age/gender group. Older speakers (Gen 2) are on the top panels (a-b), younger (Gen 3) on the bottom (c-d); males on the left, females on the right. Formant measures in Bark are on the vertical axis, time points on the horizontal (onset at 0.2, midpoint 0.5, offset 0.8). F1 is represented by F3-F1 lines at the bottom of each panel, F2 by F3-F2 at the top. Dashed lines represent 95% confidence intervals around the means, shown as thick solid lines.

These plots show that /ɛg/ and /eg/ overlap almost completely all along their trajectories, so that the gold lines for /eg/ are largely obscured by the dark blue for /ɛg/. Interestingly, their onsets are very close to that of monophthongal /ɛ/ (light blue), and they show greater change over time than the higher /e/ (tan), which does not appear to be as monophthongal as has been found in previous PNWE studies (Ingle et al. 2005; Wassink et al. 2009; Wassink 2011). Also of note is the position and trajectory of /æg/ (red) – it is considerably raised from monophthongal /æ/ (violet) and about halfway to /ɛg-eg/ in F1 with an upgliding trajectory that parallels that of the higher prevelars. This trajectory information adds an important dimension to the midpoint data above: while /æg/ overlaps /ɛ/ at midpoint, it is distinguished by beginning lower (as seen by its higher F1 at onset) and ending more front (as seen by its divergence from /ɛ/ in F2). Furthermore, this evidence of change over time supports H3, that all three prevelars are upgliding diphthongs.

Social differentiation

As was found with the midpoint data, all speaker groups overlapped /ɛg/ and /eg/ almost completely but differ in their treatment of /æg/. To illustrate the differences, Figure 4 shows SSANOVA plots for each speaker group. To make the behavior of /æg/ (red) easier to view, the heavily overlapping /ɛg-eg/ are represented as single dark blue lines.

Most striking is the position of /æg/ for Gen. 2 males (Figure 4a): /æg/ (red) substantially overlaps /ɛg-eg/ (dark blue) in F2 all along its fronting trajectory and closely parallels the changing slope of F1. This matches the observations at midpoint, in which the distribution of /æg/ extends a bit lower (i.e., with higher F1) than /ɛg-eg/. All of the other social groups also show /æg/ fronting with a rising F2 that closely overlaps /ɛg-eg/. The F1 slope of /æg/ also matches that of /ɛg-eg/ more closely than that of the monophthongal /æ/ (violet), beginning closer to the onset of /æ/ but then diverging to end closer to the offset of the higher prevelars (dark blue). The F1 offset of /æg/ is closer to that of /ɛg-eg/ than /æ/ for Gen. 2 females (Figure 4b) and about equidistant between the two for Gen. 3 males (Figure 4c), but it is much closer to /æ/ for Gen. 3 females (Figure 4d).

In short, all three prevelars have upglides, as does the plain /e/, which also raises and fronts over time, contrary to expectations following previous PNWE studies. All speaker groups show steeper slopes for the prevelar diphthongs than for the plain vowels, indicating a more diphthongal characterization for prevelars which may help to differentiate prevelars from nearby plain vowels. As for all speakers pooled, all age/gender groups show the prevelar /ɛg/ and /eg/ beginning at or near the onset of the monophthongal /ɛ/ but ending higher and more front. Similarly, all groups show /æg/ beginning near the monophthongal /æ/ and then rising and fronting, crossing the trajectory of /ɛ/ near midpoint. Thus, although /æg/ and /ɛ/ overlap substantially at midpoint, they appear to be distinguished by their trajectories, with /æg/ beginning lower but ending higher.

Duration

While spectral information has mostly fit with expectations, results from durational analysis are surprising. That is, prevelars are similar or slightly shorter in duration than their plain counterparts, and prevelar /ɛg/ remains shorter than /æg/ and /eg/, which are very similar in duration within each condition (plain or prevelar), as shown in Table 5. (Note that the durations in the plain condition include both voiced and voiceless following consonants; with only voiced consonants, the mean duration of /æ/ increases to 212 ms, /ɛ/ to 156 ms, further separating them from the prevelars. Incidentally, no tokens of /e/ before voiced non-velars were examined for this paper.) The durational separation between prevelar /ɛg/ and /eg/ may be especially important: while /ɛg/ appears to merge with /eg/ in F1xF2 space, it may still be differentiated in duration, as can be seen in the differences in 2D vs 3D *VOIS3D* overlap percentages in Table 4. The patterns in Table 5 hold for all age/gender subgroups.

So, while prevelars are more diphthongal spectrally, they are not lengthened. This may be unsurprising for the already-long /e/ and /æ/, but it is interesting that adding spectral change to /ɛ/ does not increase its duration. There is one exception to this pattern: after aspirated consonants, prevelar /ɛg/ is longer than plain /ɛ/, as seen in Table 6, which separates the data in Table 5 by preceding consonant environment (voiceless aspirated or not). While all vowels are longer after aspirates than non-aspirates, the greater lengthening of post-aspirate /ɛg/ may be due to an uncontrolled factor such as sample size (79 tokens of post-aspirate /ɛg/, 22 of /ɛ/) or lexical effects (all tokens were *peg* or *test*). (Note also that with only voiced following consonants, the duration of plain, non-post-aspirate /ɛ/ increases to 156 ms, again further separating it from its prevelar counterpart. Incidentally, all post-aspirate plain vowels in this sample occurred before voiceless consonants.)

Table 5: Mean vowel durations (ms) by following environment

Preceding Environment	Following Environment	/æ/	/e/	/ɛ/
All combined	C (plain)	168	167	130
(N = 2556)	/g/	151	153	132

Table 6: Mean vowel durations (ms) by preceding environment

Preceding Environment	Following Environment	/æ/	/e/	/ɛ/
Non-aspirate	C (plain)	168	156	130
(N = 2239)	/g/	151	149	118
Aspirate	C (plain)	n/a	185	135
(N = 317)	/g/	n/a	175	207

6 Discussion

6.1 Main findings

Hypotheses were generally supported, although not all in the expected direction. H1 is strongly supported: for all speaker groups, /ɛg/ and /eg/ are merged all along their trajectories at points between the non-prevelar /ɛ/ and /e/. Previous work on the PNWE project (Squizzero 2009; Wassink et al. 2009) found /ɛg/ to be raised for many speakers, but without tokens of /eg/, the reference point was /e/. In the current data, speaker groups do differ in the amount /ɛg/ overlaps with /e/, with younger males showing the most; however, this may be a reflex of their generally wider distribution of /ɛg/ – as with all speaker groups, the prevelar /ɛg-eg/ overlap both the plain counterparts almost equally. This is a major contribution of the current study, showing that /ɛg/-raising is indeed part of a merger, but not with /e/, as has been examined in previous studies, but rather with *prevelar* /e/, which lowers to join /ɛg/ rather than raising, as might be predicted following the coarticulatory explanation involving velar pinch. Instead, this tiny word class may be reinterpreted as belonging to the larger and phonetically proximal raised /ɛg/ (BEG) class. Bauer and Parker (2008) did examine some /eg/-class (BAGEL) words in Wisconsin and interpreted their similarity to /æg/ (BAG) words as a sign that the former have been reanalyzed as belonging to the larger BAG class. However, they did not compare their patterns with /eg/ words as a group, as was done here. The results of this study are consistent with theirs, but with the inclusion of BEG words, it is more likely that BAGEL words are reanalyzed as belonging to the phonetically and phonologically closer neighbor, the raised and diphthongal /ɛg/.

Regarding H2, /æg/was found to raise for all speaker groups, as predicted, but only to the predicted height of /ɛg-eg/ for older males. Offering partial support for H5/6, social differentiation is apparent, but only for /æg/-raising: while /ɛg-eg/ merger is equally high across speaker groups, /æg/ is highest for older males, followed by older females, and then younger speakers, contrary to the prediction in H5 that younger speakers would show more raising. Gender differentiation is strong in the older generation, supporting H6, but it is less clear in the younger, with males showing more separation of /æg/ from /æ/ but females showing a wider distribution for /æg/. This could indicate retraction over time or a social association with /æg/-raising that younger speakers wish to avoid. In contrast, the stability of /ɛg-eg/ merger across groups may be indicative of a completed change, one that appears to have proceeded largely without comment.

H3 is also strongly supported: all prevelars show clear upglides as they raise and front over their durations. This especially helps separate prevelar /æg/ and /ɛg/ from their monophthongal plain counterparts, and it contributes to the clarity of the spectral merger between /ɛg/ and /eg/. Contrary to previous PNWE findings, non-prevelar /e/ does not appear to be especially monophthongal, but its change over time and movement in F1xF2 space is less than that of the prevelars. This may mean that /e/ is less diphthongal than in other dialects, but it could also be that its nucleus is spectrally higher (as found by Wassink and Riebold 2013) while the glide target height remains the same, resulting in a shorter trajectory. (It is also possible that speakers in the oldest generation included in previous PNWE studies have shorter glides than the younger speakers interviewed here.)

Finally, results for duration (H4) are mixed. Prevelars were found to be similar in duration or shorter on average than their plain counterparts, and while /æ/ and /e/ were similarly long in both conditions, prevelar /ɛ/ remained shorter. For speakers with /æg/ also merged with /ɛg-eg/ in F1xF2 space, the similar durations of /æg/ and /eg/ may reinforce their merger while maintaining /ɛg/ as shorter. This might be the only finding that remains a barrier to a declaration of full /ɛg-eg/ merger. One possible explanation is that BAGEL-class words are less common and may therefore be longer than more common words (cf. e.g., Baker and Bradlow 2009; Bell et al. 2009). However, in this study, two words were fairly common, *bagel* and *vague,* while the other two were less so, *plague* and *pagan*. Further study is needed, but not much can be done to tease apart words of varying frequencies in such a small class.

6.2 Future work

Future work will include examination of other sources of variation in prevelar raising and merger, especially regarding /æg/-raising, the most variable component. This study focused on front vowels before /g/, but their behavior before the prevelar nasal /ŋ/ will also be examined; following Baker et al. (2008), the prevelar nasal environment is expected to increase the length of upglides and therefore the extent of raising. Similarly, the behavior before the voiceless velar /k/ will be examined. Bauer and Parker (2008) explain how raising before /k/ does not have the same phonetic motivations as before voiced velars, in which the larynx is lowered for voicing, increasing the size of the pharyngeal cavity and therefore lowering F1. In other words, articulations before the voiceless /k/ are in opposition to those involved in raising; since raising in this environment is not expected on phonetic grounds, its occurrence might signal phonological extension far beyond the initial conditioning factors before voiced velars. Other linguistic conditioning factors may also be examined, such as stress, word length (mono- vs polysyllabic), and lexical frequency, which may shed light on mechanisms of diffusion.

This study was also limited in its investigation of language-external conditioning factors. Local social groupings, network density, and the urbanness or insularity of speech communities are of particular interest in describing the social value of /æg/-raising, since age and gender alone have not offered a clear explanation. Work is already in progress to examine differences between ethnic groups in Washington (Riebold 2014), and more data could be collected from the oldest generation to shed more light on earlier stages. A younger generation, such as teenagers, could also be studied to inform theories of current advancement and the social meanings attached to raising/merger (or its avoidance). Discourse factors may also contribute to our understanding of such social meanings. Only tokens from formal tasks were reported here, but further analysis will include comparison with behavior in less scripted tasks to examine the effects of style. Similarly, degree of merger may be affected by variables such as the expression of opinion, level of engagement with the topic of discussion, relationships between speakers, or demographic features of audiences. A large project currently underway ("ATAROS," supported by NSF grant IIS-1351034 awarded to PI Gina-Anne Levow) examines these factors in relation to their effect on hyperarticulation in general, and a portion of this may be devoted to their effect on prevelar raising/merger.

Finally, discussion of merger is incomplete without consideration of perception as well as production. Perception experiments are currently being designed to test listeners' classification of PNWE prevelar vowels. The PNWE project is about to begin data collection using natural stimuli extracted from interviews, and a related study will create synthetic stimuli for greater control over the isolation of the features that listeners use to identify and distinguish the affected vowels.

6.3 Conclusion

This examination of the speech of 20 Seattle Caucasians in formal reading tasks found that prevelar /ɛg/ and /eg/ (BEG and BAGEL) are merged at a position between the two vowels before other (non-velar, non-nasal, non-liquid) consonants. This holds all along their trajectories, which have raising and fronting upglides, but BEG is shorter in duration. Prevelar /æg/ (BAG) is raised and upgliding for all speakers, but it varies considerably between groups, showing social differentiation by age and gender: middle-aged males show nearly-complete three-way merger with /ɛg-eg/, while middle-aged women are less raised and show less overlap with /ɛg-eg/, and younger speakers show the least raising and little overlap with /ɛg-eg/.

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8 Appendix

Reading Passage

The Cat and the Mice

Once upon a time, a cat passed by a big house that was full of mice. Ever since she was a kitten, the cat had thought to herself, "I would be happy in that home." So, the very next evening, she moved in with the family that lived in the house. Then, the fight between the cat and the mice began. At first, the mice avoided the cat like the plague, huddling under the deck and trying not to make a peep. But the cat simply hid in a corner behind a sack of bagels and waited calmly for them to take the bait. The mice zigged and zagged down the hall, but they only had a vague idea where the cat was hidden. When she caught one, she would pen the mouse up in the corner between her paws. The mice would beg for mercy and kick their legs with all their strength. Their nagging cries made quite a din. But, the cat would simply pin them against the wall of her den and eat them up anyway. This went on for six days, until finally the mice couldn't stand it anymore. Feeling angry, they decided to go into their holes and stay there for a week. This way, bragged the mice, the mean old cat would never catch them. “That’s not fair,” said the cat to herself, as she drank the pool of milk in her bowl. “Now the only thing to do is to pull them out by a trick — then I can bake a fine mouse pie and eat like a king again.” So, she thought for a while, paced the length of the room, and hatched a plan. Eager to test her new scheme, she climbed up the wall and let herself hang down by her back legs from a peg, pretending to be dead. By and by, a mouse peeked his nose out, looking for food. The mouse paused when it saw the cat hanging there like a spider on a web. “Gosh!” the mouse cried. “You can’t fool us, you mangy cat! You can pretend to be a bag of bones hanging there until next Tuesday if you like, but don’t think you’ll catch us coming anywhere near you.”

If you are wise, you will not be fooled by the innocent actions of those you once found to be dangerous.