# Ongoing change of PIN/PEN vowels in California's Central Valley

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## ABSTRACT

This study investigates the prenasal high front vowels PIN and PEN in California' Central Valley, using sociolinguistic interview data of 54 white speakers balanced in age and gender from three representative sites. While previous studies suggest a merger in inland and rural California, the results of this study show an increasing F2 distance between PIN and PEN, resulting in a decreasing degree of overlap between the two vowels in apparent time. I argue that among older speakers, PIN and PEN become overlapped phonetically due to dialectal contact. But the phonological contrast remains and is phonetically realized among young people. Furthermore, the ongoing change causes tremendous individual variation, among speakers that overlap or separate the categories. Comparing this vowel pair with other dialects in America, the change of PIN and PEN in the Central Valley is a part of the shrinking vowel space of the California Vowel Shift.

**Keywords**: Californian English, sound change, vowels, sociophonetics, merger

## 1. INTRODUCTION

This study investigates the prenasal high front vowels, PIN and PEN, spoken in California's Central Valley. The vowels in California undergo a chain shift, known as the California Vowel Shift (CVS). In particular, the front lax vowels BIT and BET have been found to move lower and farther back [4] [11] [17]. However, how PIN and PEN, the nasal counterparts of BIT and BET, vary and change in California remains understudied, especially in the non-coastal, non-urban areas.

There is a potential merger between PIN and PEN. The Dust Bowl in the 1930s resulted in migrant families from the South settling down in the Central Valley. They brought the PIN-PEN merger, a prominent feature of Southern English, to California. A study in the 1970s [14] observed the merger among young speakers. Decades later, the merger was spotted in inland cities such as Bakersfield and Fresno, as well as among African American speakers in Los Angeles [13], leading Geenberg [6] to speculate that that African Americans and non-urban whites may be the two communities that are most likely to have the merger. However, a recent acoustic study on eight speakers from Bakersfield showed older speakers (35-65 years old) had the merger while younger speakers (16-26 years old) did not, suggesting a process of demerging [18]. Therefore, it is unclear whether the PIN-PEN merger has ever completed in inland California.

In addition, PIN and PEN's places in the shifted Californian vowel system need investigation. In coastal communities without a merger, the front lax vowels [ɪ] and [ɛ] are reported to be either raised before nasal [9] [18] or not raised [8]. Meanwhile, when the merger was found, studies reported that PEN was raised to PIN [6] [14]. Warren & Fulop [18] reported that the merged vowel is significantly higher than BIT, speculating it to be a result of the lowering BIT in California.

This paper investigates the phonological status of the PIN-PEN contrast in inland California and their phonetic realizations. Only vowels before [m] and [n] are included. Those before the velar nasal /ŋ/ are not discussed, because they are extremely rare in the data. BIT, like BAT, may also raise before the velar nasal, constituting a separate word class.

## 2. METHODS

### 2.1. Data collection

This study used data from sociolinguistic interviews in the Voices of California Project, conducted in Merced (2010), Redding (2011), and Bakersfield (2012), representing the center, north and south points of the Central Valley respectively. The free-flowing interviews were recorded in quiet rooms at a sampling rate of 44.1 kHz and 16 bits, with solid state digital recorders (Marantz PMD 660, Zoom H2, or Sony PCM-M10) and directional lapel microphones worn by the speakers.

Among all the interviews, those of 54 white speakers from the three fieldwork sites were chosen, 18 from each site. In each community, the sample was balanced evenly in sex and represented the adult life course (18 to 73 years old).

### 2.2. Acoustic analysis

The interviews were orthographically transcribed and forced aligned by FAVE [16]. All the words

with the PIN and PEN vowels in stressed syllables in the chosen interviews were extracted by Praat [14]. Words were excluded if (a) the target vowels are preceded by [l] and [r]; (b) they are audibly breathy, creaky, or interrupted by background noise. Tokens of PEN vowels with shorter duration than 50ms and PIN shorter than 40ms were eliminated. The onset and offset were manually adjusted. For each speaker, the aim was to select 25 tokens for each vowel, with no more than two tokens per lemma. However, in cases where fewer than 25 tokens met the criteria, a third token per lemma was allowed.

Measurements of the duration and the first five formants at the mid-point of the vowels were extracted using a script in Praat, with manual corrections when tracking errors occurred. The two vowels, especially PIN, were not common in the interview data. In total, formant measurements of 1209 PENs and 676 PINs were converted into the Bart scale. Using formant measurements of the corner vowels (BEET, POOL and TRAP) of these speakers from previous VOC projects, the PIN and PEN vowels were normalized using the Fabricius, Watt, & Johnson method [5]. It should be noted that PIN and PEN are rare in speech production; the number of usable PIN and PEN tokens is imbalanced between each other and across speakers.

In addition, this study also included the formant measurements of the corresponding vowels followed by non-nasals, namely BIT and BET, to put the prenasal vowels in context. All usable tokens except those from six speakers were taken from a previous study focusing on these vowels [17]. The selection of BIT and BET followed the same selecting criteria of PIN and PEN, with 25 tokens from each speaker, except that the minimum duration for the BIT and BET vowels was 75ms. The measurements then went through the same procedure as PIN and PEN. In total of 1188 BETs and 1031 BITs were included in this study.

### 2.3. Statistical analysis

Both social and linguistic factors were considered in the statistical analysis. The linguistic factors were the log duration and the phonological environment of the vowels, including the preceding segments (places of articulation for consonants or a vowel), and the following nasal ([m] or [n]). The social variables were Age, Sex and Site. Age was based on the birth year of the speakers. It was treated as a continuous variable, instead of a categorical one, because of the uneven distribution of age across different sites in this sample. Sex was based on speakers' self reports.

Statistical analyses were used to address the research questions. First, mixed-effects models were used to examine the high/mid-front vowel space of the speakers considering both the linguistic and social factors. Second, the relations between PIN and PEN of individual speakers were tested using t-tests and discriminant analysis. Third, the apparent-time change of merging between PIN and PEN in the population was examined by three measurements that quantify the distance and degree of overlapping between PIN and PEN: ΔF1/ΔF2, Euclidean Distance, and Pillai Scores.

## 3. RESULTS

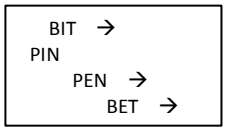
### 3.1. Change of high front vowels

The mixed-effects models included F1 or F2 measurements separately to show whether the social and linguistic variables have significant effects on the changing locations of the vowels in the speakers' vowel space. For the frontness of PIN and PEN, Age shows a significant main effect in the model for PEN ($p<0.005$) but not for PIN, indicating that PEN but not PIN has moved farther back over the years. A main effect of Sex ($p<0.05$) shows that female speakers produce farther back PIN and PEN. Furthermore, both vowels are significantly farther back after coronal and labial consonants ($p<0.01$ in all cases), before [m] than [n] ($p<0.001$ in all cases), and when they are shorter ($p<0.05$ for PIN and $p<0.0001$ for PEN).

For the height of PIN and PEN, no significant main effects are shown for the social factors, indicating no apparent-time change for these vowels. They are significantly lower followed by [m] than by [n] ($p<0.05$ for both vowels), and with a longer duration ($p<0.0001$ for PEN and $p<0.001$ for PIN).

Apparent-time backing led by women was found for BIT and BET vowels (Sex and Age have significant main and interaction effects), but not for their vowel heights. The results suggest that BIT, BET, and PEN all undergo backing but not raising or lowering, while PIN stays stable. Additional mixed-effects models among all vowel pairs show that PIN is fronter and lower than BIT, and higher than PEN; while PEN is higher and fronter than BET (all significant, Figure 1).

**Figure 1**: The relative positions and apparent-time change in the high front vowel space



### 3.2. PIN and PEN by individual speakers

For every speaker, two-sample t-tests were performed to compare F1 and F2 separately between PIN and PEN. 38 speakers show overlap between PIN and PEN, indicating many speakers produce overlapping PIN and PEN in one or both dimensions of the vowels, among them 17 do not distinguish them on either the F1 or F2 dimension. 16 speakers produce separate PIN and PEN with significant differences in both F1 and F2. When the t-test results are sorted by Age of speakers, it can be observed that speakers who produce significantly distinct F2 between PIN and PEN appear to be younger than those who produce overlapped F2, while no visible age difference is shown for F1.

I also use discriminant analysis to show the confusability between the PIN and PEN categories, where misclassification rates (MR) are calculated based on how many tokens were misclassified into the other category by each speaker. A low MR indicates clear separation between categories. The results show that there is a tremendous variability in the overall MR across speakers, ranging from 0% (clear separation of the vowels) to 53.85% (complete merger of the two categories).

### 3.3. Distance and overlapping of PIN and PEN

Mixed-effects models were applied to the Euclidean Distance between all the PENs and the mean of PINs for each speaker, with the social and linguistic factors, as well as Speaker and Word as random effects. No social or linguistic effects were shown. However, when modeling the differences in F2 and F1 between PIN and PEN separately, significant social and linguistic effects emerge for F2, but only linguistic effects surface for F1. The results show significant larger F2 distance in female and younger speakers (Sex and Age both significant at $p<0.05$), as well as when PENs follow coronals and labials ($p<0.01$), are followed by [m] ($p<0/001$), and have longer log duration ($p<0.0001$). Larger F1 distance is shown with longer PENs ($p<0.05$) or PENs followed by [m] ($p<0.0001$). This pattern indicates that the PIN and PEN become more distant among younger people and female speakers, but only in terms of vowel frontness and not height.

The Pillai Score resulted from a MANOVA test for each speaker with Word as a random factor. It measures the degree of overlapping between two categories in the F1-F2 space. The higher the score is, the lower the degree of overlapping between the two vowel categories, and the less likely a merger [7]. A linear regression model for the Pillai scores from each speaker shows a general trend of the PIN-PEN "demerger". With a main effect of Age ($p<0.0001$), the Pillai Scores of younger people are significantly higher than older people, indicating that over the years, the two vowel categories have become less overlapped. Parameter estimates suggest that female speakers from Bakersfield seem to have the smallest Pillai Score among all the speakers ($p<0.0001$).

## 4. DISCUSSION

This study investigates PIN and PEN in relaton to BIT and BET. The PIN vowel is significantly lower than BIT while PEN significantly higher than BET, concurring with studies that demonstrate shorterned F1 distance between prenasal vowels [1]. This provides the acoustic basis for a potential merger. The results also show that the PIN vowel has not moved farther back over the years even though BIT has. In contrast, PEN has moved farther back together with BET. As a result, the PIN vowel is significantly fronter than BIT, while PEN is significantly farther back than BIT though fronter than BET. Female speakers consistently produced farther back vowels, significantly more advanced in the sound change than male speakers. Linguistic environment also conditions the change. PIN and PEN are farther back after labial and coronal consonants. They are also farther back when followed by bilabial [m] than the alveolar [n]. In addition, the longer the vowel is, the farther back the vowels appear to be. Because PEN moves farther back while PIN appears stable, there is an enlarged F2 distance confirmed by the mixed-effects model.

The different patterns between F1 and F2 in the overlaps suggest that they may take different roles in the variation. Apparent-time change is observed only along the F2 of PEN, while there are no effects along the F1 of either vowel or the F2 of PIN. It is possible that the varying vowel frontness of PEN is responsible for the apparent-time decreasing degree of overlap between the two vowels, shown by the decreasing Pillai Score. The farther back a speaker's PEN is, the less overlapping the two vowels are. The varying vowel heights of PIN and PEN have little to do with the apparent-time decrease in overlap but may contribute to individual variation.

Warren & Fulop [18] suggested there might be a demerging process in the area, however, it may be possible that PIN and PEN never truly merged. Emergence of a merger is not uncommon in sound change, but the reversal of a merger is very rare. Once merged, the reversal of the process through linguistic means is extremely difficult, especially if there are few minimal pairs between the contrastive categories, or if the contrast relies on few phonetic features [12], two criteria that the PIN-PEN pair

seems to meet. In the rare cases where a merger seems to have gone through a reversal, such as the loss of the LOIN-LINE distinction in the century after 1650, motivations such as standardized spelling [10] and educational target [2] have been proposed. Deeming these motivations insufficient, Numberg [15] proposed that LOIN-LION never truly merged; instead, a near merger took place where the contrast was not perceivable by the speakers, but subtle phonetic differences remain in the production. This happens because at a stage of a sound change, the perceptual space of two categories may overlap as the phonetic targets of the two categories approach each other. However, when the sound change continues, and the phonetic targets move pass from each other, the contrast between the two categories will resumed in perception.

The merger of PIN and PEN observed by Metcalf [14] reflected the overlapping tendency of the two categories. Young speakers in his time – now older speakers in this sample – are shown to have overlapped PIN and PEN. However, a closer look at individual data show remarkable variation of the placement of these speakers' overlapped categories: some overlapped PIN-PEN raise to where BIT is, some lower to where BET is, and some lie in between. This shows that the "merger" was an ongoing change, and there was not a homogeneous phonetic target for the "merged" category among these speakers. Much like the LION-LOIN case discussed above, the "merger" is an illusion of phonetic proximity in an ongoing sound change, very likely brought by the Dust Bowl in the 1930s, where many families from the South moved to California and made the Central Valley their home. This is evident in many interviews, where the speakers talked about growing up in an "Okie" family (from Oklahoma or other southern states) or with "Okies" in their neighborhood. Some speakers also noted that these families from the South speak a different dialect; but the kids grew up speaking the "Cali-accent". One speaker even explicitly talked about "PIN and PEN are the same for us", but did not associate it with their southern ties. These meta-linguistic awareness shows that the overlapped vowels have their southern roots, but have been incorporated as a local feature.

Furthermore, the results show that PIN and PEN have become more separate among younger speakers, owing to PEN moving farther back in the vowel space while PIN staying stable. If there were a complete merger, one would expect the merged PIN and PEN should behave the same way in sound change. Because this is an ongoing change, there are also different degrees of overlapping among younger speakers whose vowel categories are not entirely overlapped. Both the "demerging" and the variation across speakers suggest that the PIN and PEN have never truly merged into one phonological category. The phonological contrast remains even some older speakers overlap the two categories due to contact with the southern dialect. Among younger speakers, the contrast surface again in phonetic forms.

Finally, the change of BIT, BET and PEN should be considered in the context of the California Vowel Shift. BIT and BET moving father back is part of the chain shift, and PEN seems to participate in this hift with BET. Although it is unclear why PIN stays stable, the change of PEN is enough to separate itself from PIN, recovering the contrast. Moreover, by moving farther back, these high front vowels participate in a shrinking vowel space characteristic of the Californian vowels [17].

## 5. CONCLUSION

This study investigates the variation and change of PIN and PEN in inland California. Although the PIN-PEN merger is expected to occur in the inland and rural areas in California based on past studies, the results show otherwise. PIN and PEN have different behaviors in apparent-time sound change: while PIN remains stable, PEN has become farther back with the other front lax vowels in the California Vowel Shift. This results in an enlarged distance between PIN and PEN on the F2 dimension, and causes the degree of overlap between the two vowels to decrease in apparent time. Since there is less overlap among young people, it is likely that the "PIN-PEN merger" observed in past studies might be a stage of sound change when the two vowels overlap in production, and thus not a true merger. It is possible that the convergence of PIN and PEN is a result of contact with Southern English. However, a complete merger might not have taken place. As PEN participates in the California Vowel Shift, the two vowels become separate phonetically again. The results show tremendous variation across speakers (especially in terms of the vowel height of PIN and PEN). The prevalent interspeaker variation might be characteristic of an ongoing sound change. It also suggests that sound change like PIN-PEN merger might not be as unidirectional and homogeneous as previous studies often depict. Furthermore, this reversal of what appears to be a merger show that a phonological contrast can persist through sound change even when the phonetic forms of the phonological categories become highly overlapped in a historical process.

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