The Movement of Front Vowel Allophones Before Nasals in Southern Illinois White Vernacular English (The PIN~PEN Merger)

by

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Approved by
Supervising Committee:

Dedication

This thesis is dedicated first of all to my fiancé, Shawn M. Law. Also, to Judy and Steve Bigham, my parents; my three sisters; two nephews; one niece; and all of my aunts, uncles, and cousins who have helped me along my way. This is also dedicated to Janet M. Fuller, my undergraduate advisor and friend, and the many professors at Southern Illinois University – Carbondale and the University of Texas – Austin who have helped me become the scholar I am. This thesis is dedicated to Anne Abney, Nathan Ogren, Nikki Seifert, Anne Webb, and Jessica White for their ongoing friendship and support, and most especially to Christina Reese, the best friend anyone could ask for, for making fun of the way I talk. Finally, this thesis is dedicated to Southern Illinois:

the land, the people, the folklife, and the mystery.

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Abstract

The Movement of Front Vowel Allophones Before Nasals in Southern Illinois White Vernacular English (The PIN~PEN Merger)

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This work considers the merger of the allophones of /ɪ/ and /ɛ/ before nasals, commonly called the PIN~PEN merger. Vowel tokens from twenty speakers in Southern Illinois are sampled; statistical information and vowel graphs, based on F1 measurements, are generated for discussion. While the majority of these Southern Illinois speakers do show the PIN~PEN merger, there is a wide range of variation in the ways and degrees that each individual speaker participates in the merger. Data on pre-nasal allophones of /æ/ are also included, and the effect of the PIN~PEN merger on pre-nasal /æ/ is examined. The possibility of a change in progress, from a PIN~PEN merger to a PEN~PAN merger is considered. The data reported here provide an important link between the phonetics literature and the sociolinguistic/dialectology literature on the effect of nasals on preceding vowels.

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0. Epigraph

Southern Illinois sits on the back doorstep as poor as Job's turkey, as beautiful as redbud trees in spring. . . more passionate, more violent, stubborn, stingy. . . a sweeter Illinois with soft southern linguals, magnolia blossoms, and a generous heart. . . (Baker Brownell, *The Other Illinois*, p.3).

1. Introduction

The merger of the allophones of /ɪ/ and /ɛ/ before nasals, commonly called the PIN~PEN merger (because it creates homophony in word pairs like *pen ~ pin* or *chem ~ Kim*), is one of the most popularly commented on features of Southern U.S. dialects (Bailey 1997, Wolfram & Schilling-Estes 1998, Berrey 1940, Thomas 2001), yet few studies exist of either its range or its phonetic characteristics. Brown (1991) offers the most extensive treatment, but this is an historical account.

Typically, the account of the PIN~PEN merger is as in E. Thomas (2001): /ɛ/, being generally higher in the South than in the North, is more susceptible to interference from the nasal formant trough, which causes it to raise, or be interpreted as raised, to /ɪ/ in pre-nasal contexts. This hypothesis has not been tested acoustically, however. Further, although [æ] has separately been shown to raise in pre-nasal contexts (e.g. Labov 1994), it has not yet been considered as part of the 'classical' PIN~PEN merger. Based on my own pilot studies for this research project, I found that speakers were engaging in a form of 'hypercorrection' away from a PIN~PEN merger and towards a PEN~PAN merger; therefore, I included measurements of the pre-nasal and pre-oral allophones of /æ/ in this study. Furthermore, I included two differing types of reading tasks (described below) with the hope of eliciting both the hypercorrect and regular variants of the pre-nasal allophones of the front vowels.

Southern Illinois is the site for my research. It has historically been a cast-off of dialectologists, considered variously as part of the South Midland (Frazer 1996), North Midland (Davis & Houck 1995), or the Ozark Foothills/Western Appalachians (Dickson 2000). None of these accounts, however, adequately sample Southern Illinois speech; instead, they rely on assumptions and folk ideals concerning the region. This region is an especially important place to consider because of its position as a dialect transition area; this positioning makes it as far north as any “southern” feature should reach, and the speakers who live in this region have real exposure to varieties both with and without the PIN~PEN merger.

My work is a move toward filling in some of these gaps in our understanding of the PIN~PEN merger. Twenty speakers were sampled from three counties across the 16 counties constituting Southern Illinois. Three tokens of /ɪ/, /ɛ/, and /æ/, in pre-alveolar and pre-labial environments, in two different reading tasks, were collected for each speaker in both pre-nasal and pre-oral stop contexts (~1,440 tokens total). F1 values were measured at the vowel steady-state midpoints (or at target points for diphthongs).

1.1. Pilot Studies

Based on my experience growing up in Southern Illinois and previous impressionistic research I had conducted as an undergraduate, it was thought that Southern Illinois English was a dialect which participated in the PIN~PEN merger. My original impressionistic study was informally conducted for an undergraduate class. In this study, I asked the speaker "What is this?" as I held up either an ink pen or a stick pin (straight pin). After an initial response, I said, "Did you say [pɪ̞n]?" and recorded the speaker's careful pronunciation response. I noticed two things from this informal study. First, as expected, Southern Illinois speakers used the same vowel for both "pin" and "pen", which I heard and recorded as [ɪ]. Second, however, when Southern Illinois speakers were asked to make a 'careful pronunciation' distinction between PIN and PEN, the vowel in PEN would sound more like [æ] than [ɛ].

In my further research, I had also made the observation that the sociolinguistic literature seemed to disagree with the phonetics literature regarding how the PIN~PEN merger should be realized (as discussed below). Briefly, the phonetics literature suggests that the pre-nasal /ɪ/ and pre-nasal /ɛ/ allophones in the PIN~PEN merger neutralize to a more [ɛ]-like vowel, while the sociolinguistics literature lists a more [ɪ]-like vowel for the pronunciation of the affected allophones (though the vowel given varies from source to source). Because I wanted to describe these merger phenomena more precisely, and because of the issues surrounding impressionistic methods (see discussion below and e.g. Lass 1984, Labov, Karen, & Miller 1991), it was decided that a study based on something other than impressionistic phonetics was needed.

Therefore, the pilot study which directly preceded the research for this thesis was based on acoustic phonetics. The goals of the pilot study were to discover (a) if the 'target vowel' in the PIN~PEN merger in the speech of Southern Illinoisians could be located within an acoustic statistical analysis and (b) if these speakers in Southern Illinois could 'undo' this merger when their attention was drawn to it. However, I believed that some speakers, in undoing the merger, would hypercorrect the PEN vowel to a more [æ]-like pronunciation (a PEN~PAN merger).

The pilot study recorded six speakers producing ten tokens of [ɪ], [ɛ], and [æ] in both pre-nasal and pre-oral contexts, in two distinct reading lists (a more 'casual' style and a more 'careful' style) in the hopes of eliciting a PEN~PAN merger at the expense of a PIN~PEN merger. This pilot study led to three findings: (i) that only five of six speakers had the PIN~PEN merger and therefore, that Southern Illinois might not be a fully merging dialect, (ii) that speakers participated in the PIN~PEN merger in different ways (i.e., some speakers showed the pre-nasal [ɪ] allophone lowering to the /ɛ/ position, while some showed the pre-nasal [ɛ] raising to the /ɪ/ position), and (iii) that some speakers show a neutralization of the distinction between not just PIN~PEN or PEN~PAN allophones, but between all three front vowels in pre-nasal position. No speakers, however, showed what could be seen as the 'hypercorrect' PEN~PAN merger alone (as I had first assumed). While the first two findings had direct influence on my thesis methods, the third finding of the pilot study was more troubling. Although not supported by my pilot study, I still firmly believed that the hypercorrect PEN~PAN merger would be realized in careful pronunciation. Since the pilot study suffered from an insufficient amount of data, I decided that I would still include 'careful' and 'casual' type reading lists in the eventual thesis work.

1.2. Goals, Research Questions, & Hypotheses of the Current Work

The research goals that inform this work are three-fold. First, I set out to provide an analysis of the PIN~PEN merger based primarily on acoustic, rather than impressionistic, methods to finally locate this merger (or at least the Southern Illinois variety of it) within an acoustic analysis framework. Accomplishing this goal, then, raises the question: In regards to pre-nasal merger, is the phonetics literature or the sociolinguistics literature better corroborated? That is, if these speakers are participating in the PIN~PEN merger, are they realizing these pre-nasal allophones as more [ɪ] like or more [ɛ] like?

Specifically, I tested for the location of the mean F1 of pre-nasal and pre-oral allophones of the front vowels /ɪ/, /ɛ/, and /æ/. The hypothesis was that, if the phonetics literature were corroborated, we would first expect to see, regardless of any merger phenomena, that the pre-oral /æ/ allophone would have the highest mean F1, followed by pre-nasal /æ/; pre-nasal and pre-oral /ɛ/ would have similar mean F1 values; and finally the pre-nasal /ɪ/ would be higher than pre-oral /ɪ/, which would show the lowest mean F1 value. Then, if speakers were participating in the PIN~PEN merger, the phonetics literature would predict that pre-nasal /ɪ/ would show a mean F1 value similar to both pre-oral and pre-nasal /ɛ/ ('/ɪ/-lowering'). If, however, the sociolinguistics literature were corroborated, then in speakers who show the PIN~PEN merger, we would expect pre-nasal /ɛ/ to have a lower mean F1 than pre-oral /ɛ/– in fact it should be equivalent to the mean F1 value of both pre-oral and pre-nasal /ɪ/, which should show similar values ('/ɛ/-raising') (the sociolinguistics literature makes no predictions about what should be found for Southern Illinois speakers when no merger is present).

This first goal, then, is achieved by virtue of the nature of my study and the answer to my research question seems to support the phonetic, rather than the sociolinguistic, literature. That is, while in the sociolinguistics literature it is generally accepted that /ɛ/ raises to meet /ɪ/ in the PIN~PEN merger, my data show that /ɪ/ lowering, or a combination of /ɪ/ lowering and /ɛ/ raising, is much more common (that is, the mean F1 value for pre-nasal /ɪ/ and pre-nasal /ɛ/ are equivalent and this mean is greater than the mean F1 for pre-oral /ɪ/ and lower than the mean F1 for the pre-oral /ɛ/).

Second, I wanted to provide direct evidence that speakers in Southern Illinois participate in the PIN~PEN merger and, thus, provide support that Southern Illinois should be included within the South Midland, rather than the North or North Midland, dialect boundary. However, due to the statistically small sample size, the results I have found cannot be generalized to all Southern Illinois speakers, and these questions about larger patterns and dialect boundary remain for future research.

Finally, third, I wanted to see if speakers, when encouraged to make a distinction between the vowels in PIN, PEN, and PAN, would switch from a PIN~PEN merger to a hypercorrected PEN~PAN merger. This goal was approached by utilizing two distinct list styles, a 'casual' and a 'careful' pronunciation list.[1] Specifically, I hypothesized that, for speakers who participate in the PIN~PEN

[1] I am aware that in a Labovian-type analysis, use of any kind of reading list falls on the 'careful pronunciation' side of the casual to careful attention-paid-to-speech scale (Labov 1972a) and that, therefore, both of the reading lists I used would be considered careful pronunciaiton. However, there is still an allowance for more and less careful styles. For the sake of brevity, in this thesis *casual* refers to 'less careful' pronunciation and *careful* referes to 'more careful' pronunciation, in Labovian terms.

merger, the casual list production of F1 values for pre-nasal /ɪ/ and pre-nasal /ɛ/ allophones would show equivalent means while pre-nasal /æ/ allophones would remain distinct, whereas in the careful list production the pre-nasal /ɛ/ allophones would show F1 means equivalent to pre-nasal /æ/ allophones while pre-nasal /ɪ/ allophones would remain distinct.

Unfortunately, this third goal offers many questions that have no easy answer. The ability to adequately address the question of hypercorrection is bound up in the assumption that, in a PIN~PEN merging dialect, all speakers will participate in this merger in the same way[2] and, therefore, a comparison can be drawn between casual and careful styles. But this simplistic relationship has not been found among my Southern Illinois speakers. Therefore, the outcome of this third goal is that I can no longer consider a PEN~PAN merger as necessarily distinct from (or a hypercorrected form of) a PIN~PEN merger; rather, both kinds of merger are better seen as acting in concert as part of a more unified front vowel system.

As will be shown below, the data I collected show a dynamic pattern for the pre-nasal allophones of front vowels. For example, in older speakers, we find the typical pattern of /ɪ/ ~ /ɛ/ merger before nasals, while the two vowels remain distinct in pre-oral contexts, but the relation of the mean F1 value for these neutralized allophones does not show the same pattern for every older speaker. Also, for the younger speakers, we find evidence of both /ɪ/ ~ /ɛ/ merger and /ɛ/ ~ /æ/ merger in pre-nasal contexts, but again, the specific ways in which the allophones of these vowel pairs are neutralizing are varied. Finally, whether these processes are the result of stable variation or language change cannot yet be known. However, these results

[2] Actually, to thoroughly address the question of hypercorrection, vowel merger should be examined not only in its physical manifestation but also in the psychological attitudes of speakers regarding the vowels in question.

show us that the PIN~PEN merger in Southern Illinois should be given careful consideration as a site of linguistic variation.

1.3. Organization of Sections

Section 2 begins with a review of the background research and literature, which is further subdivided into a discussion of the literature on vowels (§2.1), nasals and nasalization (§2.2), and finally the general sociolinguistic and dialectology literature (§2.3), with emphasis on the site for research, Southern Illinois (§2.3.1) and works that have mentioned the PIN~PEN merger specifically (§2.3.2). In Section 3, I discuss the methods of my research, including speaker selection (§3.1), recording methods (§3.2), token elicitation (§3.3), and measurement procedures (§3.4). Section 4 presents the statistical analysis and results. Section 5 discusses the implications and interpretation of these results, with specific focus on the kinds patterns found among individual speakers. In Section 5.4, I briefly present some final concerns regarding this work, and in Section 6, I draw my final conclusions and discuss ways for expanding this research in future studies.

2. Literature Review

The background literature for a study like this one comes out of three areas. There is the vowel literature, which regards the acoustic properties, measurement methods, and phonetic variability of vowels; there is the nasal(ization) literature, which regards the acoustic properties of nasals in general, as well as the effects of nasals on the surrounding vowels and the extent to which nasals interfere with vowel perception; and there is the sociolinguistic/dialectological literature, which regards the distribution, both geographically and socially, of the PIN~PEN merger phenomena and also looks at issues related to the dialectal features of the Southern Illinois region. The background literature section, then, will be subdivided into these three main parts.

2.1. Review of Vowel Literature

In 1952, Delattre et al. found that predictions and perceptions of vowel 'color' could be determined reliably for the front vowels in American English with only two formants; a description of the first and second formants of a vowel is now generally considered adequate for vowel analysis (Ladefoged 2000). In another early work, Peterson & Barney (1952), in exploring the vowels of American English, showed that, aside from what appears to be a slight /ʊ/ fronting, the F1-F2 values of American English vowels fit what would be expected given the traditional vowel triangle/trapezoid. Since this ground-breaking study was published, the values it reported for F1, F2, & F3 have become something of a standard, with the vast majority of later American English vowel work using the Peterson & Barney report either as a benchmark or as a partial source of data.

2.2. Review of Nasal(ization) Literature

Typologically, vowels are allophonically nasal in the context of a nasal consonant in possibly all languages. Furthermore, phonemically nasal vowels are found in 20-25% of the world's languages, but languages can differ in the degree of nasalization on these vowels (Beddor 1993).

It has been known for quite some time that a nasal segment following a vowel will contribute 'extra resonances' , which cause an overall 'damping' modification of the acoustic signal to the vowel spectrum (see the discussion in House & Stevens 1956). However, the degree of damping will vary from speaker to speaker due to differences in vocal tract, nasal tract, and the overall amount of nasal coupling (House & Stevens 1956, Stevens 1999). The triggering of a nasal percept is likewise vowel dependant to a certain degree. For the purposes of this paper, it is sufficient to know that nasal coupling adds a nasal pole/zero pair to the vowel spectrum which will "broaden and flatten the peaks in the vowel spectra" (House & Stevens 1956:225), shifting the frequencies, bandwidths, and intensity of equivalent oral vowels. Overall, these nasalization effects coalesce to contract the vowel space and diminish the distinctiveness between vowel categories.

Hawkins & Stevens (1985) report that nasal vowels can be perceived as a class distinct from oral vowels even in languages without phonemic nasalization (Butcher 1976, Wright 1980), but that native language experience may effect these perceptions (Beddor & Strange 1982). Hawkins & Stevens also propose that a [+nasal] feature in actual language use is likely accompanied by additional acoustic properties, the most important of these being the way in which vowel height is perceived in concordance with center of gravity effects (Chistovich & Lublinskaya 1979).

Beddor, Krakow, & Goldstein (1986), and Krakow, Beddor, Goldstein, & Fowler (1988) explicitly tackle the issue of the interplay of vowel height and vowel nasality. Surveying the cross-linguistic data, Beddor et al. (1986) show that phonemically nasal—non-nasal vowel pairs that seem to have historically originated from contextual nasalization now show an additional difference of height (e.g. French *fine* [fin] / *fin* [fæ̃]). Furthermore, these shifts in nasal vowel height can be categorized by five general patterns.

A.) High (contextual and non-contextual) nasal vowels are lowered.
B.) Low (contextual and non-contextual) nasal vowels are raised.
C.) Mid non-contextual nasal vowels are lowered.
D.) Mid back contextual nasal vowels are raised.
E.) A mid front contextual nasal vowel is raised in a language where the corresponding back vowel is also raised; otherwise, mid front contextual nasal vowels are lowered.

What is important for my work are principles (A), (B), and (E): all high nasal(ized) vowels lower, all low nasal(ized) vowels raise, and contextually nasalized mid front vowels can be assumed to lower unless data on contextually nasalized mid back vowels is available.

Beddor et al. (1986) claim that, given the universality of these patterns, there must be a phonetic explanation that would lead, at least partially, to these results. As mentioned, the addition of a pole-zero pair to a vowel's spectrum will increase the frequency of the first formant (F1). Since F1 and vowel height are inversely related, this effect of the pole-zero pair on F1 explains why high vowels will lower when nasalized, but this would not also cause low vowels to raise— if anything, low vowels should be getting lower according to this principle. To account for effects on low vowels, Beddor et al. (1986) point out that, for low vowels, the addition of a nasal pole-zero pair will not only increase the frequency of the first formant but also place this shifted F1 (F1') as the second actual formant in the vowel spectrum, coming after the nasal formant (FN) (work by Maeda (1993) further explains this FN-F1 crossover). Given the spectral center-of-gravity (CoG) effects (Chistovich & Lublinskaya 1979), the pole-zero placement would then cause the CoG of low vowels to lower (causing them to "raise" on the classic vowel triangle) and the CoG of high vowels to raise (causing them to "lower"). Later, Beddor & Hawkins (1990) refined the claim that spectral center-of-gravity will affect the perception of nasal vowel height by showing that listeners' mean responses for oral-nasal vowel matches (except [ĩ]) will fall between the F1 and the CoG. Using Ohala's (1981[3]) idea of sound-change as listener mis-perception phenomena, Beddor et al. (1986) point to the fact that the complex acoustic consequences coming from the nasal coupling may be misperceived as changes in tongue height, thereby creating, over time, a height difference between oral and nasal vowel counterparts. More importantly, however, Beddor et al. claim that nasalization will only affect the perception of vowel height in those conditions where an environmental cause of the nasalization cannot be recovered.

But the primary focus of these works has been phonemically nasal vowels in comparison with phonemically oral vowels. However, in American English, vowels are only contextually nasalized (except, see Malécot 1960), which Beddor (1986) has shown operate slightly differently from phonemically nasal vowels. What, then, is the effect of contextual nasalization on the perception of vowel height? Krakow et al. (1988) confirm the assumption that (non-contextual) nasalization will lower the perceived vowel height. Furthermore, they propose that American listeners, unfamiliar with non-contextual nasal vowels (i.e., phonemically nasal vowels), will call upon their tacit knowledge of tongue height to resolve the effects of nasalization– and that such misperceptions might not occur in an environment where the effects of nasalization can be attributed to something else, i.e., the effects of a following nasal consonant. The results Krakow et al. (1988) report show that assumed contextual nasalization has no effect on the perception of vowel height. Further studies have shown that American English speakers will judge nasal vowels as less nasal in nasal contexts than in oral contexts (Kawasaki 1986, Krakow & Beddor 1991), providing support for the effect of nasal-consonant context compensation on perceived vowel

[3]Later expanded in Ohala 1993a, 1993b.

nasality (and, thus, height). However, the environment used for the contextual nasalization test could be problematic in that it is exactly this context (nasal followed by a homorganic stop) that Malécot (1960) claims would allow for phonemic (i.e., non-contextual) nasal vowels in American English.[4]

In summary, then, the majority of studies of vowel nasalization support the over-all claim of Beddor et al. (1986) that "listeners' ability to distinguish the acoustic consequences of velic vs. tongue body gestures might break down if the listener encounters a nasal vowel, but neither detects a conditioning nasal consonant nor expects non-contextual vowel nasalization" (211-212).

One question Beddor (1993) raises is “whether vowel nasality functions as an independent perceptual parameter for listeners whose native language lacks oral-nasal vowel contrasts” (Beddor 1993:174). As discussed above, evidence from American English speakers would suggest that there is a perceptual oral-nasal distinction (Beddor & Strange 1982, Hawkins & Stevens 1985) and that “listeners respond to the same acoustic properties in distinguishing oral and nasal vowels, regardless of the phonological status of nasalization in their native language” (Beddor 1993:175). Beddor interprets these data as evidence that listeners whose language lacks distinctive nasalization respond phonetically to nasalized vowels, while listeners coming from a language that has an oral-nasal distinction respond phonemically. As Beddor points out, a simple oral-nasal distinction may be too simplistic. To this we could add the following: in what order does a vowel that is allophonically nasal before a nasal consonant change to a phonemically nasal vowel with a shifted height? Must the contextual nasal consonant be deleted before the nasal vowel can change

[4] MacMillian et al. (1999) offer a slightly different view. While still showing that the perception of vowel height and nasality are directly linked, they found no FN-F1 perceptual crossover (cf. Maeda 1993) nor any effect for following consonant nasality (cf. Krakow et al. 1988). MacMillian et al. claim that this dissonance between their findings and others' work is due to differences in the types of studies being conducted and, therefore, that their results are still compatible with, and not in contradiction of, previous findings. One interesting possibility they raise is that, rather than being a CoG effect, it may be that the perception of vowel height is a result the perception of harmonic intensity, which interacts directly with the nasal pole-zero pairs. This theory has not yet been substantiated by other researchers, however.

height? Or, could it be that phonemic nasalization alone can change the vowel height? Unfortunately, proposing that phonemically nasal vowels are present in a language's phonology but only before nasal consonants would present researchers with some difficulty. Clearly, the interaction of vowel height and vowel nasality is still a complex area of research, the findings of which would directly bear on the work presented here.[5]

2.3. Review of Relevant Sociolinguistic and Dialectology Literature

The PIN~PEN merger has not been given the linguistic scrutiny that has been afforded other sociophonetic issues. Unlike the Northern Cities Shift or the Southern Vowel Shift, little is known, acoustically, about the PIN~PEN merger. Although there have been reports of its occurrence in pockets throughout the country (see sources below), it is typically considered a general Southern feature. By 'general' it is meant that it has been shown to be influenced no longer by race/ethnicity, age, sex, or social class[6] (Brown 1991, Bailey & Maynor 1989, Pederson 1983). In calling it a 'Southern feature' it is meant that one expects to find this merger largely in the core South and South Midland (i.e., mainly below the Ohio River and east of the Mississippi River), but not usually outside these regions.

Likewise, Southern Illinois, 'the land between the rivers', can be an elusive, nebulous, area to study. Not much linguistic work has been done on the region and,

[5] One possible limitation of the phonetics research is that none seem to have controlled for the possible dialectal variation of their subjects. The Peterson & Barney (1952) data, showing that American English vowels are generally equivalent to the traditional "vowel chart" representation of vowel space, seems to be taken as a given. However, one of the major contributions of Hillenbrand et al. (1995) (also, Hagiwara 1997) was showing that the Peterson & Barney categorization of vowel space is not accurate for all dialects of American English. Specifically, the Hillenbrand et al. speakers (who could be generally characterized as coming from Northern Cities region) were shown to have an average /æ/ value nearly equal to their /ɛ/ (the female subjects actually having an /æ/ higher than their /ɛ/). If the speakers tested by Krakow et al. (1988) were operating with the vowel space of this (or a similar) dialect, it would skew their results drastically.

[6] However, see Wolfram & Schilling-Estes (1998), who call the merger "highly socially stigmatized." This is the only mention of the merger as having a particular stigma attached to it that I have found. See discussion, below.

in the work that does exist, there is much that is in disagreement or is up for debate. Southern Illinois's inclusion in any of the major dialect maps is based more on anecdotal evidence or geographic assumptions than on data collection from within the area.

The expectation of the presence of the PIN~PEN merger based on dialect raises the first tricky issue specific to the geographic region that is my concern in this work. Can Southern Illinois be considered a cohesive dialect region and, if so, how should the dialect of Southern Illinois be categorized with respect to the larger (traditional) dialect regions? Before one can answer that, however, 'Southern Illinois' must first be defined.

2.3.1. Southern Illinois

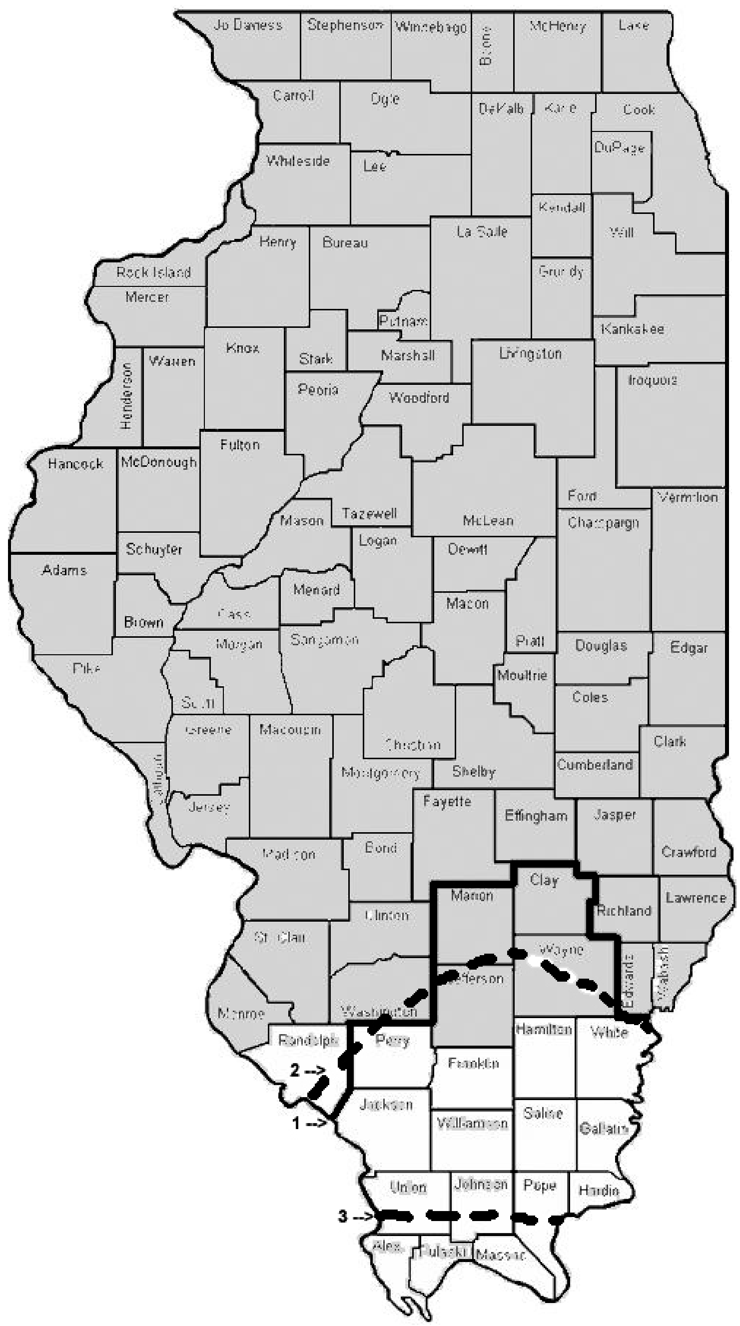
One thing that is certain, Southern Illinois is *not* Northern Illinois, nor is it even Illinois in the eyes of many of the people who live there. For as long as Illinois has had statehood, there has been a movement for Southern Illinois to secede from the rest of the state. The idea was there during the Civil War, but was quashed mostly due to the efforts of John A. Logan (Jones 1995). Most recently, the Committee to Form the State of South Illinois circulated a petition and had plans to mount a campaign in the US Congress (Daily Egyptian 2002) to estabilish a state separate from the rest of Illinois. But, at least for now, Southern Illinois is subsumed by the rest of Illinois and, as such, needs to have its borders defined.

Brownell (1958) considers "southern Illinois" to be the lower 32 counties of Illinois, below the 39th parallel, roughly bordered by I-70, or the old National Road. Dakin (1966) supports this division, citing evidence from settlement history and further topographic evidence such as the prairie grass vegetation which does not extend below this northern line. Dakin further subdivides south Illinois into the four regions he labels Western Wabash Valley, American Bottoms, Shawnee Hills, and the Pennyroyal-Purchase. Later work by Frazer (1987) shows, more or less, these same areas but collapses the Shawnee Hills and Pennyroyal-Purchase areas in south Illinois to "Egypt" (Southern Illinois is locally known as 'Little Egypt' or just 'Egypt').

However, the opinions coming from within the region would not be so generous. Instead, for native 'Egyptians', Southern Illinois is considered to include only the sixteen southernmost counties of Illinois (E.C.S.I. 1949, Horrell 1973). This is the area that corresponds, mostly, to Dakin's (1966) Shawnee Hills & Pennyroyal-Purchase areas, or Frazer's (1987) "Egypt." Topographically, this is the area of Illinois not below the prairie line, but below the glaciation line, roughly bordered by I-64, below the 38th parallel.[7] The responses from my speakers support this view as well. Responses to the question "What or where is Southern Illinois?" often cite I-64 or the cities that lie along it as the northern border for Southern Illinois. Only one respondent, Speaker D, cites the larger 32 county region as being 'Southern Illinois'. It was from this smaller 16-county section that speakers for the present study were drawn, and it is this smaller area to which 'Southern Illinois' will refer for the rest of this work (See Map 1).

Moving on to the issue of dialect, we have already seen that Dakin (1966) includes Southern Illinois in his study of the dialect of the Ohio River Valley. His final claim regarding larger dialect regions shows the northern border of Southern Illinois (his Shawnee Hills and Pennyroyal-Purchase sections, specifically) to be coterminous with the northern border of the South Midland dialect. Also, he shows a tentative southern border of the North Midland dialect mostly in line with the northern border of his and Brownell's (1958) 32-county south Illinois, although somewhat lower than Shuy's (1962) southern boundary of the North-Midland. Frazer (1987) supports the view that "Egypt" is the only area of Illinois to be purely South Midland, but points out the extreme difficulties in charting the dialect areas in south

[7] Of course, much more could be said about the history, settlement, topography, and culture of the southern part of Illinois. However, since this work is primarily a socio-phonetic report which is informed by dialect studies, and not a dialectology, these issues are beyond the scope of this work. Readers are referred to Adams (1994), Brownell (1958), Dakin (1966), and Pooley (1905) and the further references in these.



Map 1: Counties of Illinois. Adapted from the Northern Illinois University Center for Government Studies archive. Southern Illinois (as I use the term) is in white. Frazer's "Egypt" boundary is line 1 (the solid line); Dakin's "Shawnee Hills" is line 2 and the "Pennyroyal Purchase" is line 3 (dashed lines).

and central Illinois, claiming the larger 32-county south Illinois as the "absolute limit" of the South Midland dialect.

Carver's (1987) reinterpretation of Dakin's (1966) boundary would shift the South Midland boundary down to the Ohio River and Southern Illinois would be included only in a "transitional" region. Carver (1987) also points out the difficulty of delimiting the Southern (and South Midland) dialect, which are traditionally much less sharp than the Northern dialect boundaries. However, Carver (1987) also cites the cultural boundaries of North-South as described by Gastil (1975) and Zelinsky (1973), both of whom place Southern Illinois within the South, while Carver (1987) himself seems to include Southern Illinois within his "South I Primary" boundary.

Beyond these works, there is a vast amount of further literature discussing the dialectal gerrymandering of the United States, always with Southern Illinois floating in the periphery (see the works and references in, for example, Davis & Houck 1992, Flanigan 2000, Frazer 1993, Wolfram 2003, Kretzschmar 2003). However, one thing clearly agreed upon is that Southern Illinois is the upper-most limit of 'southern-ness' if the area is included in a southern region, or is the lower-most limit of 'northern-ness' if it is included in a northern region. Perhaps best explained by one of the few authors to center on the linguistics of Southern Illinois specifically, Dickson, a local 'Egyptian' herself, states that depending on which larger divisions one focuses on, "Southern Illinois is part of the larger Midwest … the South-Midland … the Central Midland … Ozark and Appalachian speech … Southern Illinois also has some features which separate it from other areas making it its own dialect area" (Dickson 2000:12).

2.3.2. Review of Literature Specific to the PIN~PEN Merger

After over a century of American dialectology, the PIN~PEN merger has amassed a veritable mountain of dialect work that mentions it, or at least mentions the merging (but, specifically, not just the interrelated movements) of the allophones of the vowel categories /ɪ/, /ɛ/, and /æ/ in some form. Unfortunately, most of the descriptions are little more than a paragraph, and the reports are often conflicting.

The most extensive work on the PIN~PEN merger is by Brown (1990, 1991). These works are derived from an historically based data set taken from the dialect surveys of the *Linguistic Atlas of the Gulf States (LAGS)* (Pederson et al. 1986-1993), the *Linguistic Atlas of the Middle and South Atlantic States (LAMSAS)* (McDavid et al. 1980), and the transcriptions of the *Tennessee Civil War Veterans Questionnaires* (archive). The first work, Brown 1990, is a phonetic variationist account; the second, Brown 1991, is an historical explanation of the merger.

In her 1990 work, Brown looks at the possible phonetic constraints for merger. She finds that monosyllabic words without consonant clusters are the most favored environments for the merger and that neither the place of articulation of the following nasal consonant (/m/ or /n/), nor the preceding consonant, have much effect on the merger. Further, she points out that the environments which disfavor merger are those same environments which serve to shorten and deemphasize vowels (as in Ladefoged 2000) such that merger seems directly tied to vowel prominence. Finally, she notes that the constraints which operate in the PIN~PEN merger are the same constraints that operate in Labov's (1972b, 1991) tensing, peripheralization, and raising paradigms for vowels.

The focus of Brown (1991) is an historical account of the adoption and spread of the merger through Tennessee, but much of what she has claimed has been accepted as the probable way this merger spread throughout the South as a whole (Bailey 1997). Looking at the social evolution of the PIN~PEN merger through Tennessee, Brown found that by the 1850's the vowel of PEN had the competing, but stable, variant forms [ɪ] and [ɛ]. At first, [ɪ] was the less prestigious variant, until around 1875 when it gained in popularity in a typical S-curve fashion that plateaued, replacing the [ɛ] variant, by 1930. Also, although the merger occurs in both black and white vernaculars, Brown found no direct link between the two. Brown also found that the merger was likely adopted and spread first by women and that it spread out from rural areas into the more urban spaces. More recent work by Bailey et al. (1995) supports the date of 1930 for the completion of merger in Oklahoma as well, but shows that shortly after WWII, the non-merging variants began to expand due in large part to the influx of speakers to Oklahoma from traditionally non-merging dialect regions.

Bailey (1997) includes the PIN~PEN merger on his 'Southern-speech features' checklist and later calls it one of the "most widely recognized features of [Southern American English]" (1997:267). Likewise, Wolfram & Schilling-Estes (1998) mention the PIN~PEN merger as a Southern phenomenon, with both /ɛ/ and /ɪ/ usually being realized as [ɪ], and that this "well-known" merger is "highly socially stigmatized" (it is not known if Wolfram & Shilling-Estes intended that the merger is stigmatized in the South or stigmatized within a Standard American English paradigm). Numerous researchers have presented brief accounts of the PIN~PEN merger, and these are summarized below. These sources are grouped roughly in three sections: sources which do not claim a single value for the varying PIN~PEN vowel, sources which claim an [ɪ] realization for the PIN~PEN merged vowel, and sources which claim an [ɛ] realization for the PIN~PEN merged vowel.

C.K. Thomas (1935), describing New York dialects, shows /æ/ raising to [ɛ] generally, but especially before nasals; later C.K. Thomas (1958) states that the /ɪ/~/ɛ/ phonemic distinction is lost before nasals "chiefly in the South, but also to some extent in the [South Midland]" (1958:209) and that the nasal coda forms have "a vowel ranging between the limits of [ɪ] and [ɛ]" (1958:210). Wolfram & Christian (1976) mention the merger's presence in Appalachian speech and call it "fairly well known" and a "collapse of the contrast between [/ɛ/ and /ɪ/] before nasals" (1976:67), though they do not mention which value (if either) is the new target. Flanigan (2000) finds that the PIN~PEN merger in the Ohio River Valley is rare. O'Cain (1977), describing Charlestonian (South Carolina) speech, notes that, historically, the vowels in both PIN and PEN were realized as [ɛ] in "cultivated" speech and [ɪ] in "folk" speech and that the merger itself is not traditional to Charleston, but had been imported from a more general South Carolina dialect. The pattern described by O'Cain is in line with Brown's (1991) findings. Colbourne (1982), in work as far north as Newfoundland, mentions that /ɛ/ and /ɪ/ lack a phonemic contrast, both before nasals and before certain other consonants (e.g. /t/), but he, too, does not mention what the new target vowel sounds like. Lastly, Rose & Hall-Lew (2004), the only other acoustic-based study of which I am aware, find the PIN~PEN merger in rural Arizonans, and, to a lesser extent, in the urban community of Flagstaff. They believe that the spread of the merger from the rural areas to towns is linked to "qualities of patriotism, masculinity, and romance" for an imagined pastoral of "American" life, but again, what the specific target of the merger sounds like is not reported.

Some researchers, however, have been more specific with regards to the phonetic quality of the vowel form used in the PIN~PEN merger. Research in which an [ɪ] realization has been claimed for both the vowel in PIN-type words and PEN-type words is discussed first. Wise (1933), describing a general "southern" dialect, claims that "[ɛ] shows a strong tendency to become [ɪ] before [n]"; he cites the cause as anticipatory tongue raising and says that the same "may occur before [m]." Hall (1942) states, of Smoky Mountain speech, that "[ɛ] is often raised to or toward [ɪ]" and "movement of [ɛ] toward [ɪ] before nasals … is present to a degree in the speech of everyone" (1942:19). He also includes non-pre-nasal examples where this "merger" is present (e.g. [gɪt] for *get*). Hall says little about the /æ/~/ɛ/ interaction except that /æ/ often becomes an [ɛ͡e] diphthong in various contexts. Labov (1996) explicitly claims that the PIN~PEN merger takes place before both /m/ and /n/ and that it is usually [ɪ] (specifically, a high front vowel) that is realized for both. In Labov's work, the merger, is best represented in the "South"; but it also shows up in pockets in New England, California, and the western plains states and is prolific along the Ohio River Valley states (though, again, see Flanagin 2000). Gordon (2001), working in southern Michigan, shows the classic PIN~PEN merger (i.e., /ɛ/ raising to [ɪ] before nasals), but for his speakers, the merger was neither consistent in production nor complete in terms of vowel distinction. That is, while Gordon did find allophonic /ɛ/ raising, it often still remained distinct from [ɪ]. Finally, E. Thomas (1996) shows the PIN~PEN merger for nearly half his respondents in an Ohio community. He only includes tokens before /n/, no pre-/m/ analysis is given, and he does not explicitly comment on the direction of the merger. In his 2001 work, however, he again comments on the merger and claims that it is a merger caused by the pre-nasal allophone of /ɛ/ raising to/toward [ɪ]. His explanation is the most detailed and, so far, the only published phonetic explanation that I have found. He claims that "/ɛ/ is generally higher … in the South than in the North … [which makes the] F1 of /ɛ/ more susceptible to being canceled by the anti-formant and thus would make the first nasal formant into the perceived F1" (p. 52). However, this argument seems to run counter to the phonetic studies by Beddor, Krakow, and their colleagues which imply that /ɛ/, if it were higher, would be more susceptible to perceptual lowering, not raising. E. Thomas (2001) also mentions that pre-nasal /æ/ raising, often to a point where it is merged with /ɛ/, is quite common throughout modern North American English dialects, but he does not link this to the PIN~PEN merger.

Finally, the reports of other researchers have been more in line with what the phonetics literature would predict by citing cases where allophones of /ɪ/ have lowered to an [ɛ]-like vowel. Emerson (1891), working on the dialect of Ithaca, New York, shows allophones of /ɪ/ lowering to [ɛ] and allophones of /ɛ/ lowering to [æ] in both pre-nasal and pre-oral environments, although pre-nasal environments are favored in the former. Berrey (1940), in the Southern Mountain dialect (Appalachian/Ozark), finds both allophones of /ɛ/ raising to [ɪ] and allophones of /ɪ/ lowering to [ɛ] in many word tokens, but especially before alveolar nasals. He also gives two examples of /æ/ being allophonically realized as [ɪ] *after* an alveolar nasal, though this is likely only tangentially related to the PIN~PEN phenomena. Klipple (1945) shows allophones of both /ɪ/ and /æ/ moving to [ɛ] before [ŋ] in the Spicewood dialect of Texas. Finally, Pederson's (1983) work on East Tennessee speech calls both the /ɪ/ and the /ɛ/ vowel before nasals "retracted and lowered" and makes the point that this movement is most common before the alveolar nasal "where the alternation of /ɪ/ and /ɛ/ is most frequently observed" (1983:61). Pederson's work seems, in many ways, the most applicable to the current study. He points to a wide range of allophonic variation of these two vowels pre-nasally. Specifically, he cites informants who have the PIN-type vowels and PEN-type vowels in their standard form (41 citations), switched– i.e., 'stick PEN' and 'ink PIN'– (1 citation), both as [ɛ] (7 citations), both as [ɪ] (20 citations), and finally, one citation of [ɪ] as in the standard form and [æ] for /ɛ/ (i.e., 'stick PIN' and 'ink PAN').

While it could be that the PIN~PEN merger involves different vowel realizations in different dialect areas, another cause for the discrepancies among the finding of the research literature may be that the previous literature has all been based on impressionistic transcriptions. Even in studies that are acoustically based, such as

E. Thomas (2001) and Labov (1996), when the PIN~PEN merger is discussed, analyses switch from acoustic to impressionistic methods. None (except Rose & Hall-Lew 2004[8]), to my knowledge, have used acoustic analysis techniques for tracking the F1 values of these pre-nasal front vowels to determine either degree or direction of merger.

My contention with impressionistic studies is not meant to imply that acoustic measurements are inherently superior. In fact, it has been pointed out that acoustic analysis techniques may be introducing their own kind of biases (Labov 2001, Ladefoged 2003). But, while impressionistic transcription methods are not inherently flawed, there are certain issues, such as merger, for which impressionistic methods seem less suitable. As Lass (1984) points out, in impressionistic phonetics there is not necessarily an agreed upon relationship between the graphemes used in phonetic notation and the acoustic events that they are supposed represent (at least not in practice). The lack of a well described and accepted representational methodology can then lead to unconscious normalization of the variety of (assumed) allophones. This 'normalization' not only destroys potential data, but also makes the transcriptions from one study not wholly comparable with any other study. This is, of course, not a problem with the works, per se, but a more general problem within the field of phonetic description. In the area of mergers, unconscious normalization of this sort is an even more dangerous pitfall (see, for example, the works by Labov, Karen, & Miller 1991, Di Paolo & Faber 1990, Faber & Di Paolo 1995). Conversely, acoustic measurement techinques limit the amount of data that can be measured and the reliabilty of the acoustic measurements decreases with the informality of the

[8] Rose & Hall-Lew use a technique for determining merger based on the mean F1 range of distance between pre-nasal /ɪ/ and /ɛ/ divided by the mean F1 range of distance between the high point vowels /i/ and /u/. The vowels are considered "merged" when the calculated mean F1 range is near or around 100Hz (Hall-Lew p.c.). This technique is an intriguing one which merits further investigation in future work. Specifically, it would be interesting to compare the method for determining merger developed by Rose & Hall-Lew (2004) to the method I developed (described below) and check these methods against the more traditional impressionistic analysis used by other researchers when discussing the PIN~PEN merger.

recording situation. In my work, therefore, I have settled for the smallest amount of confounds (i.e. emotion, attention to speech as speech vs. attention to speech as story, discrepancies in the amount of tokens gathered per speaker, etc.) by using two word lists but have sacrificed any claim to naturalistic speech production by not including data gathered during interviews, for example.

3. Methods

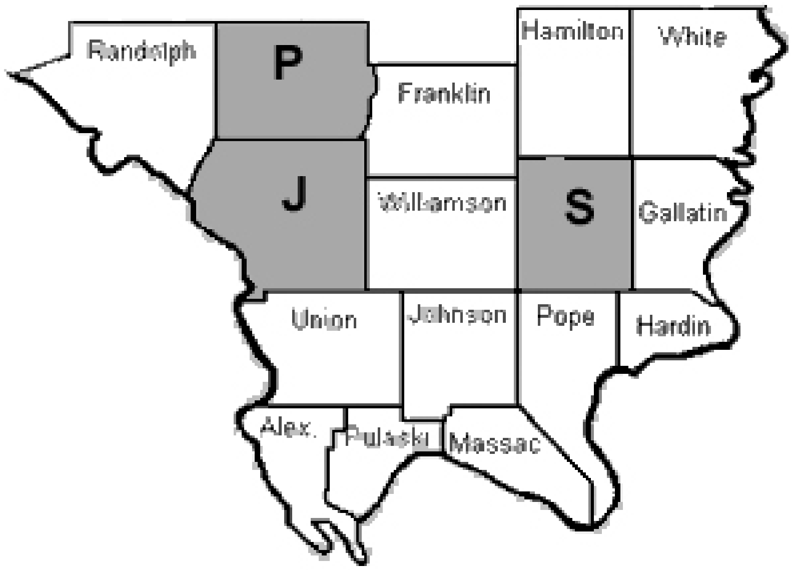
Methods for data collection were as follows. Twenty speakers were recorded while they read three short reading tasks and then participated in a question-answer session about their lives and beliefs about Southern Illinois. At the end of the question-answer session, speakers were encouraged to participate in free discussion with the researcher. However, as noted above, to limit the scope of this thesis and to make the project meaningful and managable from an acoustic phonetics perspective, only data from the two reading lists were used.

3.1. Speakers

There were 11 male and 9 female speakers used. Ages ranged from 15 – 65 years old, with the exception of one female speaker who was 91 years old. All speakers self-reported as having been raised, and currently living, somewhere between working and middle class. All speakers self-reported their race[9] as either "white" or "Caucasian". Speakers were chosen based on the researcher's ease of access with an effort to control as closely as possible for age, sex, and other sociologically based effects.

Three Southern Illinois counties are represented (see Map 2). There are four speakers from Saline County (2 female, 2 male), three speakers from Jackson County (2 male, 1 female), and 13 speakers from Perry County (7 male, 6 female). All speakers had been born and raised in Southern Illinois, had spent nearly their entire lives living in Southern Illinois, and most were living in Southern Illinois when the data were collected—except for the cases discussed below. Even with these exceptions, however, all speakers lived in Southern Illinois during the years most crucial to dialect formation, i.e., 2-18 years of age (Payne 1980). See Table 1 for a demographic break-down of all speakers.

[9] The actual question was "What is your race/ethnicity?" to which the most responses were something like 'My race is white and I guess my ethnicity is Irish'. Although investigating the possible effects of different 'ethnicities' (as my speakers reported them) may be interesting, it is not my concern here.



Map 2: Southern Illinois Counties. Adapted from the Northern Illinois University Center for Government Studies archive. Perry, Jackson, and Saline Counties are shaded and labeled P, J, and S, respectively.

SPEAKER	SEX	AGE	EDUCATION	COUNTY	YEARS in SoIL
A	M	62	Master's +Ed	Saline	47 years
C	F	50	B.S. Accounting	Saline	43 years
D	M	20	currently in college	Saline	from age 0-19
E	F	24	currently in graduate school	Saline	from age 0-23
G	M	57	Master's +Ed	Jackson	54 years
H	F	51	B.A. Education	Jackson	48 years
I	M	23	currently in college	Perry/Jackson	23 years
K	F	55	High School (H.S.)	Perry	55 years
L	M	56	Associate's	Perry	51 years
M	F	40	Associate's	Perry	40 years
O	M	41	High School (H.S.)	Perry	41 years
P	M	16	currently in H.S.	Perry	16 years
Q	M	15	currently in H.S.	Perry	15 years
0 (zero)	M	24	currently in graduate school	Perry	from age 0-23
1	F	91	Jr. High	Perry	91 years
2	M	55	High School	Perry	53 years
3	F	55	Associate's	Perry	52 years
5	F	24	B.A.	Perry	24 years
6	F	21	currently in college	Perry	21 years
7	M	26	High School +	Perry	26 years

Table 1: Speaker Demographics

All subjects are related in a complex network that crosses family, work, and friendship spheres. Initially, subjects were collected through a single immediate family network (Speakers 0, 2, 3, 6); these subjects then helped recruit members of their extended family as well as friends and neighbors. The final result is something akin to the "friend of a friend" collection method as described by Milroy (1987); however, nearly all speakers in the final sample were connected to nearly all other speakers in the sample by either friendship or blood/marriage ties.

3.2. Recording Equipment

Speakers were recorded in their homes. Recordings were made with a Sony ECM-ms907 microphone on a Sony Minidisc MZ-707 recorder set to record in LP4 mode (monaural). Sony Minidisc (MD) recorders use a proprietary compression algorithm known as ATRAC (Adaptive Transform Acoustic Coding), which is based on psychoacoustic properties of sound (Tsutsui et al. 1992, Minidisc.org 2004). The MZ-707, when recording in LP4 mode, uses a version known as ATRAC3. ATRAC3 is equivalent to a 32kHz sampling rate, 66kbps bitrate.[10] The MD files were then transferred to a Macintosh G4 computer via real-time recording in Macquirer. During this transfer, the files were downsampled to 22,050 Hz for speakers A-Z and 11,025

[10] Using compressed audio, such as the ATRAC format that Sony Minidisc uses, is a controversial issue in speech analysis. Briefly, it has been noted by Campbell (2002), Ladefoged (2003), and Plichta (2004) that compressed audio is unacceptable for acoustic analysis work, but this claim has not been supported with adequate empirical research. Likewise, even though Codec (COmpression / DECompression) algorithms, such as ATRAC, MPEG, Ogg Vorbis, etc., are generally accepted as sometimes creating noise and unfaithful reproductions in the ranges around and above 10kHz, Labov (2004) points out that vowel analysis, which does not normally rely on values over 5kHz, should not suffer. In actual tests, Gonzalez & Cervera (2001) report that compression even as poor as a 32kbps bitrate tested equal to raw PCM (uncompressed) data up to 6,800 Hz, while 64kbps, the closest measure to the 66kbps that I used, did not diverge from PCM quality until 11,500 Hz (high enough for accurate analysis of all phonetic data, not just vowels). Furthermore, van Son (2001), looking at semitone jumps and RMS semitone error, report that recordings suffered much more from variations in the microphone used than from any popularly available lossy compression method, including ATRAC. Finally, Campbell (2002), who decries the use of compressed data for speech analysis, finds that there is no noticeable difference between MD (compressed) and DAT (raw PCM) recordings below 5,500 Hz, well above the threshold for typical vowel analysis.

Hz for speakers 0-9. The discrepancy in downsampling was due to error on my part and is unrelated to any measures in the data. This discrepancy should not affect the analysis, however, as no measurements were made at values above even 3,500 Hz, well below both the ~5kHz cutoff for the 11,025 Hz sample rate and the ~10kHz cutoff for the 22,050 Hz sample rate. However, I do admit that the change in rates may have further complicated the occurrence of 'downsampling ghosts' that can appear in any conversion such as this.

3.3. Tokens

Six tokens of three vowels, in two consonantal following environments, in two reading tasks were measured, for 20 speakers. This gives a total of 1,440 tokens (6tokens*3vowels*2environments*2tasks*20speakers). After unanalyzable tokens[11] were removed, the actual number of vowel tokens analyzed was 1,318. The vowels under consideration were /æ/, /ɛ/, and /ɪ/. All tokens were stressed monosyllables (CVC). Initial consonant has been shown not have a large effect on the following vowel (Hillenbrand et al. 2001), so no attempt was made to hold initial consonant constant. Even so, following Labov (2001) no tokens with initial glides, liquids, or consonant clusters were used in the analysis.

Following consonantal environments were classified as either Oral (with a final /b/ or /d/) or Nasal (final /m/ or /n/). Since following consonant place has not been found to have a significant effect on vowel F1 (Hillenbrand et al. 2001), it was taken as a basic assumption of this paper that the effects of consonant place (labial or alveolar) would not affect the degree of merger exhibited by the vowels.[12]

During data collection, speakers were asked to read two word lists separated by two short stories. Tokens from the word lists were taken for analysis. The

[11] Tokens were deemed unanalyzable primarily in cases where environmental noise (air conditioners, pets, etc.) caused interference with the vowel spectra.
[12] However, given the work on near-merger (Di Paolo & Faber 1990, Faber & Di Paolo 1995), future studies should also take F2 or an F1/F2 combination, into consideration.

readings varied only slightly from Participation group A (Speakers 0-9) to Participation Group B (Speakers A-Z). The variation between the two readings is, like the variation in downsampling, an error on my part and unrelated to my methods. See Appendix A and Appendix B for the full lists.

In the first task, the Embedded List task, participants read a list of approximately 170 words wherein the token words for the present study were embedded in a larger list of words not of the type under consideration. See example (1), a section of reading task one, the Embedded List (the words that were analyzed are in ***bold italics*** for ease of demonstration but were not so indicated on the sheet the participants used):

> (1) Embedded List task selection: … tiny, get, cram, chick, ***hen***, farm, plough, hog, ***ham*****,** ***head***, body, ear, eye, now, when, then, next, laid, sat, ***did***, Dawn, Shawn, ***Ted***, thin, ***ban***, mad …

In the second task, the Minimal Triplets task, participants read a list of words where the words under consideration were presented as minimal /æ/~/ɛ/~/ɪ/ triplets only (in random orders). See example (2), a section of reading task three, the Minimal Triplets task (again, the words that were analyzed are in ***bold italics*** for ease of demonstration but were not set apart on the sheet the participants used):

> (2) Minimal Triplets task selection:
> ***din*** ***Dan*** ***den*** ***did*** ***dad*** ***dead*** ***Ken*** can ***kin***

It was assumed (following Labov 1972a) that presenting the information in this way, as Minimal Triplets, in contrast with the Embedded List, would encourage the speaker to focus a higher degree of attention on the specific quality of these three vowels. Specifically, the Embedded List task was intended to represent a more casual style while the Minimal Triplets task was intended as a more careful style though, again, both would be considered 'careful speech' in classic Labovian terms. This is directly related to my hypothesis that speakers in Southern Illinois would shift from a PIN~PEN merger to a PEN~PAN merger when they are directed to pay attention to their speech. Therefore, although reading lists are commonly thought to elicit a more attentive, less natural style (Labov 1966), it was hoped that these two different kinds of word lists would allow at least two levels, or degrees, of attentiveness.

3.4. Measurement Procedures

Since the PIN~PEN merger is usually considered a merger of height, the measurement point in relation to F1 was given primary consideration. Although the /æ/~/ɛ/~/ɪ/ vowels are traditionally considered monophthongs, there were a fair number of tokens that had diphthongized for certain speakers. These vowels, however, can still be analyzed as monophthongs given the work of Harrington & Cassidy (1994).

To discriminate between monophthongs, diphthongs, and monophthongs with short on- or off-glides, I began each token analysis began by locating the interior 60% of the vowel. Using the interior portion of the vowel as the focal point to begin an analysis ensures that any formant movements caused by onglides, offglides, or consonant-to-vowel transition effects are eliminated from consideration.

Given work by Strange and others (Strange et al. 1983, Strange 1989) which suggests that vowel perception is ongoing throughout the syllable and that vowels, therefore, are best characterized by an overall spectral change reading, one criticism that could be made of my methods is that looking at only the interior portion of the vowel to judge overall quality is misleading. However, the idea of focusing on the vowel interior is based on the principles of the target theory of vowels (Stevens & House 1956, Lindblom 1963). In support of this idea and its extension to diphthongs, Bladon (1985) found that vowel endpoints, much more than spectral change, are most important for diphthong identification. Likewise, Harrington & Cassidy (1994; corroborated by Hillenbrand & Nearey 1999) refined this view by showing that diphthongs are best specified by measurement at the endpoints and midpoint while traditional monophthongs are adequately specified by only a midpoint measurement, even when they may show diphthongization. These findings, along with Lindblom's theory of vowel undershoot (1963), give credence not only to beginning a vowel analysis with the vowel's interior but also to choosing a single F1 and F2 measurement point for the (traditionally monophthongal) /ɪ/, /ɛ/, and /æ/ vowels.

3.4.1. Monophthongs

A vowel was considered monophthongal if

a.) both F1 and F2 remained steady for the interior 60% of the vowel. Specifically, during the interior of the vowel, there must have been an overall change of less than 75Hz[13] for both F1 and F2,

or,

b.) if F1 remained steady ($\Delta F1<75$ Hz) for the interior 60% of the vowel while F2 showed a clear parabolic trajectory with a maximum or minimum point near the middle of the vowel interior.

An example of a type (a) monophthong is in Figure 1; a type (b) monophthong is in Figure 2.[14]

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[13] Since vowel steady-states often show some degree of fluctuation, some value had to be set as an acceptable level of fluctuation. The figure of 75Hz was chosen based on this researcher's previous experience.

[14] Figures 1-4 are traditional vowel spectrograms. Gray areas represent frequency intensity. The dark bars that appear to run horizontally through the figures represent the formants. The dark vertical line indicates the measurement point I used. Duration (in ms) is along the abscissa, Hz values are along the ordinate.

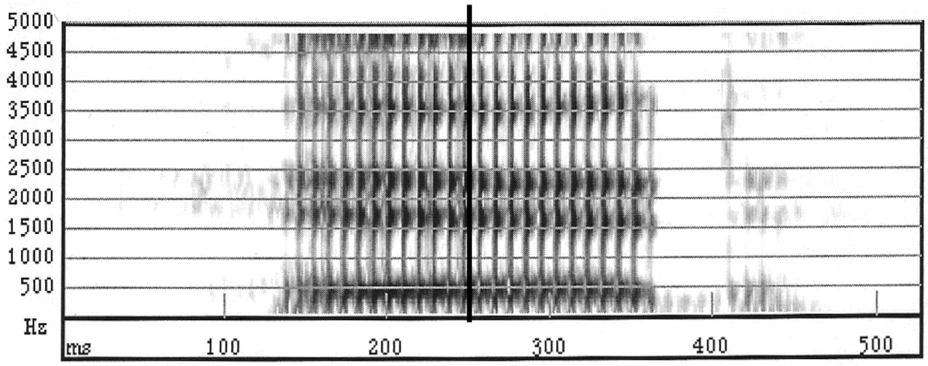

Figure 1: Type (a) Monophthong: "hid"

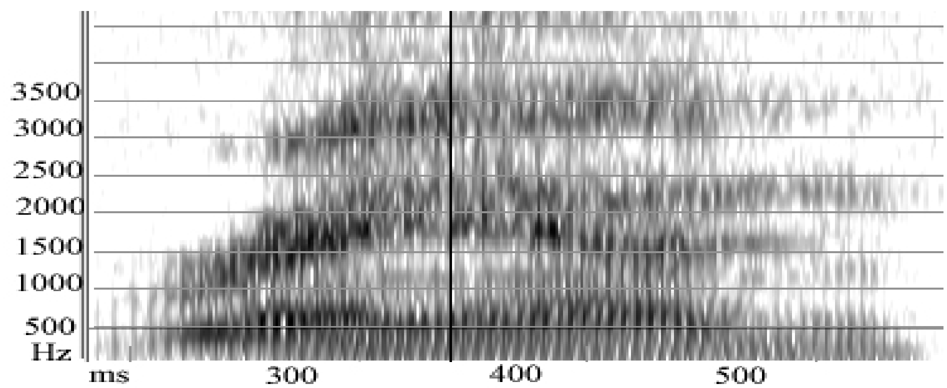

Figure 2: Type (b) Monophthong: "ran"

3.4.2. Diphthongs

Diphthongization of the vowels came in two main varieties. In the first category of diphthongs, we find what appear to be two distinct steady states for both F1 and F2. That is, it appears that two distinct monophthongs are being produced in the space of one vowel. In this work, these are referred to as 'True Diphthongs'. They are similar to Lehiste & Peterson's (1961) "proper diphthongs", though in my data the transition between the steady states was quite short while the steady states themselves were quite long, the opposite of what Lehiste & Peterson found. This pattern can be seen in Figure 3:

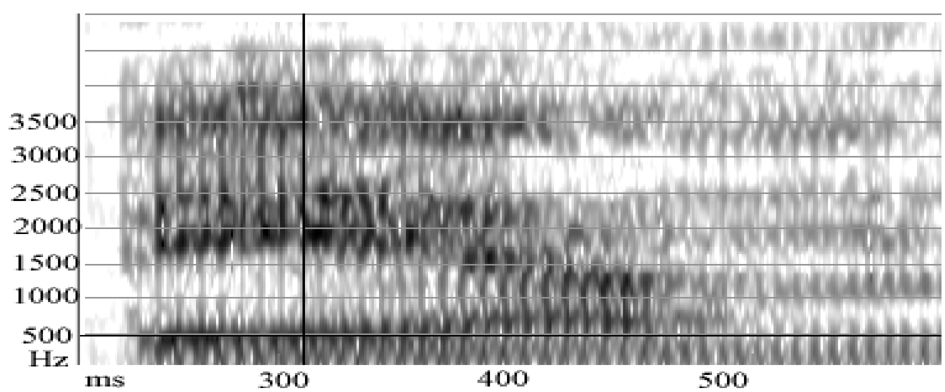

Figure 3: True Diphthong: "dim"

In the second type of diphthongization, which will be referred to as 'Breaking Diphthongs', we see a relatively steady state F1 for the entirety of the vowel, certainly for the 60% interior, but the F2 trajectory is a near-perfect downward slope, as in Figure 4. This pattern[15] may be similar to the vowel breaking pattern as described by Feagin (1987).

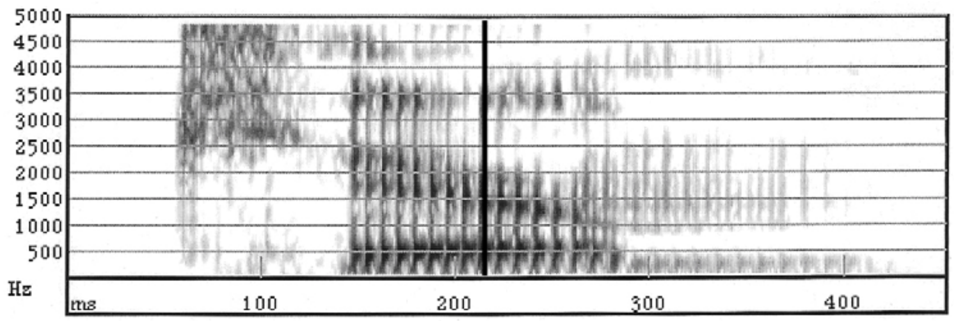

Figure 4: Breaking Diphthong: "Kim"

3.4.3. Measurement Points

Measurement points of monophthongs, then, were within 10ms of the vowel temporal midpoint for vowel type (a) or the center of the max/min point of F2 for vowel type (b) (as described above). The 10ms "window" was a cushion for finding an accurate LPC analysis if any pops, cracks, or other extra-laryngeal noise created interference; the final measurement point was always within the 60% vowel interior.

[15] Briefly, some interesting features of the Breaking Diphthong vowels in my data deserve mention. Breaking Diphthongs are mostly found in pre-nasal contexts, rarely in the pre-oral contexts; the majority of tokens are found in the Minimal Triplets list; they are much more common among females than males; and Breaking Diphthong tokens are much more common before labials than they are before alveolars. The tokens that most often diphthongized into Breaking Diphthongs are the words *him, Kim,* and *chem*. Finally, one sub-group of speakers, Speakers A, C, D, E, show the Breaking Diphthong pattern much more often than other speakers, and it may be important that these speakers come from Saline County, the eastern-most county in the sample. This type of formant movement deserves an additional study, well beyond the scope of this paper.

Measurement points for True Diphthongs were at the F1~F2 steady state midpoint for the first steady state of the pair. This is equivalent to the measurement procedures for type (a) monophthongs, only reduced in scope since, in True Diphthongs, there are essentially two "monophthongal events" in the space of one vowel. These measurements points are used in the analysis, as the first portion of a True Diphthong is the target that corresponds to the target for monophthongs (Harrington & Cassidy 1994).

Since the Breaking Diphthong–type vowels show an F1 steady state equivalent to a monophthongal F1 steady state, the F1 midpoint values of Breaking Diphthongs were used for the analysis.

Formants were analyzed with Macquirer software. First, a spectrogram was generated with a frequency range of 5000 Hz, a dynamic range of 40dB, and a bandwidth of 172 Hz, adjusted to 344 Hz for some female speakers or 86Hz for some male speakers. The F1 and F2 values were eye-balled and estimated by hand at the measurement point. Then, Macquirer's FFT/LPC auto-tracking option was used to generate spectra for the measurement point. The FFT/LPC was set with a 5000Hz frequency range, a frame window length of 11ms, average step size 10ms, 26 coefficients, and a frame length bandwidth of 172Hz, adjusted as described above. Many of these settings are Macquirer defaults. The formant values reported are based on the FFT/LPC values, checked against the original spectrogram estimates. If an original estimate and an FFT/LPC value were not reasonably similar, another measurement point was chosen, as described above. If the spectrogram estimates and the FFT/LPC values did not coincide after three attempts, the token was discarded. Measurement logs were generated for each speaker and imported into StatView software for statistical analysis.

One concern with measuring nasalized vowels is that in the LPC/FFT analysis, and even in the visual check of the spectrogram, one may mistake the nasal formant (FN) as a vowel formant, typically F1. This type of error, while perhaps not completely eliminated, was kept in check by monitoring the bandwidths of the listed formants. Nasal formants usually have a substantially greater bandwidth (~200 Hz) than vowel formants bandwidths (~30-70Hz) (Stevens 1999). Therefore, when an LPC/FFT peak was in doubt, disallowing any peaks that showed bandwidths over 100Hz, while not a perfect rule of thumb, allowed a measure of control over the automated outputs.

Despite the differences in male and female vowel space, no normalization procedures were carried out. Although most sociophoneticians use the normalization method developed by Nearey (1978), this method is still controversial (see Disner 1980, Nearey 1989, Labov 2001 for a full discussion). As yet, there is still no normalization technique that can accurately account for interspeaker variability, especially cross-dialectally (though see Watt & Fabricius 2002). It was decided that any mathematical normalization procedure may end up generating more problems than it would solve. Therefore, I have chosen to represent individual vowel ranges with only the most basic visual normalization; that is, the same 2"x3" vowel plots are used for all speakers and the axis values are varied internally. Thus, while one speaker's vowels may only show a 150Hz difference between maximum and minimum values, and another may show 425Hz difference, both differences will be represented in a relative-equal way by using the same 2"x3" abstraction of their vowel space.

3.4.4. Analysis of Tokens

After measurements were made, the token values were analyzed with StatView statistical software. To uncover possible factors influencing the merger, ANOVA analyses were run with for each speaker with the dependant variable VOWEL IN CONTEXT (i.e., comparison of the variables: æ, æ̃, ɛ, ɛ̃, ɪ, ɪ̃; represented as /æ/oral, /æ/nasal, etc.). Furthermore, to determine whether or not two vowels were statistically significantly distinct, Fisher's PLSD pairwise comparisons of all possible vowel-in-context sets were generated.

4. Results

The results section is set up as two different experiments, each performed on twenty different speakers. The first experiment is labled the Embedded List task type, and the second is labled the Minimal Triplets task type. Considering the PIN~PEN merger as a merger of height, only F1 values are reported; in the results presented, significance is decided at the level α=0.05. Specifically, if it is found that the mean F1 value of the allophones (either pre-nasal or pre-oral) of two vowels which are canonically distinct do not show a significance of α >/= 0.05 then we can conclude that there is evidence warranting further inspection on the possibility that these vowel allophones have merged.

4.1. Results from the Embedded List Task

Before we can begin to search for merged vowel pairs, it must first be shown that there is some distinction among the vowel allophones. That is, in order to show that vowel allophones are merging, it must first be shown that they are not inherently similar. To show this initial distinction, a one-way ANOVA was run for each speaker with the factor VOWEL IN CONTEXT (where the variables were /æ/nasal, /æ/oral, /ɛ/nasal, /ɛ/oral, /ɪ/nasal, /ɪ/oral). Table 2 shows the ANOVA results (degrees of freedom, F-value, *p*-value) for each speaker. Results that are NOT significant (*p*>0.05) are in **bold**.

Speaker	dF	F-Value	*p*-Value
1	5	5.19	0.0025
0	5	49.58	<.0001
2	5	11.16	<.0001
3	5	36.33	<.0001
5	**5**	**1.83**	**0.1461**
6	5	12.19	<.0001
7	5	18.39	<.0001
A	5	19.84	<.0001
C	5	16.82	<.0001
D	5	11.18	<.0001
E	5	9.47	<.0001
G	5	7.18	0.0002
H	5	9.99	<.0001
i	5	79.16	<.0001
K	5	5.94	0.0006
L	5	47.07	<.0001
M	5	5.99	0.001
O	5	24	<.0001
P	5	8.87	<.0001
Q	5	12	<.0001

Table 2: Embedded List Task, ANOVA results

From these results we can conclude that there is, indeed, at least one vowel allophone group of the six that is significantly different from the rest for nearly all speakers. Therefore, to find evidence of merger we must look now at the post-hoc pairwise comparisons and consider each vowel pair set separately. However, before continuing, a special mention of Speaker 5 is needed. The ANOVA results for Speaker 5's Embedded List data are shown to be not statistically significant. This would lead one to believe that, therefore, all six vowel allophones are neutralized. Although Speaker 5 shows no significant variation in her six vowel allophones, she will continue to be included in the discussion because the graphs of her vowel production can still shed light on the patterns of variation at the heart of this thesis. Table 3 shows the mean F1 value and standard deviation (in parentheses, *italics*), rounded to the nearest whole number, of each vowel allophone for each speaker.

	nasal /̂/	**oral /̂/**	**nasal /[/**	**oral /[/**	**nasal /j/**	**oral /j/**
Speaker 0	522 *(26)*	642 *(5)*	495 *(15)*	574 *(21)*	501 *(17)*	452 *(24)*
Speaker 1	608 *(128)*	658 *(85)*	449 *(46)*	561 *(25)*	520 *(129)*	427 *(19)*
Speaker 2	561 *(34)*	604 *(15)*	480 *(26)*	520 *(53)*	465 *(51)*	450 *(31)*
Speaker 3	657 *(50)*	700 *(32)*	474 *(19)*	595 *(19)*	490 *(51)*	463 *(32)*
Speaker 5	525 *(190)*	636 *(149)*	538 *(145)*	568 *(80)*	445 *(63)*	431 *(16)*
Speaker 6	613 *(31)*	730 *(40)*	626 *(37)*	671 *(45)*	623 *(15)*	560 *(35)*
Speaker 7	488 *(17)*	565 *(19)*	486 *(8)*	512 *(26)*	490 *(13)*	459 *(17)*
Speaker A	583 *(44)*	643 *(24)*	492 *(33)*	492 *(50)*	483 *(38)*	444 *(50)*
Speaker C	659 *(18)*	703 *(22)*	611 *(59)*	608 *(36)*	586 *(47)*	500 *(33)*
Speaker D	615 *(16)*	635 *(18)*	561 *(71)*	559 *(26)*	532 *(47)*	470 *(46)*
Speaker E	714 *(150)*	858 *(75)*	716 *(142)*	742 *(37)*	576 *(18)*	542 *(35)*
Speaker G	475 *(40)*	522 *(20)*	444 *(39)*	492 *(31)*	439 *(38)*	433 *(16)*
Speaker H	527 *(141)*	790 *(51)*	656 *(91)*	652 *(74)*	535 *(63)*	492 *(50)*
Speaker I	468 *(17)*	648 *(23)*	523 *(38)*	617 *(24)*	414 *(18)*	397 *(25)*
Speaker K	591 *(78)*	793 *(50)*	574 *(107)*	618 *(22)*	592 *(70)*	514 *(146)*
Speaker L	617 *(30)*	626 *(36)*	494 *(36)*	504 *(20)*	494 *(16)*	418 *(20)*
Speaker M	742 *(92)*	822 *(82)*	698 *(158)*	692 *(56)*	599 *(144)*	514 *(36)*
Speaker O	551 *(38)*	712 *(20)*	522 *(66)*	584 *(16)*	514 *(51)*	465 *(25)*
Speaker P	738 *(81)*	775 *(67)*	721 *(82)*	614 *(40)*	707 *(145)*	502 *(26)*
Speaker Q	620 *(32)*	673 *(24)*	560 *(38)*	576 *(34)*	540 *(71)*	496 *(26)*

Table 3: F1 means for each vowel allophone, Embedded List, separated by speaker

4.2. Results from the Minimal Triplets Task

Again, for the Minimal Triplets task, a one-way ANOVA was run for each speaker with the factor VOWEL IN CONTEXT (where the variables were /æ/nasal, /æ/oral, /ɛ/nasal, /ɛ/oral, /ɪ/nasal, /ɪ/oral). Table 4 shows the ANOVA results (degrees of freedom, F-value, *p*-value) for each speaker. Again, results that are NOT significant (p>0.05) are in **bold**.

Speaker	DF	F-Value	P-Value
0	5	22.116	<.0001
1	5	9.965	<.0001
2	5	17.732	<.0001
3	5	18.578	<.0001
5	5	26.57	<.0001
6	5	16.507	<.0001
7	5	22.486	<.0001
A	5	18.97	<.0001
C	5	23.718	<.0001
D	5	9.605	<.0001
E	5	8.446	<.0001
G	5	9.732	<.0001
H	5	27.648	<.0001
I	5	20.723	<.0001
K	5	8.225	<.0001
L	5	53.313	<.0001
M	5	11.296	<.0001
O	5	14.928	<.0001
P	5	13.726	<.0001
Q	5	35.02	<.0001

Table 4: Minimal Triplets Task, ANOVA results

Table 5 shows the mean F1 value and standard deviation (in parentheses, *italics*) of each vowel allophone for each speaker. From these results, like the results from the Embedded List task, we can conclude that there is at least one vowel allophone group of the six total that is significantly different from the rest for all speakers and we are therefore justified in examining the post-hoc tests to see wherein the variation lies.

	nasal /̂/	oral /̂/	nasal /[/	oral /[/	nasal /j/	oral /j/
Speaker 0	510 *(37)*	683 *(21)*	518 *(64)*	597 *(25)*	490 *(29)*	452 *(16)*
Speaker 1	738 *(103)*	673 *(51)*	572 *(90)*	537 *(17)*	596 *(81)*	440 *(55)*
Speaker 2	541 *(34)*	633 *(28)*	488 *(23)*	544 *(31)*	528 *(48)*	447 *(10)*
Speaker 3	647 *(48)*	726 *(52)*	498 *(46)*	627 *(28)*	512 *(83)*	461 *(33)*
Speaker 5	817 *(111)*	834 *(101)*	588 *(129)*	684 *(64)*	376 *(38)*	425 *(9)*
Speaker 6	633 *(16)*	943 *(152)*	637 *(11)*	675 *(60)*	639 *(25)*	574 *(56)*
Speaker 7	508 *(24)*	608 *(33)*	498 *(19)*	504 *(26)*	485 *(19)*	443 *(22)*
Speaker A	608 *(36)*	626 *(20)*	515 *(53)*	468 *(45)*	524 *(63)*	412 *(44)*
Speaker C	697 *(18)*	717 *(39)*	605 *(74)*	568 *(36)*	578 *(22)*	500 *(44)*
Speaker D	647 *(39)*	640 *(28)*	640 *(65)*	574 *(36)*	540 *(95)*	476 *(34)*
Speaker E	665 *(127)*	786 *(93)*	726 *(79)*	724 *(28)*	568 *(75)*	542 *(47)*
Speaker G	547 *(20)*	578 *(33)*	510 *(61)*	503 *(49)*	481 *(31)*	438 *(15)*
Speaker H	495 *(55)*	781 *(35)*	637 *(59)*	693 *(67)*	530 *(89)*	477 *(28)*
Speaker I	469 *(112)*	710 *(31)*	640 *(103)*	551 *(40)*	416 *(32)*	405 *(15)*
Speaker K	586 *(86)*	766 *(55)*	470 *(54)*	593 *(64)*	538 *(115)*	527 *(107)*
Speaker L	685 *(43)*	640 *(32)*	481 *(40)*	469 *(17)*	507 *(37)*	389 *(23)*
Speaker M	684 *(76)*	795 *(45)*	567 *(114)*	659 *(57)*	612 *(66)*	489 *(38)*
Speaker O	542 *(60)*	697 *(23)*	557 *(85)*	585 *(30)*	537 *(69)*	433 *(19)*
Speaker P	702 *(49)*	777 *(93)*	658 *(42)*	612 *(60)*	626 *(62)*	515 *(11)*
Speaker Q	625 *(15)*	678 *(36)*	617 *(30)*	608 *(13)*	604 *(20)*	508 *(12)*

Table 5: F1 means by vowel allophone, Minimal Triplets, separated by speaker

4.3. Results of the Post-Hoc Tests for Both the Embedded List and the Minimal Triplets

Since, overall, both the Embedded list and Minimal Triplets list ANOVAs show that there is a distinction between these six vowel allophones, the reader is now directed to Table 6 and Table 7 as well as the post-hoc tests in Appendix C. The tables in the appendix are an expanded version of the tables shown here, separated by speaker. They show the mean and standard deviation for each variable, as well as Fisher's PLSD post-hoc pairwise comparisons, separated by speaker. The Embedded list data are in Tables 10–28 while the Minimal Triplets data are in Tables 29–48.

Upon examining the post-hoc tests, we must ask in which vowel pairs distinction is neutralized. For example, if a speaker's post-hoc test shows that /æ/oral and /æ/nasal are not significantly different, then we assume that the contrast between these two vowel allophones is neutralized. In this example, the neutralization tells us that the following environment does not effect the vowel. However, if we should find a neutralization between, say, the /ɛ/nasal and /ɪ/nasal tokens, then the neutralization would tell us that the 'word-class' (i.e., PIN words vs. PEN words, or some might claim the 'underlying phoneme' or even the 'Standard English phoneme') has no effect on the vowel production. This second kind of neutralization is what we are looking for when we look for evidence of vowel merger because it shows that speakers are not attending to word class (or 'Standard English' pronunciation norms) when speaking, but instead pronouncing these different token types as 'the same'.

Tables 6 and 7 here give an at-a-glance view of the pairwise comparisons from the post-hoc tests. In these two tables, an 'X' occurs for each pairwise set for which a speaker shows a neutralization (significance below the α=0.05 level). These data, however, still cannot show the direction in which the mean F1 of these vowels is shifting (i.e., it cannot tell us if a presumed merger is accomplished via /ɪ/-lowering or /ɛ/-raising). Therefore, while the information in these tables may be suggestive, it is only when we couple this information with descriptive graphs that we can begin to develop an overall picture of possible vowel merger(s). This information will be presented in the discussion in Section 5.

In order to better understand these Tables 6 and 7, I will now provide a detailed description of each pairwise comparison set. Line numbers are represented in the leftmost column by miniscule Roman numerals, Speaker Codes are represented along the topmost row. The data for Speaker 5 in Table 6, the Embedded List table, are not applicable as this speaker's ANOVA results were not significant.

A neutralization in line (i), (ii), or (iii) indicates that the speaker shows no significant difference between the pre-oral and pre-nasal vowel allophones of a given vowel, that is, following consonant place has no effect on mean F1 vowel production. Neutralization in line (iv) indicates no significant difference between PAN-class words and PEN-class words, taken alone this could indicated a PEN~PAN merger.

Neutralization in line (v) indicates no significant difference between PEN-class words and PIN-class words, taken alone this could indicated the PIN~PEN merger. This is by far the most common type of neutralization found in my data. Neutralization in line (vi) indicates no significant difference between PAN-class words and PIN-class words, taken alone this could indicated a PIN~PAN merger. This form of neutralization is perhaps the most surprising and exists as the only pre-nasal merger for just one speaker. The implications of this finding are discussed further below. A neutralization shown in lines (vii)-(xii) indicates, like in lines (i)-(iii), no significance between pre-oral and pre-nasal vowel allophones. However, unlike lines (i)-(iii), the neutralizations shown in lines (vii)-(xii) are across vowel types. Of specific interest are the neutralizations shown in: in regards to /ɪ/~/ɛ/ merger, line (vii), which could indicated pre-nasal /ɪ/-lowering as compared to line (viii), which could indicate pre-nasal /ɛ/-raising; in regards to /ɛ/~/æ/ merger, line (ix), which could indicate pre-nasal /æ/-raising as compared to line (x), which could indicate pre-nasal /ɛ/-lowering. Neutralization shown in line (xi), which could indicate extreme pre-nasal /æ/-raising, is a rare occurrence, and neutralization shown in line (xii), which would indicate extreme pre-nasal /ɪ/-lowering, is non-existent. Finally, neutralization shown in lines (xiii), (xiv), and (xv), which is also rare, could point towards a vowel-shift beyond the type discussed in this thesis.

		0	1	2	3	5	6	7	A	C	D	E	G	H	I	K	L	M	O	P	Q
i	/æ/nas, /æ/oral		X	X	X	-				X	X						X	X		X	X
ii	/ɛ/nas, /ɛ/oral			X		-	X		X	X	X	X		X	X	X	X	X			X
iii	/ɪ/nas, /ɪ/oral		X	X	X	-			X			X	X	X	X	X		X	X		X
iv	/æ/nas, /ɛ/nas					-	X	X		X		X	X			X		X	X	X	
v	/ɛ/nas, /ɪ/nas	X	X	X	X	-	X	X	X	X	X		X			X	X	X	X	X	X
vi	/æ/nas, /ɪ/nas	X	X			-	X	X					X	X		X		X	X	X	
vii	/ɛ/oral, /ɪ/nas		X			-		X	X	X	X					X	X	X		X	X
viii	/ɛ/nas, /ɪ/oral		X	X	X	-			X				X			X					
ix	/æ/nas, /ɛ/oral		X	X		-						X	X			X		X	X		X
x	/æ/oral , /ɛ/nas					-												X		X	
xi	/æ/nas, /ɪ/oral					-								X		X					
xii	/æ/oral, /ɪ/nas					-															
xiii	/æ/oral, /ɪ/oral					-															
xiv	/ɛ/oral, /ɪ/oral					-			X							X					
xv	/æ/oral, /ɛ/oral		X			-							X								

Table 6: Neutralizations for the Embedded List data

		0	1	2	3	5	6	7	A	C	D	E	G	H	I	K	L	M	O	P	Q
i	/æ/nas, /æ/oral		X			X			X	X	X		X								
ii	/ɛ/nas, /ɛ/oral		X			X	X	X	X	X		X	X	X			X		X	X	X
iii	/ɪ/nas, /ɪ/oral	X			X	X	X					X	X	X	X	X					
iv	/æ/nas, /ɛ/nas	X					X	X			X	X	X			X			X	X	X
v	/ɛ/nas, /ɪ/nas	X	X	X	X		X	X	X	X			X			X	X	X	X	X	X
vi	/æ/nas, /ɪ/nas	X		X			X	X						X	X	X		X	X		X
vii	/ɛ/oral, /ɪ/nas		X	X			X	X		X	X		X			X	X	X	X	X	X
viii	/ɛ/nas, /ɪ/oral				X		X									X		X			
ix	/æ/nas, /ɛ/oral			X	X		X	X				X	X			X		X	X		X
x	/æ/oral , /ɛ/nas		X								X	X			X						
xi	/æ/nas, /ɪ/oral						X							X	X	X					
xii	/æ/oral, /ɪ/nas		X																		
xiii	/æ/oral, /ɪ/oral																				
xiv	/ɛ/oral, /ɪ/oral															X					
xv	/æ/oral, /ɛ/oral											X									

Table 7: Neutralizations for the Minimal Triplets data

There are three major trends, then, that can be found in these results. These trends all involve the neutralization of pre-nasal allophonic distinction; generally, speakers maintain distinction for all pre-oral vowel allophone pairs in both task types.

The first major trend is represented by cases where the distinction between the pre-nasal allophones of /ɪ/ and /ɛ/ has been neutralized (as shown by similar mean F1 values). Most speakers (all but Speakers E, H, I for the Embedded List data; all but Speakers 5, D, E, H, I for the Minimal Triplets data) show this lack of significant distinction. This is the kind of evidence that one would expect for the PIN~PEN merger.

The second major trend is represented by cases where a neutralization of the distinction of the allophones of all three front vowels in pre-nasal position occurs.

This trend can be found for the Embedded List data in Speakers 6, 7, G, K, M, O, P and in the Minimal Triplets data for Speakers 0, 6, 7, K, O, Q. Again, this pattern will be discussed in relation to actual 'vowel merger' in the section below.

The third trend to follow from the results is that of either (a) the neutralization of the distinction of the allophones of /ɛ/ and /æ/ in pre-nasal position or (b) the neutralization of the distinction of the allophones of /ɪ/ and /æ/ in pre-nasal position. When these two trends are distinguished from the second trend (above), we see that these two kinds of neutralization are, for the most part, mutually exclusive. That is, except for Speakers E, H, and I, all speakers show a second pre-nasal neutralization in addition to the PIN~PEN neutralization.

However, these are only statistical trends; they are not answers to the questions I have posed regarding degree of merger. Furthermore, these trends cannot tell us in which direction these neutralizations are taking place. That is, for the first trend (neutralization of pre-nasal /ɪ/ and /ɛ/), we still do not know if the mean for these vowels is closer to the pre-oral allophones of /ɪ/ or /ɛ/ (that is, are we seeing /ɪ/-lowering or /ɛ/-raising?). As will be seen in the discussion section, given the wide range of variation most speakers show for production of both their pre-nasal and pre-oral vowel allophones, this question has no easy answer. However, the descriptive discussion with vowel graphs presented below will make the complexity and range of variaiton these speakers exhibit more clear.

5. Discussion

As can be seen from the results presented in section 4, the Southern Illinois speakers in my research show quite a range of variation regarding the merger of pre-nasal allophones of front vowels. In order that we may better understand the patterns behind this variation, graphs will be presented for visual comparison in the following sections.

When all speakers are pooled into one dataset, we see, as expected from Beddor's and Krakow's work, that there has been a contraction (or 'flattening') of the vowel space when comparing pre-nasal to pre-oral allophones, as in Figures 5 and 6.[16] In both task types the three vowels, both pre-orally and pre-nasally, are still at three distinct F1 heights even though the nasalized vowels are now in closer proximity to one another on the F1 plane. Specifically, there is an F1 difference from /æ/ to /ɪ/ of 65Hz in pre-nasal contexts as compared to 218Hz in pre-oral contexts for the Embedded List task (Figure 5), and a difference of 81Hz in pre-nasal contexts as compared to 244Hz in pre-oral contexts for the Minimal Triplets task (Figure 6).

[16] NOTE: For vowel line graph figures, /ae/ = /æ/, /E/ = /ɛ/, and /I/ = /ɪ/. Further, since F1 has an inverse relationship to vowel height, the line graphs are opposite of the traditional vowel triangle. That is, the high front vowel /i/, in the upper left corner of the traditional vowel triangle, would be at the lower right corner in the graphs presented here. Filled circles represent pre-oral vowels; open squares represent pre-nasal vowels.

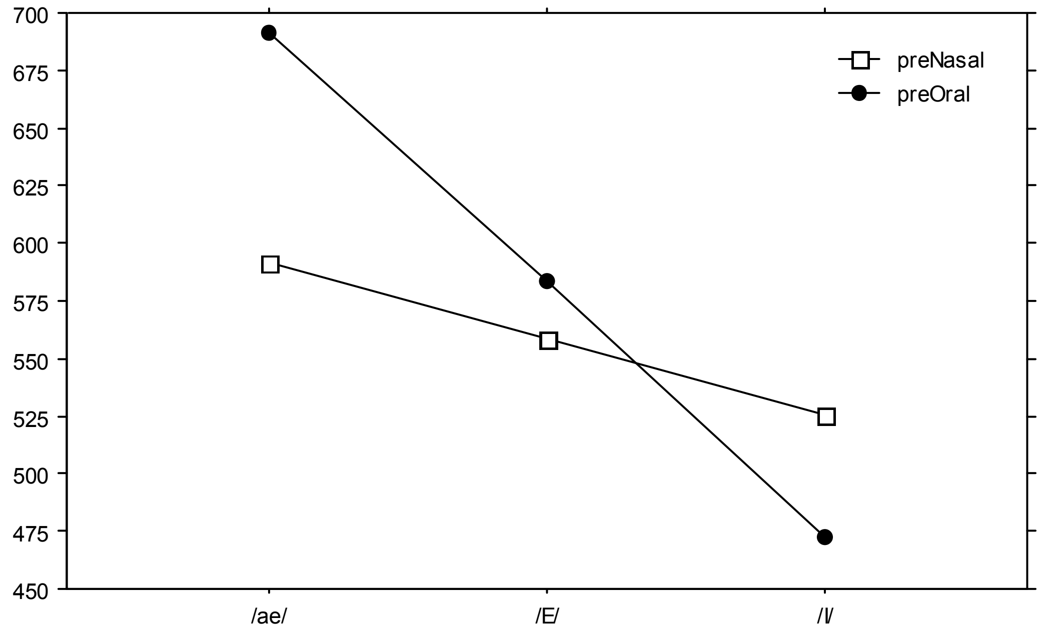

Figure 5: Embedded List data, all speakers pooled. Mean F1 values along the abscissa.

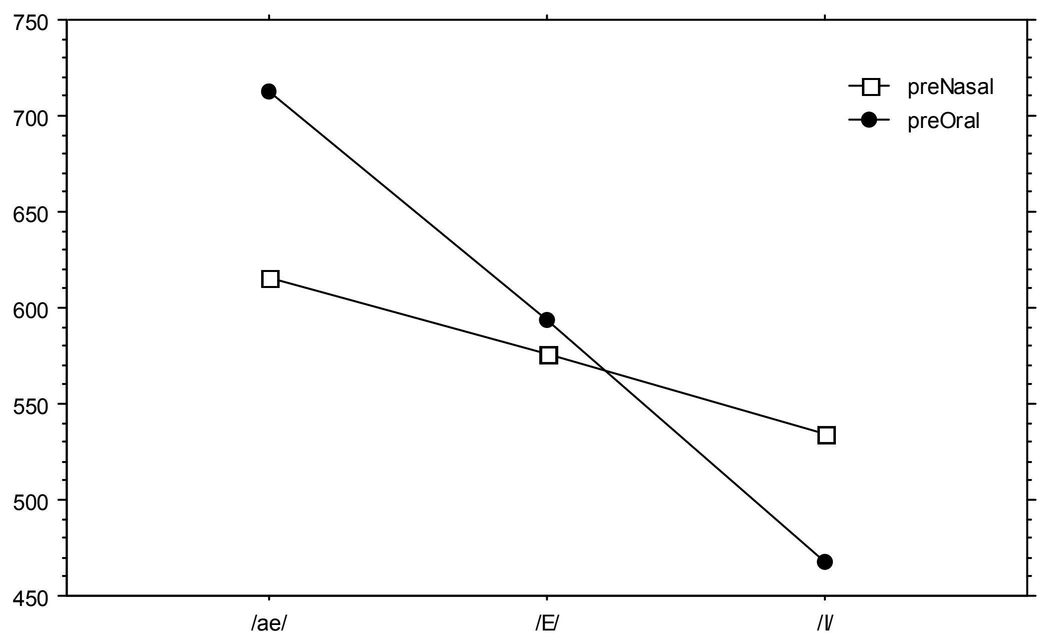

Figure 6: Minimal Triplets data, all speakers pooled. Mean F1 values along the abscissa.

However, pooling data in this manner is not quite a fair representation of the nature of the data. For example, it is known that males and females use different ranges of vowel space (see the discussion in Diehl et al. 1996), so by pooling the data from these groups together, we unfairly skew the data. Furthermore, based on the results given in section 4, pooling the results in this manner cannot capture the variation between speakers. It is therefore reasonable to separate out values for each speaker as the starting point of discussion.

5.1. Individual Speaker Results

In looking at individual speakers, I would like to address the following questions: First, what pattern, or patterns, can these graphs show us for the PIN~PEN (~PAN) merger? Second, how do the results found in the post-hoc tests given in Table 6 and Table 7 relate to the patterns of merger found when we look at the graphs of individuals? Third, do speakers' patterns shift from the Embedded List task to the Minimal Triplets task (when more attention is, presumably, paid to speech)? Results are grouped primarily according to the patterns displayed,[17] and only secondarily according to any sociological information.

Furthermore, in the following sections, although Age Group was not a factor in my analysis, I will be using it as a simple grouping in order to shed light on issues of a possible language change in progress among these speakers. What we will see in this section is that, while older male speakers generally pattern together, the other possible sociological groupings (older females, younger speakers, etc.) show more variable patterning. The question that will remain, however, is how might the generation of speakers who are the children of my older speakers have made sense of, and internalized, these differing patterns of variation?

[17] The patterns and groupings discussed here are revised from my earlier work (Bigham 2004) and thus differ slightly.

5.2. Pattern A: Merger of /ɪ/~/ɛ/ Allophones in Pre-Nasal Position

Pattern A is the expected pattern for loss of distinction in the allophones of pre-nasal front vowels– a PIN~PEN merger. This pattern corresponds to the first trend mentioned in the post-hoc results in section 4. Overall, it can be said that the older male speakers participate in the merger of the pre-nasal allophones of /ɪ/ and /ɛ/ and that task type does not affect the pattern of merger in the pre-nasal vowels. Since the results in section 4 show neutralization, then, it is now fair to investigate the vowel graphs to see if we can uncover the direction of these neutralizations.

Pairwise comparison *p*-values of pre-nasal /ɪ/ and /ɛ/ and pre-oral /ɪ/ and /ɛ/ in the Embedded List task are presented here in Table 8 (again, results that are not significant are in **bold**); followed by individual graphs (Figures 7–10) to locate the direction of merger:

	pre-nasal /ɪ/, pre-nasal /ɛ/	pre-oral /ɪ/, pre-oral /ɛ/
Speaker 2	**0.55**	0.01
Speaker A	**0.67**	**0.06**
Speaker G	**0.79**	<0.01
Speaker L	**0.99**	<0.01

Table 8: /ɪ/~/ɛ/ merger in Older Male speakers; Embedded List

As can be seen from Table 8, the pre-nasal allophones of /ɪ/ and /ɛ/ are not significantly distinct for any of the four older male speakers. Also, three speakers show significantly distinct /ɪ/~/ɛ/ vowels in pre-oral positions, and Speaker A, who does not show a significant difference for oral vowels at the p=0.05 level, is very close at p=0.06. We must now consider what the ranges of these vowels look like to discern the direction of the PIN~PEN merger. By looking at the graphs, we can compare the mean value position of an oral vowel to the mean value position of its nasal counterpart to locate the direction of merger.

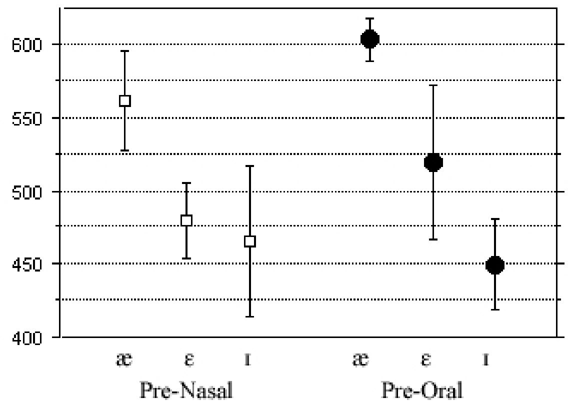

Figure 7: Speaker 2, Embedded List

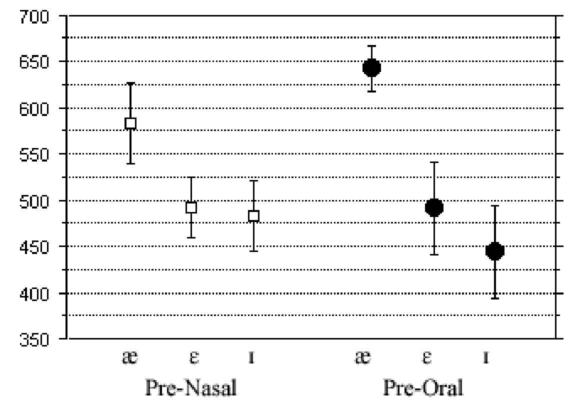

Figure 8: Speaker A, Embedded List

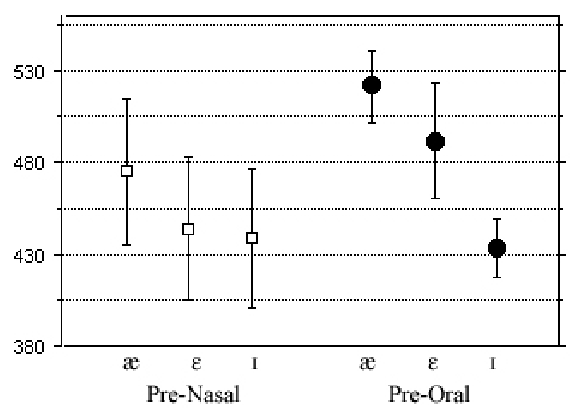

Figure 9: Speaker G, Embedded List

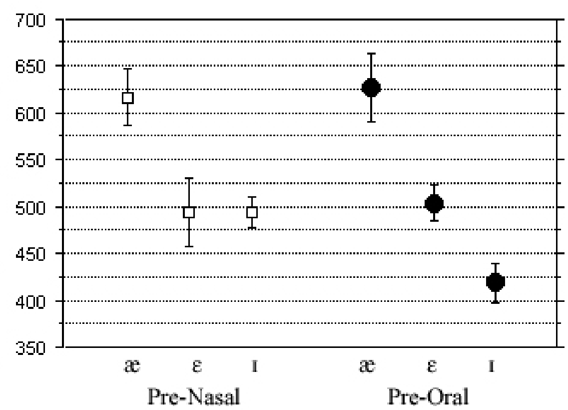

Figure 10: Speaker L, Embedded List

In looking at the graphs for Speakers 2, A, G, and L, we see that Speaker 2 and Speaker G appear to be participating in the PIN~PEN merger via both allophonic /ɛ/ raising and /ɪ/ lowering (since the nasal allophones of these vowels are midway between their two oral counterparts), while Speaker A and Speaker L are participating in the PIN~PEN merger predominantly via allophonic /ɪ/ lowering (since the pre-nasal allophones of both /ɪ/ and /ɛ/ are along the same range as the pre-oral /ɛ/ allophone). Furthermore, we see that there is considerable variation in the range of F1 for both the oral and nasal vowel allophones. This range of F1 variation will be discussed further in the conclusion.

For comparison, we will now look at individual speaker results for the older females for the Embedded List task, who (except Speaker H), based on the statistical analysis above, could be expected to show a similar pattern for the neutralization of the pre-nasal allophones of /ɪ/ and /ɛ/. Again, pairwise comparison *p*-values of pre-nasal /ɪ/ and /ɛ/ and pre-oral /ɪ/ and /ɛ/ in the Embedded List task are repeated here in Table 9; followed by individual graphs[18] (Figures 11–13) to locate the direction of merger.

	pre-nasal /ɪ/, pre-nasal /ɛ/	pre-oral /ɪ/, pre-oral /ɛ/
Speaker 3	**0.4822**	<0.0001
Speaker C	**0.2942**	<0.0001
Speaker K	**0.7233**	**0.0527**

Table 9: /ɪ/~/ɛ/ merger in Older Female speakers; Embedded List

[18] For Speaker C, the Minimal Triplets graph is given instead of the Embedded List graph. This is for ease of comparison only. As noted above, task type does not have an effect on Pattern A type mergers. See Appendix E.

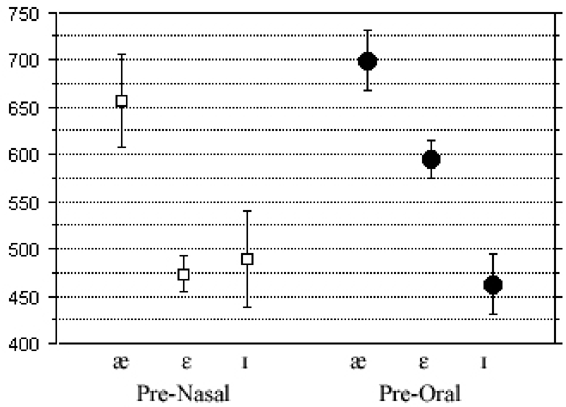

Figure 11: Speaker 3, Embedded List

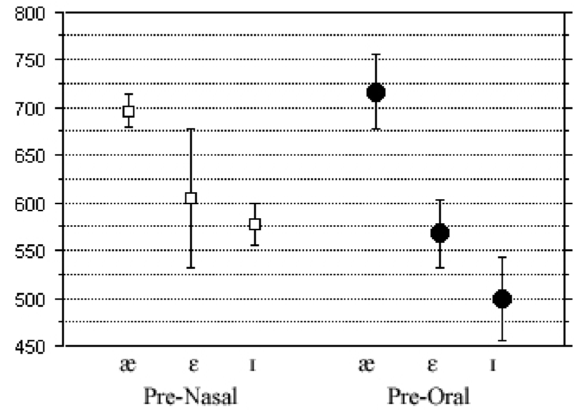

Figure 12: Speaker C, Minimal Triplets

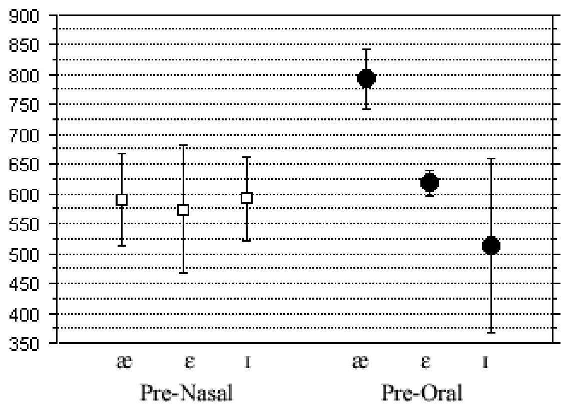

Figure 13: Speaker K, Embedded List

From Table 9, we see that, aside from Speaker H (discussed below), all older female speakers show a lack of significant distinction of the pre-nasal /ɪ/ and /ɛ/ vowels. From the graphs, however, we also see that not all speakers are participating in this merger in the same way. For example, Speaker C merges the PIN and PEN vowels via allophonic /ɪ/ lowering (since her pre-nasal /ɪ/ is at or below the level or her pre-oral /ɛ/), but, for Speaker 3, we see the 'classic' PIN~PEN merger, that is, merger via pre-nasal /ɛ/ raising (both her pre-nasal /ɪ/ and pre-nasal /ɛ/ show equivalent means to her pre-oral /ɪ/). Finally, Speaker K seems to be engaged in pre-nasal /ɪ/ lowering and both pre-nasal /ɛ/ and pre-nasal /æ/ raising. Therefore, Speaker K can be said to not fit the Pattern A type of merger at all, but instead shows a Pattern B merger (described below).

As these data have shown, much more is needed when discussing vowel mergers than statistical tests. That is, the statistical tests can only report which vowel pairs are and are not distinct; they cannot, however, show us how those distinctions or lack of distinctions unfold in a given speaker's vowel system. So, although on an individual statistical basis it appears that the ɪ~ɛ distinction is lost in pre-nasal position for most speakers, whether or not this neutralization can then be considered evidence of the PIN~PEN merger requires closer examination. Further, the specific ways in which speakers participate in this merger show a great deal of variation and require a more nuanced and qualitative discussion than can be provided by the ANOVA and post-hoc tests presented in section 4.

As mentioned above, regardless of *how* these Pattern A-type speakers participate in the vowel merger, they show no difference in their vowel patterns between the Embedded List task and the Minimal Triplets task. There are, however, two exceptions. Speaker 2 and Speaker G show different patterns of merger depending on task type (graphs for Speaker A and Speaker L are included here for comparison only).

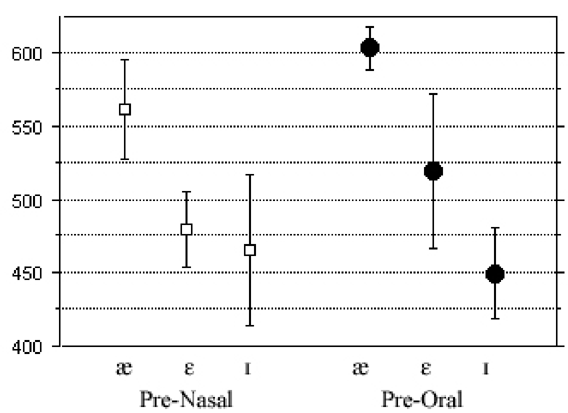

Figure 14: Speaker 2, Embedded List

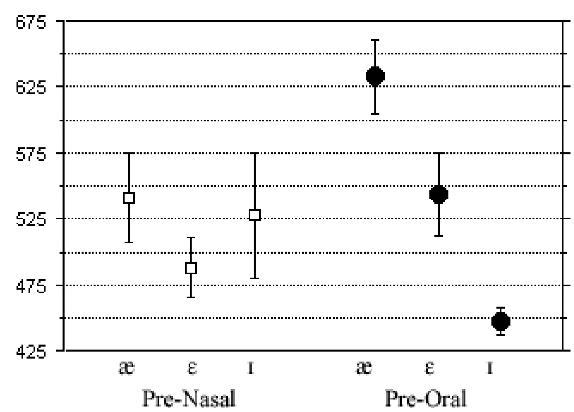

Figure 15: Speaker 2, Minimal Triplets

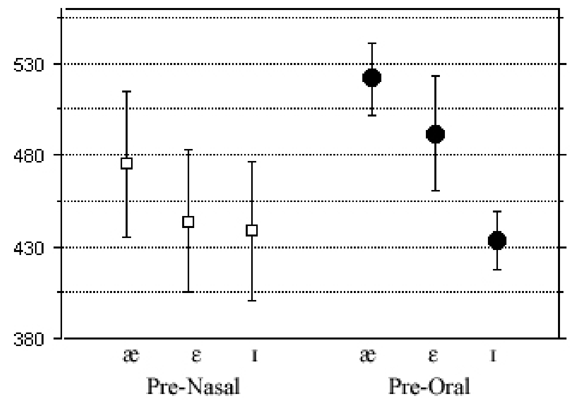

Figure 16: Speaker G, Embedded List

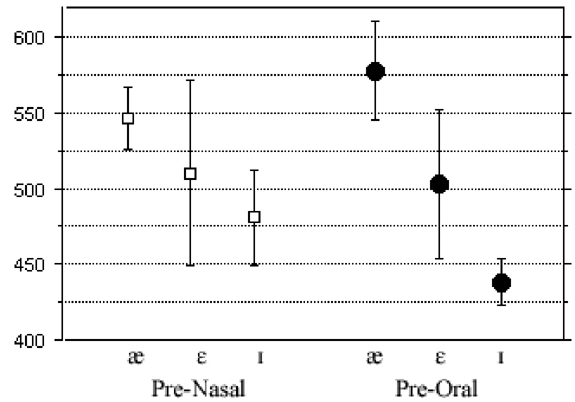

Figure 17: Speaker G, Minimal Triplets

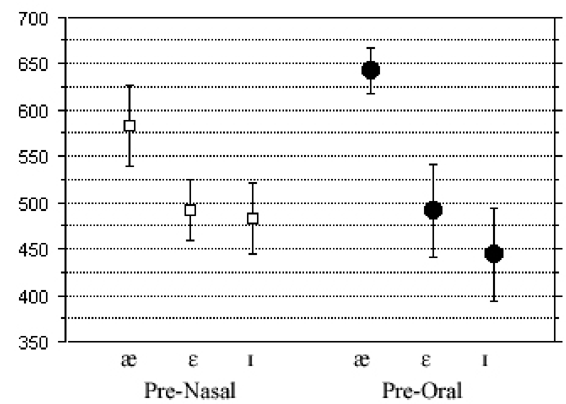

Figure 18: Speaker A, Embedded List

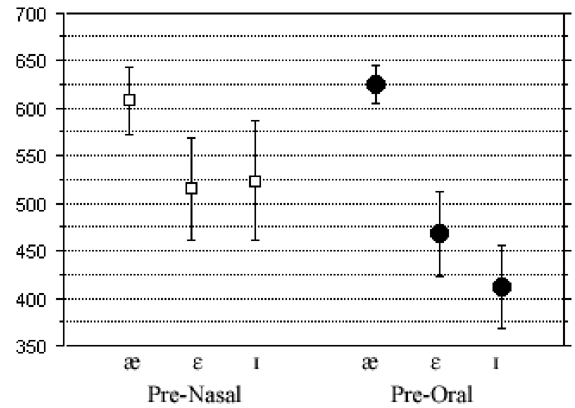

Figure 19: Speaker A, Minimal Triplets

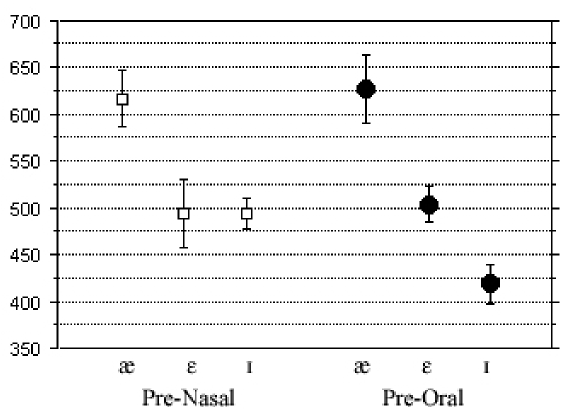

Figure 20: Speaker L, Embedded List

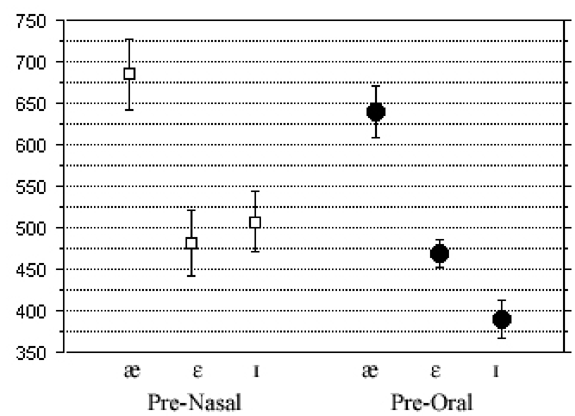

Figure 21: Speaker L, Minimal Triplets

Specifically, from these graphs, we see that for Speaker 2, while he shows the Pattern A type PIN~PEN merger in the Embedded List task, in the Minimal Triplets task, he shows a merger of the pre-nasal allophones of /æ/ and /ɪ/ (Pattern D2, below). For Speaker G, the effect of the Minimal Triplets task was to shift all pre-nasal allophones higher in F1, thereby lowering all pre-nasal front vowel allophones, but his mean values for pre-oral vowels remain distinct. In effect, Speaker G seems to switch from a PIN~PEN merger via /ɛ/-raising to a PIN~PEN merger via /ɪ/-lowering.

5.3. Younger Speakers

If the PIN~PEN merger is complete in Southern Illinois, we would expect to find the same pattern among the younger speakers as we found among the older speakers. However, as is noted above, both older females and all younger speakers show much more variety in their front vowel allophones. The pre-oral allophones of /ɪ/, /ɛ/, and /æ/ continue to behave as expected, that is, remaining at three distinct (and fairly canonical) heights regardless of task type. The pre-nasal allophones of the front vowels, however, are more complex. Overall, this variation can be described by four different patterns for the merger of front vowel allophones in pre-nasal position. These patterns will be discussed individually.

5.4. Pattern B: Merger of /ɪ/~/ɛ/~/æ/ Allophones in Pre-Nasal Position

In Pattern B we find that the pre-nasal allophones of all three front vowels have merged, yet all the pre-oral allophones of these three front vowels remain distinct. This pattern is related to the second statistical trend noted in section 4. Speaker 6 and Speaker 7 show this pattern for both the Embedded List task and the Minimal Triplets task; however, it can be noticed from Speaker 7's production of the Minimal Triplets task (Figure 25), that some separation of the pre-nasal front vowel allophones occurs. Finally, Speaker 0 shows this pattern in his Minimal Triplets data (Figure 26), but not in his Embedded List data (see Appendix E), and Speaker K, though not in the same age cohort as Speaker 6, 7, 0, shows this pattern of vowel merger in her Embedded List data (Figure 13, above).

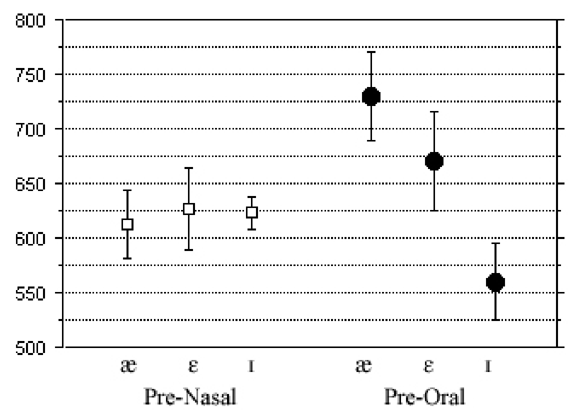

Figure 22: Speaker 6, Embedded List

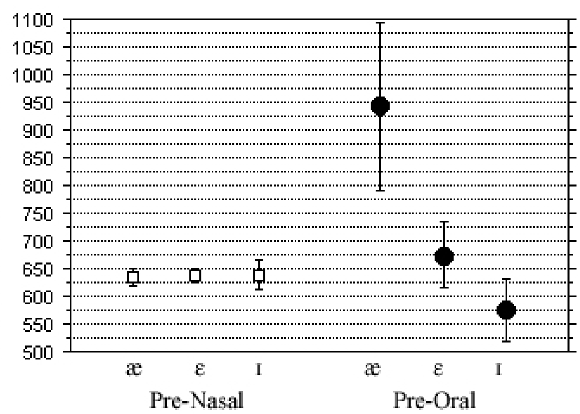

Figure 23: Speaker 6, Minimal Triplets

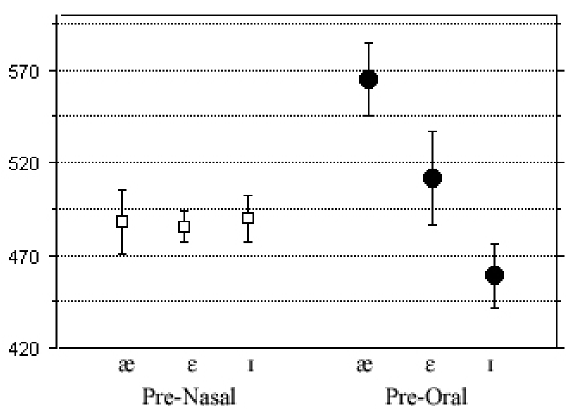

Figure 24: Speaker 7, Embedded List

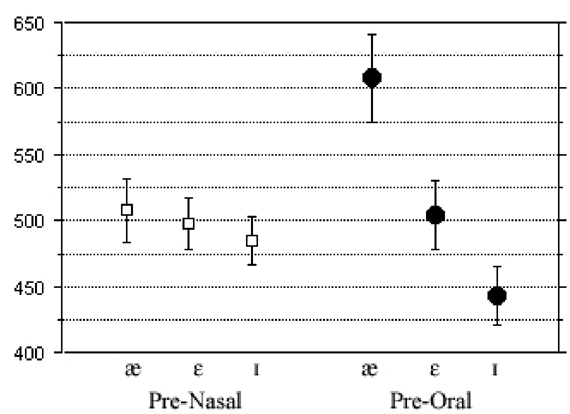

Figure 25: Speaker 7, Minimal Triplets

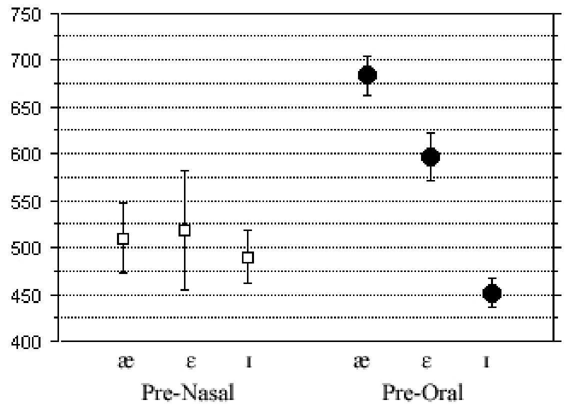

Figure 26: Speaker 0, Minimal Triplets

5.5. Pattern C: Merger of /ɛ/~/æ/ Allophones in Pre-Nasal Position

The second pattern that can be seen primarily among the younger speakers, Pattern C, is what could be called a PEN~PAN merger. This is part of the third statistical trend noted in section 4. In this pattern, the pre-nasal allophones of /ɛ/ and /æ/ have merged via /æ/ raising, while /ɪ/ remains distinct. With regard to the difference between the Embedded List task and the Minimal Triplets task, this pattern is highly variable. For example, Speaker 5 shows this pattern in her Embedded List data (Figure 27) (though, again, caution should be taken with Speaker 5 since her Embedded List data were not statistically significant), but shows no mergers in her Minimal Triplets list (Figure 28). Speaker E shows Pattern C in her Embedded List data (Figure 29), but in her Minimal Triplets data (Figure 30), her mean pre-nasal /æ/ allophone has raised even higher than her mean pre-nasal /ɛ/ allophone (this is similar to Pattern D1, below). Finally, Speaker D shows Pattern C in his Minimal Triplets data (Figure 31), but the /ɛ/~/æ/ merger is accomplished via the lowering of his pre-nasal /ɛ/ allophone, not via /æ/ raising.

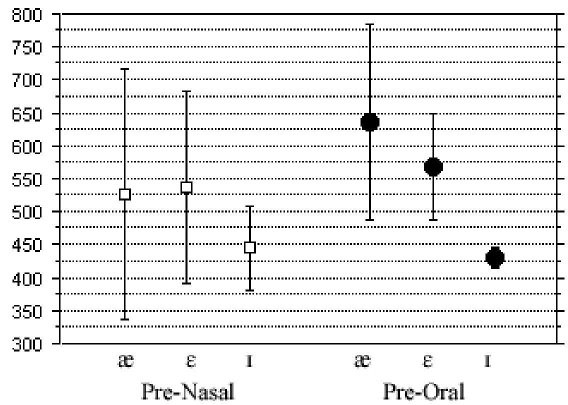

Figure 27: Speaker 5, Embedded List

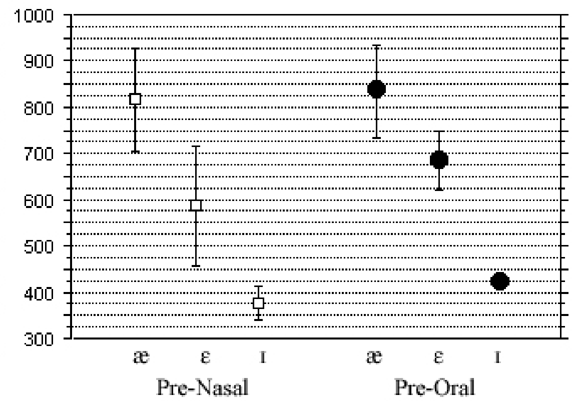

Figure 28: Speaker 5, Minimal Triplets

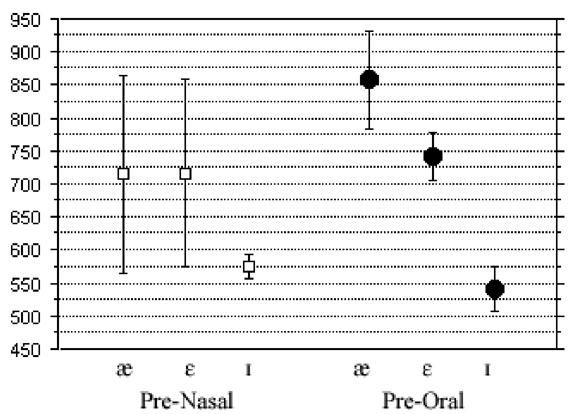

Figure 29: Speaker E, Embedded List

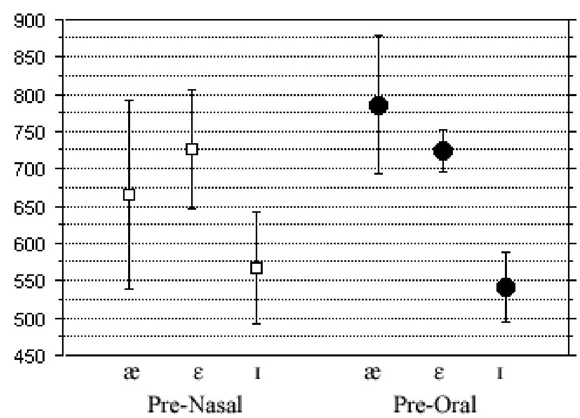

Figure 30: Speaker E, Minimal Triplets

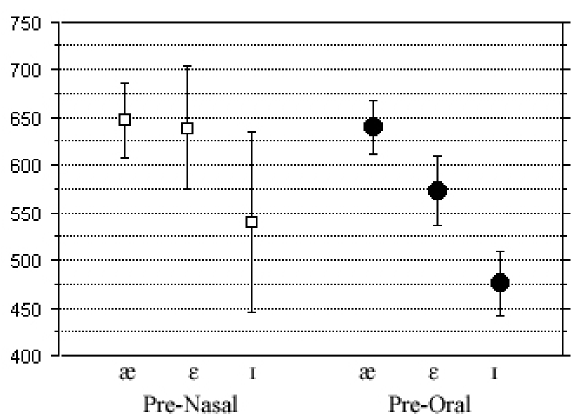

Figure 31: Speaker D, Minimal Triplets

5.6. Pattern D: Merger of /ɪ/ and /æ/ Allophones in Pre-Nasal Position

Pattern D is, perhaps, the strangest with regard to the movement and merger of the pre-nasal allophones of front vowels. In this pattern, the (b) version of the third statistical trend noted in section 4, /ɪ/ and /æ/ allophones have merged in pre-nasal environments while pre-nasal /ɛ/ remains distinct. That is, Pattern D is a PIN~PAN merger. Pattern D comes in two different varieties, D1 and D2. In Pattern D1, the pre-nasal allophone of /ɪ/ is slightly lower than its pre-oral counterpart, the pre-nasal allophone of /ɛ/ either has lowered or is fairly similar to its pre-oral counterpart, and the pre-nasal allophone of /æ/ has raised drastically in relation to the pre-oral /æ/ allophone. This pattern is found among both older and younger speakers, specifically, Speaker H and Speaker I (also, compare the Minimal Triplets data for Speaker E (Figure 30), who could also be said to exhibit this pattern, though less extremely than Speaker H or Speaker I). For Speaker H, we see that the pre-nasal allophones of /ɪ/ and /æ/ show the same range of production in both the Embedded List task (Figure 32) and the Minimal Triplets task (Figure 33). For Speaker I, we see the same basic pattern of vowel position (Figure 34, Figure 35), but post-hoc tests reveal that pre-nasal /ɪ/ and pre-nasal /æ/ are neutralized in Speaker I's Minimal Triplets task, but they remain distinct in his Embedded List task.

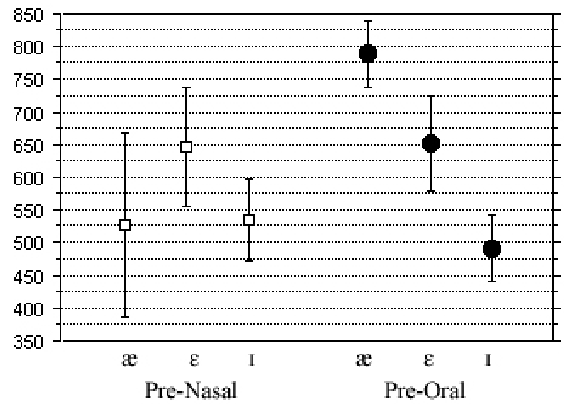

Figure 32: Speaker H, Embedded List

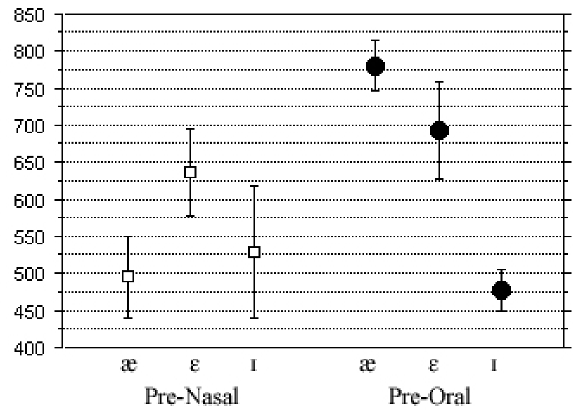

Figure 33: Speaker H, Minimal Triplets

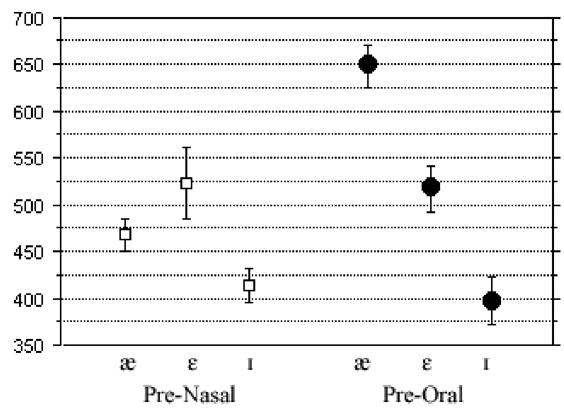

Figure 34: Speaker I, Embedded List

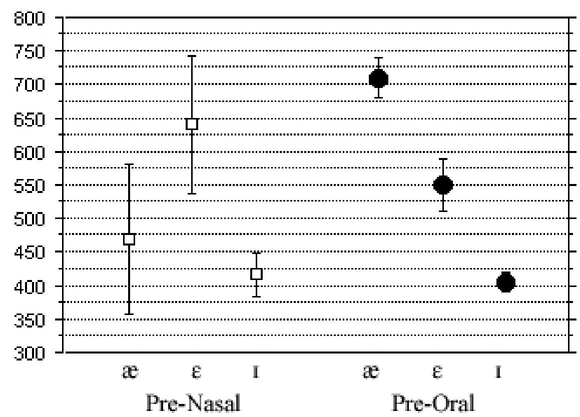

Figure 35: Speaker I, Minimal Triplets

The second pattern where we find that pre-nasal allophones of /ɪ/ and /æ/ have merged (while pre-nasal /ɛ/ remains distinct), Pattern D2, is the inverse of Pattern D1. In Pattern D2, the pre-nasal allophone of /æ/ has again raised, though not so far as in Pattern D1; the pre-nasal allophone of /ɪ/, however, has lowered so that it is roughly equivalent to the pre-oral allophone of /ɛ/; and the pre-nasal allophone of /ɛ/ has raised, such that it is now the vowel allophone with the highest mean F1. That is, in Pattern D2, we find that in pre-nasal contexts, the /ɪ/ and /ɛ/ vowels have basically switched position with regards to their pre-oral counterparts. This pattern can be seen in the Embedded List data for Speaker 1 (Figure 36) and the Minimal Triplets data for Speaker 2 (Figure 15, repeated here as Figure 37), Speaker K (Figure 38), and Speaker M (Figure 39) (the Minimal Triplets data for Speaker 1 shows a Pattern A type merger, via pre-nasal /ɪ/ lowering. See Appendix E).

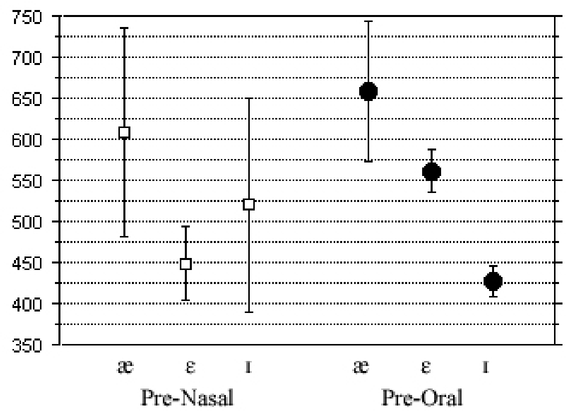

Figure 36: Speaker 1, Embedded List

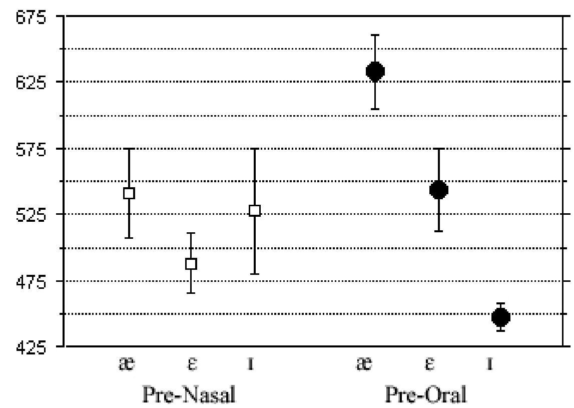

Figure 37: Speaker 2, Minimal Triplets

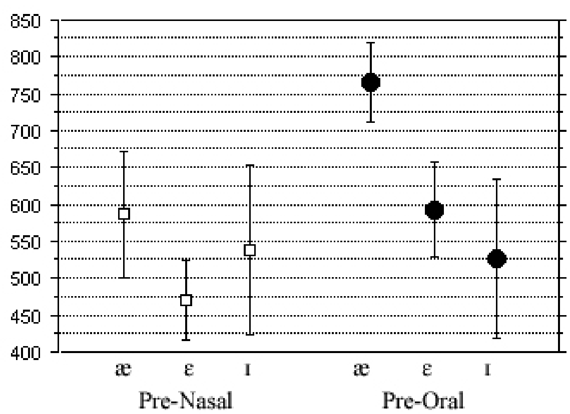

Figure 38: Speaker K, Minimal Triplets

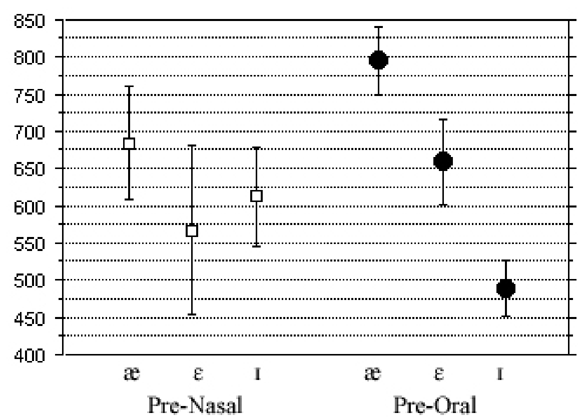

Figure 39: Speaker M, Minimal Triplets

Of the four speakers exhibiting Pattern D2, it is interesting that only two are members of the age cohorts previously defined. That is, Speaker 2 and Speaker K both belong to the Older Speaker group. Speaker 1 is the oldest speaker in my sample, a parent of Speaker 3, and Speaker M is of the generation midway between the Older and Younger speaker groups; she is, in fact, a parent of one of the youngest speakers, Speaker P, a fact to which we will return shortly.

What, then, can be said about Pattern D? As for Pattern D2, I can find no explanation in either the phonetics literature or the sociolinguistic literature that would account for finding this kind of allophonic shift without an accompany shift in the pre-oral vowel allophones. Likewise, I offer no explanation here and instead leave this pattern for future research. However, upon further inspection of the graphs, Pattern D1 begins to make more sense. For Pattern D1 what we find are cases where the pre-nasal allophone of /æ/ has been drastically raised. For both speakers, this allophone is now higher than both pre-nasal /ɛ/ and pre-oral /ɛ/, and is often raised as high, or higher, than the mean pre-nasal /ɪ/. It is precisely this kind of shift that has been said to be the first movement in the Northern Cities Vowel Shift (NCS) (Labov 2001, Eckert 1989). Why Speaker H should show the beginnings of the NCS is unknown, but it is worth noting that Speaker I, although living in Perry County, has spent much time in Randolph county, in a town just outside of St. Louis, where the NCS has been shown to be taking place (Gordon 2001, Goodheart p.c.).

5.7. Final Concerns

There is one final concern to which we now turn. For nearly all speakers, in both task types, there can be seen a vast range of variation of the production of vowel tokens (as shown in the graphs by the error bars representing +/- one standard deviation). By way of example, let us examine the results for Speaker D's Embedded List data (Figure 40). What we must consider, even if we cannot reach a definite conclusion, is whether what we see here is actually the PIN~PEN merger phenomenon, or if it is simply influence from the nasal pole-zero pair. Figure 40, again, plots the mean F1 values (on the ordinate) for the three vowels (on the abscissa) in both contexts. Vertical error bars are +/- one standard deviation.

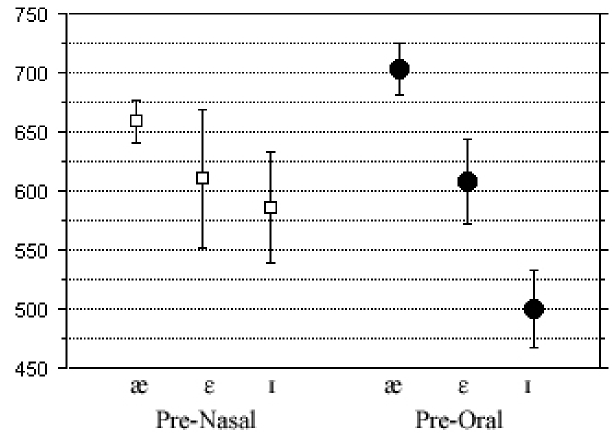

Figure 40: Speaker D, Embedded List

In looking at only the mean values in Figure 40 (the boxes and circles), it could be said that Speaker D is not, in fact, participating in the PIN~PEN merger, but only exhibiting signs of nasalization interference. That is, the mean values for the pre-nasal allophones of both /ɪ/ and /ɛ/ still appear to be at two distinct heights, and the /ɪ/ and /æ/ shifts could be explained via simple nasalization effects. However, when we consider the range of the allophonic production (as represented by the error bars) we see that Speaker D shows considerably varied pronunciation. In the pre-oral context, this variation does not encroach on any kinds of merger-type effects—even his lowest pre-oral /ɛ/ remains distinct from his highest pre-oral /æ/ and his highest pre-oral /ɛ/ remains distinct from his lowest pre-oral /ɪ/. However, in the pre-nasal vowel series, Speaker D's variability is quite wide. It can be seen that his pre-nasal /ɛ/ has values ranging from nearly the lowest pre-nasal /æ/ to the highest pre-nasal /ɪ/. From this graph alone, however, no strong claims can be made. Speaker D's statistical report (see Appendix C, Table 18) shows four types of neutralization: (i) a lack of distinction between pre-nasal /ɛ/ and pre-nasal /ɪ/ at p=0.25, (ii) a lack of distinction between pre-nasal /æ/ and pre-oral /æ/ at p=0.45, (iii) a lack of distinction between pre-nasal /ɛ/ and pre-oral /ɛ/ at p=0.94, (iv) a lack of distinction between pre-nasal /ɪ/ and pre-oral /ɛ/ at the p=0.28 level. These four results, when coupled with the descriptive graph (Figure 40), allow us to claim that the degree of merger exhibited by Speaker D, then, cannot be denied by appealing to a more general nasal pole-zero effect. However, given the range in his production of the pre-nasal /ɛ/ and /ɪ/ allophones, it should not yet be confirmed as a PIN~PEN merger. That is, it seems that Speaker D maintains in his speech repertoire the ability to make the PIN and PEN vowels in distinction; while he has merged these vowel allophones on a global scale, he could still make local distinctions. This is a possibility for most other speakers as well (a fact especially apparent with the data in the Minimal Triplets task) who show a wide range in possible F1 values for their pre-nasal allophones of /ɪ/, /ɛ/, and often /æ/.

Finally, although most speakers do exhibit the kind of range as shown for Speaker D, some speaker, like Speaker 3 or Speaker L, do not show this range. For these speakers, when the range of one vowel is small and completely subsumed by the other, it must be concluded that a merger has gone to completion.

6. Conclusions & Considerations for Future Research

I began this research with two main goals. First, I wanted to discover if speakers in Southern Illinois can be shown, via acoustic methods, to display the PIN~PEN vowel merger. Although I cannot generalize to all of the Southern Illinois dialect region (indeed, in this thesis, I have not even shown that Southern Illinois constitutes a 'dialect region'), it can now be concluded that, yes, generally, the Southern Illinois speakers in my data do participate in the PIN~PEN merger although the ways and degrees in which they participate are highly varied from one speaker to the next. But the /ɪ/~/ɛ/ comparison is not the only vowel set in our purview. The second main goal of this study was to determine whether or not the speakers in Southern Illinois, when their attention was focused on their pronunciation of these three front vowels, would pronounce the words PIN and PEN more like PIN and PAN, that is, would a careful pre-nasal /ɛ/ be lowered to an /æ/? We now turn our inspection to this possibility.

The Minimal Triplets task was formed as a way to encourage speakers to produce the /ɛ/~/æ/ merger at the expense of the /ɪ/~/ɛ/ merger. Although the effect of task type to produce this 'hypercorrect' PEN~PAN merger did not obtain, a merger of the pre-nasal allophones of /ɛ/ and /æ/ did. Note that the speakers who show /ɛ/~/æ/ merger show *both* /ɛ/ and /æ/ raising. Therefore, for these vowels to have merged, /æ/ has undergone extreme raising, even past the pre-oral /ɛ/. I feel that, at this point, there is still too little information to make a conclusion regarding these points, especially in light of the discussion, below, on a possible change in progress.

Perhaps the most important finding of this work, then, is related to my first research goal. That is, I believe the PIN~PEN merger can now be linked to the predictions of the phonetics literature and that the sociolinguistic literature may need to be revised. When we look at the data in the most general way, we see that, regardless of any actual vowel merger, the pre-nasal /ɪ/ allophones lower, the pre-nasal /æ/ allophones raise, and the pre-nasal /ɛ/ allophones also raise, if they move at all. That is, all vowels are behaving according to the general phonetic principles of nasalization, as described in section 2.2.[19] However, if the PIN~PEN merger is to be explained on the basis of general phonetic principles, then the conclusion drawn by Beddor et al. (1986) and Krakow et al. (1988) that contextual nasalization will *not* influence the perception of vowel height may need to be revised. One line of thought is that what we find in the PIN~PEN merger is a classic example of the effects of nasalization being compounded by misperception until the two heights are no longer distinct. This would go against the principles devised by Beddor and her colleagues, as all the nasal vowels in my data are *contextual* nasals.

However, another line of thought would be that there is no misperception of height in these dialects. Instead, given general phonetic principles, we find /ɛ/ slightly raised and /ɪ/ slightly lowered. If the oral counterparts of these vowels are close enough to begin with, then the effects of lowering one while raising the other would be that, pre-nasally, there simply is no distinction between these vowels. This may explain why, in the impressionistic work on the PIN~PEN merger, we find scholars in varying in regards to which vowel to choose when representing the form. Eventually, due to politics and fashion, it could have become a kind of internalized belief that we hear /ɪ/ before nasals in these dialects. What is needed before a decision can be reached, however, are many more acoustic studies on both the PIN~PEN merging dialects and the non-merging dialects. Perhaps the real issue is that Southern dialect front vowels are more compacted than Northern dialect front vowels; therefore, when the phonetics of nasalization apply, any distinction between /ɪ/ and /ɛ/, or even /ɛ/ and /æ/ (since Beddor et al. (1986) also allow for front

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[19] Actually, a full test of the general phonetic principles would require data from pre-nasal /o/ or /ʌ/ since contextually nasal front mid vowel movement is linked to nasalized back vowel movement.

contextually nasalized mid vowels to lower), is naturally erased. That is, the actual *merger* may not be a dialectal phenomenon, but only a natural outcome of an unrelated phenomenon– that of systemically contracted vowel space.

6.1. The Special Consideration of Change in Progress

What of the question of change in progress? If the variation seen in these data is evidence that this is indeed a kind of change in progress (even if not in the strictest Labovian sense of 'change in progress'), it could be that the pre-nasal allophones of front vowels are moving from a Pattern A type system, through Pattern B to a Pattern C type system. Recall that in the Minimal Triplets task, we see /ɪ/ raising for most speakers, /æ/ lowering for most speakers, but both /ɛ/ raising and /ɛ/ lowering. If the Southern Illinois dialect were undergoing change in progress, from a PIN~PEN merger to a PEN~PAN merger, this kind of variation is what we would expect. That is, when a speaker's attention is focused on the way they are producing the pre-nasal /ɛ/ vowel, some speakers will produce the older variant, while some will hypercorrect to produce the newer variant. Consider briefly four speakers not discussed above. For example, considering Speaker M (a female) and Speaker O (male) as the generation between the Older and Younger groups, and Speakers P and Q (both male) as the generation below the Younger group, we can perhaps see how this change might be moving. For example, beginning with the Older group, we see no /ɛ/~/æ/ merger among the males (Speakers 2, G, A, L), and some, though not much, among the females (Speakers K and C, specifically). If this is not an age-graded phenomenon, then this would be the incipient stage of this change. Then, in Speaker M and O, we see overall a Pattern B type of vowel chart, but the pre-nasal /æ/~/ɛ/ merger is more pronounced, and that the female is in advance of the male (though caution should be taken with only two speakers). See Figures 41–44.

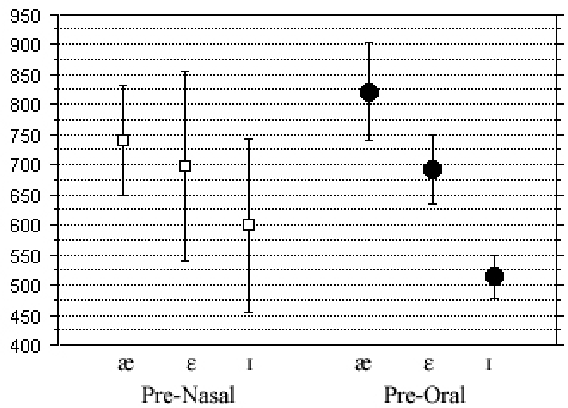

Figure 41: Speaker M, Embedded List

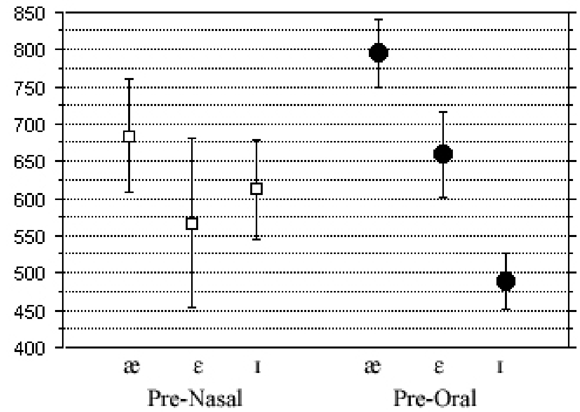

Figure 42: Speaker M, Minimal Triplets

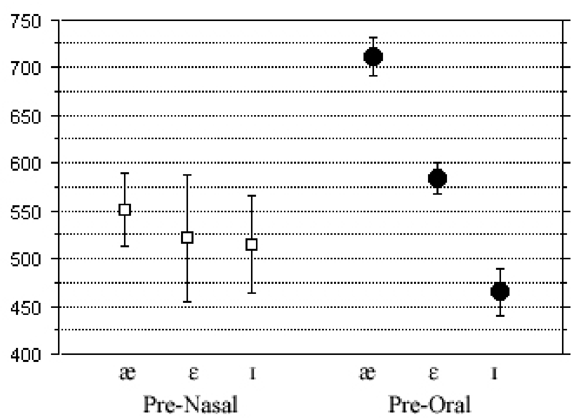

Figure 43: Speaker O, Embedded List

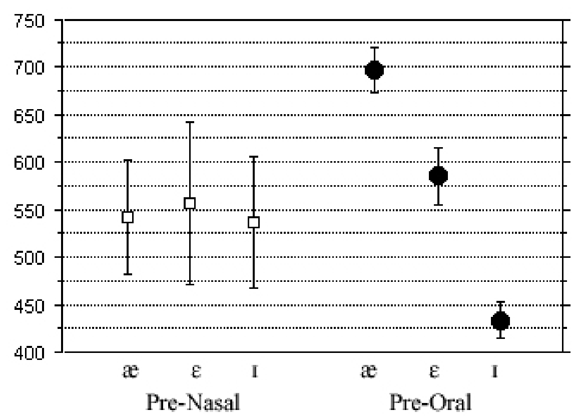

Figure 44: Speaker O, Minimal Triplets

The next generation, the Younger group, shows females moving the pre-nasal /æ/~/ɛ/ merger toward completion (Speaker 5, Speaker E), so much so, in fact, that they show degrees of merger equivalent to what the Older Males show for the classic /ɪ/~/ɛ/ merger. Finally, the two youngest speakers, both male, again show this pattern of variation which could be classified as a Pattern B type moving towards a Pattern C type (Figures 45 – 48). It is unfortunate that there is not also data from females in this youngest (12-19) age range.

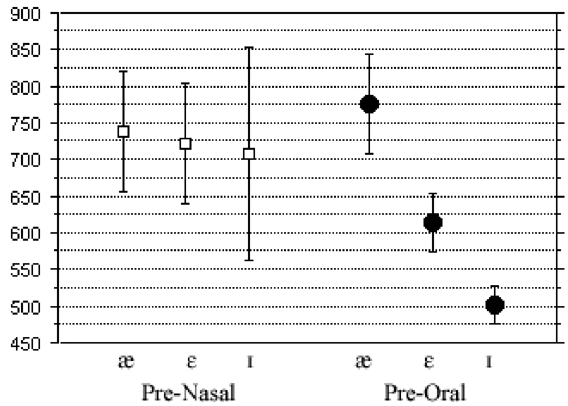

Figure 45: Speaker P, Embedded List

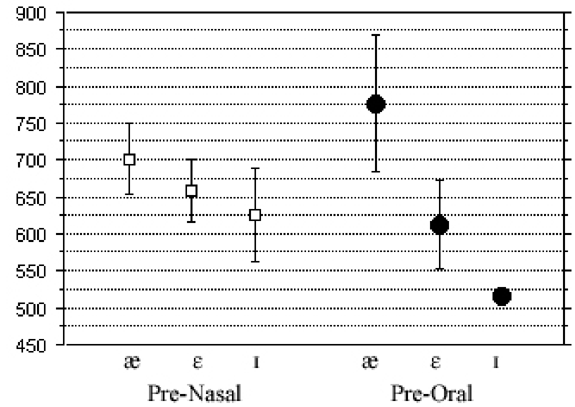

Figure 46: Speaker P, Minimal Triplets

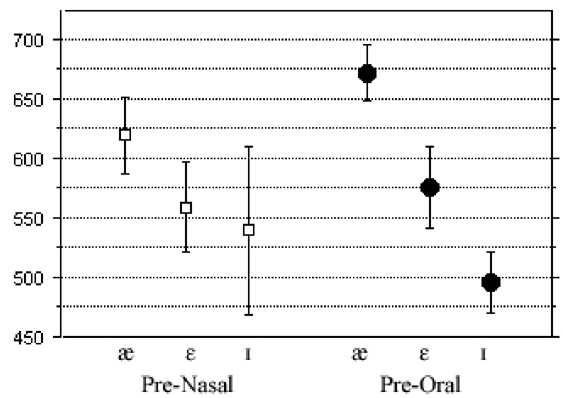

Figure 47: Speaker Q, Embedded List

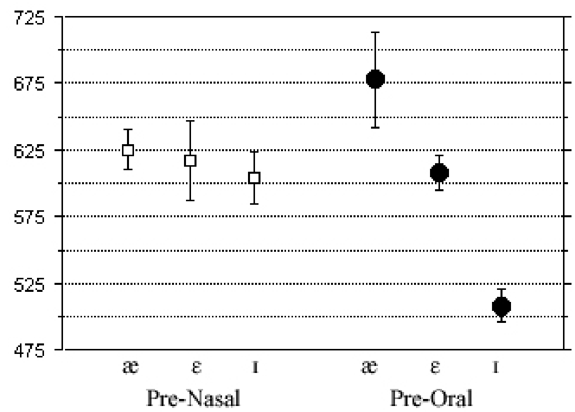

Figure 48: Speaker Q, Minimal Triplets

6.2. Closing Remarks

So, how does one make sense of the seemingly wide variation found in pre-nasal Southern Illinois English front vowels? Likely, what we appear to be seeing is the kind of simple interspeaker variation that anyone would find in a large scale dialect study. This wide range of variation further supports the idea that descriptions of vowel merger, even when conducted primarily impressionistically, must be supported with acoustic measurements. Without these detailed instrumental methods, for example, I might never have known that for some speakers we find /ɪ/ lowering, for some we find /ɛ/ raising, but for the majority we find something in between, both /ɪ/ lowering and /ɛ/ raising to some midpoint between the two.

Another explanation may be in the work of Kluender et al. (1998) which shows that experience plays a key role in phonetic boundary maintenance. Thus, in the four speakers from Saline County, a nuclear family group, all show pre-nasal /ɛ/ raising in the Minimal Triplets task, whereas four of the speakers from Perry County, Speakers 2, 3, 6, 0, another nuclear family grouping, all show pre-nasal /ɛ/ lowering in the Minimal Triplets data. The causes behind these variations in vowel pronunciation, then, could be supported by the idea that language experience is not just a global 'English' kind of input, but a much more local phenomenon, with the 'language' of one's primary care-givers being of specific importance. Therefore, a closer examination of speaker networks is needed in future research.

It was also considered that a geographical distribution of the speaker results might be of some interest, comparing, for example, speakers from the Western side of SoIL (in Perry and Jackson County) to speakers nearer Indiana, in Saline County. Unfortunately, the distribution of the speakers was skewed in such a way as to make this comparison futile. The familial differences noted above could be evidence for an eastern-western split, but it is not possible to tease the two possible factors apart at the current time.

Another feature that seemed to dominate the speech tokens of the Saline County subjects was the way that F2 seemed to interact with the degree of merger. While this influence was only slight, it did appear that my Saline County speakers treated pre-alveolar nasalized vowels differently than pre-labial nasalized vowels. Although I was unable to investigate this further in the current work, this possible influence from following consonant place is an issue which cannot be ignored in future research. Although, as mentioned above, Hillenbrand et al. (2001) have shown no significant effect on F1 dictated by the place of the following consonant, a full report of this merger (or these mergers, possibly) cannot be given until both F1 and F2 values are reported. Although F1 values may not rely on following consonant place, F2 values certainly do. Therefore, teasing the data apart on this dimension can only further our knowledge of this phenomenon.

Likewise, this thesis only considered data taken from reading lists. In a traditional Labovian-type framework, reading lists (of any kind) are considered to be a 'careful pronunciation' medium. While I designed my reading lists to take advantage of more- and less- 'careful' pronunciation (and have been calling these 'casual' and 'careful' speech), in the future, data from other speech genres, such as interviews, casual conversation, and reading story passages, must also be taken into account.

What can be said with some certainty is that the Southern Illinois speakers in my data are participating in the PIN~PEN merger (or, at least, *a* PIN~PEN merger). This would be partial evidence to support a South Midland dialect boundary above the Southern Illinois border. However, Southern Illinoisans also seem to be showing a 'confusion' between a PIN~PEN merger and a PEN~PAN merger when encourage to make their pronunciations of these vowels distinct. This could either be due to a current change in progress, or it could be evidence that Southern Illinois is not quite within the South Midland boundary. If the latter were true, it could be that speakers are coming into contact with a PIN~PEN merging dialect, but, not having it naturally in their own phonology, are misinterpreting what they hear, and this is reified in their (mis)production. Further, if Southern Illinois were not quite within the South Midland boundary, then its 'non-southern-ness' could explain why the PEN~PAN merger has not yet been mentioned in the literature. That is, it could be that there is not necessarily a change in progress in Southern Illinois speech, but a case of stable variation along the northern-southern border, just above the South Midland.

Support for the idea that Southern Illinois is a transition region is that geographically it is almost midway between Memphis (~3 hours drive) and St. Louis (~2.5 hours drive). In Memphis, the PIN~PEN merger is known to exist (Brown

1990, 1991) and the Southern Vowel Shift is in progress (although somewhat altered, see Fridland 2000 for a full discussion) and, in St. Louis, the Northern Cities Vowel Shift is in effect (Gordon 2001). Perhaps what my data show, then, is both a PIN~PEN merger and the beginning of a NCS type vowel shift (as mentioned in the discussion of Speaker H and Speaker I), leading to an overall loss of distinction in the pre-nasal allophones of all front vowels. As was briefly noted above, speakers who show /ɛ/~/æ/ merger all show /ɛ/ and /æ/ *both* raising. Therefore, for these vowels to have merged, /æ/ has undergone extreme raising, even past the pre-oral /ɛ/. The existence of /æ/ raising to a point equal to or above /ɛ/ is a common early stage in the Northern Cities Vowel Shift. The presence of /æ/ raising in my data, then, could be evidence that Southern Illinois is undergoing the first stages of NCS, perhaps on top of the remnants of an earlier Southern-dialect influence. The possible influence of St. Louis's Northern Cities Shift pattern on Southern Illinois speakers should be investigated more closely in future work.

Or, finally, it could be that the variation that Brown (1990, 1991), Pederson (1983), and others noticed between the /ɪ/-, /ɛ/-, and occasionally /æ/-sounding variants for the vowels in PEN and PIN in 'remnant folk speech' simply remained stable in Southern Illinois. This would only provide further support of 'Little Egypt' as a transitional dialect which may use this variation to maintain its own linguistic identity when faced with competition from both the North and the South.

0.0. Postscript

Southern Illinois is … beautiful, a glory and damnation … This other Illinois has become a symbol of something in America that we cannot afford to lose … We lose it at our peril. But lose it we shall…

(Baker Brownell, *The Other Illinois*, p. 19-20).

Appendix A. Reading Tasks, Speakers 0-9

This appendix is a replication of the reading tasks used for Speakers 0 – 9. Due to the requirements for formatting of this thesis, the margins here are not the same as the margins on the actual reading tasks used by the speakers. Therefore, no assumptions should be made regarding 'final word' or other 'list effects' on pronunciation of tokens.

1. Please read the following words.

Sunday, pan, all, bid, tumpt, been, run, ran, walking, tad, wash, tan, dead, Ozark, moon, toilet, cad, hunting, gin, Monday, hid, here, there, Manny, Egypt, Jim, pit, coal, Illinois, tin, had, prison, rebel, bad, red, head, Tuesday, fall, goat, farm, hen, chicken, cow, rib, slab, ham, women, men, woman, man, wed, kin, dad, mom, crib, kid, child, grain, pet, bib, back, pad, bed, return, Pinckneyville, did, Ken, Ted, their, mini, hair, Wednesday, Jeb, sick, pills, med, folk, get, ten, give, Du Quoin, they're, Dan, crab, ice, Carbondale, jam, many, dance, Deb, him, Perry, Jackson, lab, when, then, Randolph, itch, can, tid-bit, tid, bit, heavy, Thursday, lion, den, cave, lake, rim, fishing, Friday, ghost, cold, coat, web, pin, stitch, hem, stick pin, Cairo, fib, lie, tattle, cheat, sleep, dream, REM, there, their, they're, fog, soda, bin, every, gem, noise, sound, din, apple, peach, cram, talking, Saturday, ban, ram, swim, lake, boat, Kentucky, wren, pat, ear, eye, stem, told, university, where, bat, drop, pinch, pen, write, scratch, ink pen, jab, Daniel, Ben, bet, boogers, miner

2. Please read the following short stories about Southern Illinois.

(a) SOUTHERN ILLINOIS IS A PLACE LIKE NO OTHER.

Once you leave the central part of the state of Illinois and drive south, it's as though you have entered another state altogether, or perhaps even another world. The scenery and the landscape become as varied as the people, with vast acres of forest, caves, swamps, and even the edge of the Ozark Mountains. The people there embody the culture of the region with strange tales, a rich folklore, and southern drawls that you can rarely find outside of the deep south. But below the surface, another place lurks, hidden in the dark forests and forgotten among the bluffs and secret hollows. It is here in the pit of Illinois where the memory of the region's violent history still lingers... and where ghosts and "boogers" dwell.

As mentioned already, southern Illinois, or "Little Egypt" as it is often called, is a place like no other, with a nickname that is unforgettable and a landscape that is breath-taking. The history here is rich, colorful and turbulent, lending itself to the ghost stories and haunts that have been so well-known for so many years.

The first people in southern Illinois were the ancient Americans, who came before the Indians and built mysterious mounds and stone forts. Many of these structures have disappeared over the years, but many remain, some known and some unknown, to puzzle curiosity-seekers today. Even stranger than the mounds that exist in places like Cahokia, the stone forts have provided a puzzle all their own. They have been studied many times over the years, but so far, no one can comprehend their purpose. The question remains as to what these forts were used for? Who built them, who hid inside them, and why? The puzzle may never be solved, but one has to wonder... if the forts truly are scattered in a rough line between the two rivers, what enemy were the inhabitants trying to keep out?

After the War of 1812, the region was opened to settlers and most came from the southern states of North Carolina, Kentucky, Tennessee, and Virginia. They brought with them their southern ideas and traditions and these traditions would long hold sway over the thoughts and politics of the region.

As time has gone by, Little Egypt has greatly changed and gone are many of the old ways of the past. In some places, however, little has changed. Deep in some of the woods and hills, the customs, traditions, and tales of the past are not yet forgotten. And of all of the region's myriad of tales, stories of the supernatural seem to fill your head more than any other. While many of the stories fall firmly into the

realm of the folk legend, there are plenty of stories to give the reader a good case of the goosebumps.... all from a weird and mysterious place called "Little Egypt."
[Adapted from http://www.prairieghosts.com/little_egypt.html, © TROY TAYLOR, 2000]

(b) IS THE BIG MUDDY MONSTER A BIGFOOT?

In 1973, Murphysboro, Illinois, a small town where the banks of the Big Muddy river will pat your back, was in excitement over several sightings of a hair and mud covered monster. On June 25 of that year, a couple sitting in their car heard weird shrieks start to come from the woods nearby; they assumed it was a cat, but then a huge figure -- nearly ten feet tall -- covered with light tan hair and what appeared to be mud, came out of the woods and lumbered toward their vehicle. When it got to them, it hit the car and crushed the hood like a tin can. The couple drove off and reported the encounter to the police, and they're still too scared to talk about it to this day. Many other sightings were to follow. Two teenagers that had a close encounter with the creature said it smelled of bad river slime. A couple who lived nearby the fairground saw the strange beast staring at their pet donkey. Murphysboro police chief Ben Berger ordered a search, but all that was found was a bed of crushed grass, broken trees, and mini-gobs of black slime. Could it be a hoax? While there's no ban on practical jokes, Ken Stevens, editor of The Southern Illinoisan, said: "This is no hoax. This is hunting country, and anyone who goes around in an animal costume is going to get his butt shot off."
[Adapted from http://www.bigfootencounters.com/sbs/murphysboro.htm, originally in *Strange Stories, Amazing Facts*, © READER'S DIGEST, 1976]

3. Please read these words clearly & carefully.

pin	pan	pen	bid	pad	bad	pit	pet	pat	bid	bad
bed	bit	bat	bet	ban	Ben	bin	been	Deb	bib	Jeb
jab	Ted	Jim	gem	jam	Dan	din	den	Ken	kin	dead
dad	did	kid	ked	kit	tin	tan	ten	tad	cat	get
hid	had	head	tic	tech	tack	hem	ham	him	rim	ram
rebel	lab	rib	there	their	they're	walking		talking	fishing	wren
red	ran	wed	when	fib	crib	web	cad	can	gin	hen
cram	slab	crab	skim	web	ban	pan	tin	pin	ham	slam
Ben	ten	pen	pan	tan	can					

Appendix B. Reading Tasks, Speakers A-Z

This appendix is a replication of the reading tasks used for Speakers A – Z. Due to the requirements for formatting of this thesis, the margins here are not the same as the margins on the actual reading tasks used by the speakers. Therefore, no assumptions should be made regarding 'final word' or other 'list effects' on pronunciation of tokens.

1. Please read the following words.

moon, mine, gamble, bid, nickel, than, more, less, as, ten, two, three, five, stab, kill, dead, have, had, pit, peach, doctor, pill, med, run, ran, bim, balm, dib, draught, draft, Jeb, Deb, Lynn, pad, pillow, sheet, bed, cot, sleep, dream, REM, fib, lie, steal, tin, iron, metal, can, lad, lass, boy, girl, man, woman, men, women, bet, bat, robot, bought, bite, boot, but, bit, beat, bait, boat, pan, led, crib, them, they, he, she, her, hers, him, his, its, it, I, me, light, shine, dim, camel, pet, cat, lion, den, crab, fish, spider, web, catch, caught, John, Ken, Tim, Don, hem, pin, sew, stitch, write, draw, marker, pen, tid-bit, tid, kin, gem, small, mini, tiny, get, cram, chick, hen, farm, plough, hog, ham, head, body, ear, eye, now, when, then, next, laid, sat, did, Dawn, Shawn, Ted, thin, ban, mad, rib, mom, dad, baby, sister, brother, stem, kibble, dog, dam, bib, kid, rebel, bad, bam, set, Feb., rim, edge, tan, brown, red, blue, yellow, green, Sean, Ben, Dan, Kim, fab, hid, kit, chem, tad, dumpster, bin, trash, king, throne, sit, pat, noise, sound, din, poke, jab, polka, dancing, swimming, jam, cab, taxi, jar, lid, smidgen, pinch, dab, kettle, rock, pebble, win, middle

2. Please read the following short stories about Southern Illinois.

(a) SOUTHERN ILLINOIS IS A PLACE LIKE NO OTHER.

If you bid goodbye to the central part of the state of Illinois and drive dead south, it’s as though you have entered another state altogether, or perhaps even another world. The scenery and the landscape become as varied as the people, with vast acres of forest, caves, swamps, and even the edge of the Ozark Mountains. The people there embody the culture of the region with strange tales, a rich folklore and southern drawls that you can rarely find outside of the deep south. But below the surface, another place lurks, hidden in the dark forests and forgotten among the bluffs and secret hollows. It is here in the pit of Illinois where the memory of the region's violent history still lingers... and where ghosts and "boogers" dwell.

As mentioned already, southern Illinois, or "Little Egypt" as it is often called, is a place like no other, with a nickname that is unforgettable and a landscape that is breath-taking. The history here is rich, colorful and turbulent, lending itself to the ghost stories and haunts that have been so well-known for so many years.

The first people in southern Illinois were the kin of the ancient Americans, who came before the Indians and built mysterious tan mounds and stone forts. Many of these structures have disappeared over the years, some mistaken as a lion's den in the old days, but many remain to puzzle curiosity-seekers today. Even stranger than the mounds, the stone forts have provided a puzzle all their own. They have been studied many times over the years, but so far, no one can comprehend their purpose. Diggers have uncovered a trash bin with bad burn marks, what appears to be a doll for a kid, and a tad further down in the rock bed, some hen bones. No one know what it all means. The question remains as to what these forts did for the people who lived in them. Who built them, who hid inside them, and why? The puzzle may never be solved, but one has to wonder...

After the War of 1812, the region was opened to settlers and most came from the southern states of North Carolina, Kentucky, Tennessee and Virginia. They brought with them their southern ideas, traditions, and gin and these traditions would long hold sway over the thoughts and politics of many a man's head.

As time has gone by, Little Egypt has greatly changed and gone are many of the old ways of the past. In some places, however, little has changed. Deep in some of the pan-handle woods and hills, the customs, traditions, and tales of the past are not yet forgotten. And of all of the region's myriad of tales, stories of the supernatural seem to fill your head more than any other. While many of the stories fall firmly into the realm of “dad’s folk legend”, there are plenty of stories to give the reader a good case of the goosebumps.... all from a weird and mysterious place called "Little Egypt."

[Adapted from http://www.prairieghosts.com/little_egypt.html, © TROY TAYLOR, 2000]

(b) IS THE BIG MUDDY MONSTER A BIGFOOT?

In 1973, Murphysboro, Illinois, a small town where the banks of the Big Muddy river will pat your back, was on pin-and-needle excitement over several sightings of a hair and mud covered monster. On June 25 of that year, a couple sitting in their car heard a din of weird shrieks start to come from the woods nearby; they assumed it was a cat, but then a huge figure -- nearly ten feet tall -- covered with light tan hair and what appeared to be mud, came out of the woods and lumbered toward their vehicle. When it got to them, it hit the car and crushed the hood like a tin can. The couple drove off and reported the encounter to the police, and they’re still too scared to talk about it to this day. Many other sightings were to follow. Two teenagers, Dan Williams and Ted Riker, that had a close encounter with the creature said it smelled of bad river slime. A couple who lived nearby the fairground saw the strange beast staring at their pet donkey pen. Murphysboro police chief Ben Berger ordered a search, but all that was found was a bed of crushed grass, broken trees, and mini-gobs of black slime. Could it be a bad hoax? While there’s no ban on practical jokes, Ken Stevens, editor of The Southern Illinoisan, said: "This is no hoax. This is hunting country, and anyone who goes around in an animal costume is going to get his butt shot off."

[Adapted from http://www.bigfootencounters.com/sbs/murphysboro.htm, originally in *Strange Stories, Amazing Facts*, © READER'S DIGEST, 1976]

3. Please read these words clearly & carefully.

pin	pan	pen	pid	pad	peb	bin	bid	Ben	bed	ban
bad	tad	tan	Ted	ten	tid	tin	din	Dan	den	did
dad	dead	Ken	can	kin	cad	kid	head	hen	hid	had
Lynn	led	lid	lad	win	when	mid	med	mad	men	man
min	bim	bib	bam	Jim	stem	slab	Deb	dam	dab	dib
dim	Kim	cam	chem	cab	kib	jam	gem	Jeb	gin	jab
him	ham	hem	rim	ram	REM	rib	crib	reb	crab	web
fib	Feb.	fab	them	pit	pet	pat	bit	bat	bet	then
than	thin	get	ket	kit	cat	catch	next	sat	set	sit
said										

Appendix C. Speaker Demographics Questionnaire

Questionnaire
Participant #_______ Tape #_______, Track #________

Please provide the following information about yourself:

What is your age?: ____

What is your gender/sex?: ____

What is the highest level of school you completed?:_______________________

What is your race/ethnicity?:____

What kind of work do you do, or what kind have you done in the past?__________

____

Where were you born?____

Where did you grow up?____

How long have you lived in Southern Illinois?______________________________

Have you ever lived outside of Southern Illinois?___________________________

If so, where?____

For how long?____

For what reason (school, military, etc.)?_____________________________

What/where is Southern Illinois?____

Appendix D. Vowel Means and Post-Hoc Comparison Tables

This appendix gives the full results from the ANOVA tests performed. Section A3.1 gives the results of the Embedded List task; Section A3.2 gives the results of the Minimal Triplets task. The descriptive results are presented as separate tables for each speaker. These tables list the mean and standard deviation (abbreviated 'S.D.') for each vowel type, as well as the mean difference, critical difference and *p*-value for each of the Fisher's PLSD pairwise comparison sets. Recall that Speaker 5 did not show a significant difference among the six vowel types in her Embedded List data; therefore no results are presented in A3.1. However, her results were significant for the Minimal Triplets data; therefore she is included in A3.2. Results that are NOT significantly different are in **bold**. For the sake of conserving space and paper, tables have been allowed to split across pages in the appendices.

D.1. Embedded List Data

Speaker 0			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	522	25.89	
/ae/oral	642.25	4.57	
/E/nasal	494.6	15.03	
/E/oral	573.5	21.02	
/I/nasal	500.6	17.18	
/I/oral	452	24.04	
Fisher's PLSD comparisons	**Mean Dif.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-120.25	27.04	<.0001
/E/nasal, /E/oral	-78.9	27.04	<.0001
/I/nasal, /I/oral	48.6	27.04	0.0012
/ae/nasal, /E/nasal	27.4	25.49	0.0364
/ae/nasal, /E/oral	-51.5	27.04	0.0007
/ae/nasal, /I/oral	70	27.04	<.0001
/ae/oral, /E/nasal	147.65	27.04	<.0001
/ae/oral, /E/oral	68.75	28.5	<.0001
/ae/oral, /I/nasal	141.65	27.04	<.0001

/ae/oral, /I/oral	190.25	28.5	<.0001
/E/nasal, /I/oral	42.6	27.04	0.0036
/E/oral, /I/nasal	72.9	27.04	<.0001
/E/oral, /I/oral	121.5	28.5	<.0001
/E/nasal, /I/nasal	**-6**	**25.49**	**0.6296**
/ae/nasal, /I/nasal	**21.4**	**25.49**	**0.0955**

Table 10: Speaker 0, descriptive results, Embedded List

Speaker 1			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	608.4	128.05	
/ae/oral	658.25	84.56	
/E/nasal	448.8	45.63	
/E/oral	561.2	25.49	
/I/nasal	520	129.44	
/I/oral	427	19.03	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/E/nasal, /E/oral	-112.4	111.29	0.0479
/ae/nasal, /E/nasal	159.6	111.29	0.0069
/ae/nasal, /I/oral	181.4	111.29	0.0026
/ae/oral, /E/nasal	209.45	118.04	0.0013
/ae/oral, /I/nasal	138.25	118.04	0.0237
/ae/oral, /I/oral	231.25	118.04	0.0005
/E/oral, /I/oral	134.2	111.29	0.0202
/ae/nasal, /ae/oral	**-49.85**	**118.04**	**0.3914**
/I/nasal, /I/oral	**93**	**111.29**	**0.0973**
/E/nasal, /I/nasal	**-71.2**	**111.29**	**0.1987**
/ae/nasal, /I/nasal	**88.4**	**111.29**	**0.114**
/ae/nasal, /E/oral	**47.2**	**111.29**	**0.3894**
/ae/oral, /E/oral	**97.05**	**118.04**	**0.1025**
/E/nasal, /I/oral	**21.8**	**111.29**	**0.6891**
/E/oral, /I/nasal	**41.2**	**111.29**	**0.4516**

Table 11: Speaker 1, descriptive results, Embedded List

Speaker 2			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	561.4	34.1	
/ae/oral	603.75	14.71	
/E/nasal	479.8	25.92	
/E/oral	519.6	52.86	
/I/nasal	465.2	51.43	

/I/oral	449.6	31.28	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /E/nasal	81.6	50.05	0.0026
/ae/nasal, /I/nasal	96.2	50.05	0.0006
/ae/nasal, /I/oral	111.8	50.05	0.0001
/ae/oral, /E/nasal	123.95	53.09	<.0001
/ae/oral, /E/oral	84.15	53.09	0.0033
/ae/oral, /I/nasal	138.55	53.09	<.0001
/ae/oral, /I/oral	154.15	53.09	<.0001
/E/oral, /I/nasal	54.4	50.05	0.0344
/E/oral, /I/oral	70	50.05	0.0082
/ae/nasal, /ae/oral	**-42.35**	**53.09**	**0.1125**
/E/nasal, /E/oral	**-39.8**	**50.05**	**0.1136**
/I/nasal, /I/oral	**15.6**	**50.05**	**0.5254**
/E/nasal, /I/nasal	**14.6**	**50.05**	**0.5521**
/ae/nasal, /E/oral	**41.8**	**50.05**	**0.0974**
/E/nasal, /I/oral	**30.2**	**50.05**	**0.2245**

Table 12: Speaker 2, descriptive results, Embedded List

Speaker 3			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	656.8	49.73	
/ae/oral	699.5	32.05	
/E/nasal	473.6	18.64	
/E/oral	595.2	19.34	
/I/nasal	489.8	50.84	
/I/oral	462.6	32.45	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/E/nasal, /E/oral	-121.6	47.57	<.0001
/ae/nasal, /E/nasal	183.2	47.57	<.0001
/ae/nasal, /I/nasal	167	47.57	<.0001
/ae/nasal, /E/oral	61.6	47.57	0.0134
/ae/nasal, /I/oral	194.2	47.57	<.0001
/ae/oral, /E/nasal	225.9	50.46	<.0001
/ae/oral, /E/oral	104.3	50.46	0.0003
/ae/oral, /I/nasal	209.7	50.46	<.0001
/ae/oral, /I/oral	236.9	50.46	<.0001
/E/oral, /I/nasal	105.4	47.57	0.0001
/E/oral, /I/oral	132.6	47.57	<.0001
/ae/nasal, /ae/oral	**-42.7**	**50.46**	**0.0934**

/I/nasal, /I/oral	**27.2**	**47.57**	**0.249**
/E/nasal, /I/nasal	**-16.2**	**47.57**	**0.4882**
/E/nasal, /I/oral	**11**	**47.57**	**0.6369**

Table 13: Speaker 3, descriptive results, Embedded List

Speaker 6			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	612.6	30.84	
/ae/oral	729.75	39.94	
/E/nasal	626.4	37.09	
/E/oral	670.6	44.96	
/I/nasal	622.8	14.84	
/I/oral	560	34.82	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-117.15	48.34	<.0001
/I/nasal, /I/oral	62.8	45.58	0.0091
/ae/nasal, /E/oral	-58	45.58	0.0149
/ae/nasal, /I/oral	52.6	45.58	0.0256
/ae/oral, /E/nasal	103.35	48.34	0.0002
/ae/oral, /E/oral	59.15	48.34	0.0187
/ae/oral, /I/nasal	106.95	48.34	0.0001
/ae/oral, /I/oral	169.75	48.34	<.0001
/E/nasal, /I/oral	66.4	45.58	0.0062
/E/oral, /I/nasal	47.8	45.58	0.0406
/E/oral, /I/oral	110.6	45.58	<.0001
/E/nasal, /E/oral	**-44.2**	**45.58**	**0.0567**
/ae/nasal, /E/nasal	**-13.8**	**45.58**	**0.5372**
/E/nasal, /I/nasal	**3.6**	**45.58**	**0.8716**
/ae/nasal, /I/nasal	**-10.2**	**45.58**	**0.6477**

Table 14: Speaker 6, descriptive results, Embedded List

Speaker 7			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	488.2	17.11	
/ae/oral	565.25	19.48	
/E/nasal	485.8	8.44	
/E/oral	511.8	25.68	
/I/nasal	490	12.71	
/I/oral	459	17.12	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-77.05	24.3	<.0001
/E/nasal, /E/oral	-26	22.91	0.0279
/I/nasal, /I/oral	31	22.91	0.0102
/ae/nasal, /E/oral	-23.6	22.91	0.044
/ae/nasal, /I/oral	29.2	22.91	0.0147
/ae/oral, /E/nasal	79.45	24.3	<.0001
/ae/oral, /E/oral	53.45	24.3	0.0001
/ae/oral, /I/nasal	75.25	24.3	<.0001
/ae/oral, /I/oral	106.25	24.3	<.0001
/E/nasal, /I/oral	26.8	22.91	0.0238
/E/oral, /I/oral	52.8	22.91	<.0001
/ae/nasal, /E/nasal	**2.4**	**22.91**	**0.8303**
/E/nasal, /I/nasal	**-4.2**	**22.91**	**0.708**
/ae/nasal, /I/nasal	**-1.8**	**22.91**	**0.8723**
/E/oral, /I/nasal	**21.8**	**22.91**	**0.0612**

Table 15: Speaker 7, descriptive results, Embedded List

Speaker A			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	582.67	43.8	
/ae/oral	642.83	24.25	
/E/nasal	492.17	32.82	
/E/oral	491.67	50.2	
/I/nasal	482.88	38.36	
/I/oral	444.4	50.17	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-60.17	47.71	0.0151
/ae/nasal, /E/nasal	90.5	47.71	0.0005
/ae/nasal, /I/nasal	99.79	44.63	<.0001

/ae/nasal, /E/oral	91	47.71	0.0005
/ae/nasal, /I/oral	138.27	50.04	<.0001
/ae/oral, /E/nasal	150.67	47.71	<.0001
/ae/oral, /E/oral	151.17	47.71	<.0001
/ae/oral, /I/nasal	159.96	44.63	<.0001
/ae/oral, /I/oral	198.43	50.04	<.0001
/E/nasal, /E/oral	**0.5**	**47.71**	**0.9831**
/I/nasal, /I/oral	**38.48**	**47.11**	**0.1059**
/E/nasal, /I/nasal	**9.29**	**44.63**	**0.674**
/E/nasal, /I/oral	**47.77**	**50.04**	**0.0607**
/E/oral, /I/nasal	**8.79**	**44.63**	**0.6906**
/E/oral, /I/oral	**47.27**	**50.04**	**0.0633**

Table 16: Speaker A, descriptive results, Embedded List

Speaker C			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	659	17.76	
/ae/oral	702.8	21.81	
/E/nasal	610.67	58.84	
/E/oral	608.33	35.96	
/I/nasal	586.33	46.98	
/I/oral	500	33.3	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/I/nasal, /I/oral	86.33	46.63	0.0007
/ae/nasal, /I/nasal	72.67	48.9	0.005
/ae/nasal, /E/oral	50.67	48.9	0.0428
/ae/nasal, /I/oral	159	48.9	<.0001
/ae/oral, /E/nasal	92.13	48.9	0.0006
/ae/oral, /E/oral	94.47	48.9	0.0005
/ae/oral, /I/nasal	116.47	48.9	<.0001
/ae/oral, /I/oral	202.8	48.9	<.0001
/E/nasal, /I/oral	110.67	46.63	<.0001
/E/oral, /I/oral	108.33	46.63	<.0001
/ae/nasal, /ae/oral	**-43.8**	**51.08**	**0.0899**
/E/nasal, /E/oral	**2.33**	**46.63**	**0.9191**
/ae/nasal, /E/nasal	**48.33**	**48.9**	**0.0526**
/E/nasal, /I/nasal	**24.33**	**46.63**	**0.2942**
/E/oral, /I/nasal	**22**	**46.63**	**0.3421**

Table 17: Speaker C, descriptive results, Embedded List

Speaker D			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	615.2	16.39	
/ae/oral	635	17.99	
/E/nasal	561.17	71.31	
/E/oral	559.17	26.5	
/I/nasal	532.17	46.62	
/I/oral	470.33	45.55	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/I/nasal, /I/oral	61.83	50.42	0.018
/ae/nasal, /E/nasal	54.03	52.88	0.0455
/ae/nasal, /I/nasal	83.03	52.88	0.0032
/ae/nasal, /E/oral	56.03	52.88	0.0386
/ae/nasal, /I/oral	144.87	52.88	<.0001
/ae/oral, /E/nasal	73.83	50.42	0.0056
/ae/oral, /E/oral	75.83	50.42	0.0045
/ae/oral, /I/nasal	102.83	50.42	0.0003
/ae/oral, /I/oral	164.67	50.42	<.0001
/E/nasal, /I/oral	90.83	50.42	0.0009
/E/oral, /I/oral	88.83	50.42	0.0012
/ae/nasal, /ae/oral	**-19.8**	**52.88**	**0.45**
/E/nasal, /E/oral	**2**	**50.42**	**0.9359**
/E/nasal, /I/nasal	**29**	**50.42**	**0.249**
/E/oral, /I/nasal	**27**	**50.42**	**0.2824**

Table 18: Speaker D, descriptive results, Embedded List

Speaker E			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	714.33	150.11	
/ae/oral	858	74.87	
/E/nasal	716.5	141.65	
/E/oral	741.83	37.33	
/I/nasal	575.67	18.36	
/I/oral	541.67	34.54	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-143.67	108.84	0.0114
/E/nasal, /I/nasal	140.83	108.84	0.0129
/ae/nasal, /I/nasal	138.67	108.84	0.0143
/ae/nasal, /I/oral	172.67	108.84	0.0029

/ae/oral, /E/nasal	141.5	108.84	0.0126
/ae/oral, /E/oral	116.17	108.84	0.0373
/ae/oral, /I/nasal	282.33	108.84	<.0001
/ae/oral, /I/oral	316.33	108.84	<.0001
/E/nasal, /I/oral	174.83	108.84	0.0026
/E/oral, /I/nasal	166.17	108.84	0.004
/E/oral, /I/oral	200.17	108.84	0.0007
/E/nasal, /E/oral	**-25.33**	**108.84**	**0.638**
/I/nasal, /I/oral	**34**	**108.84**	**0.5283**
/ae/nasal, /E/nasal	**-2.17**	**108.84**	**0.9678**
/ae/nasal, /E/oral	**-27.5**	**108.84**	**0.6096**

Table 19: Speaker E, descriptive results, Embedded List

Speaker G			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	475.33	40.03	
/ae/oral	521.67	19.9	
/E/nasal	444	39.03	
/E/oral	491.83	31.42	
/I/nasal	439	38.02	
/I/oral	433.17	15.84	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-46.33	37.87	0.0182
/E/nasal, /E/oral	-47.83	39.72	0.0199
/ae/nasal, /I/oral	42.17	37.87	0.0303
/ae/oral, /E/nasal	77.67	39.72	0.0004
/ae/oral, /I/nasal	82.67	36.49	<.0001
/ae/oral, /I/oral	88.5	37.87	<.0001
/E/oral, /I/nasal	52.83	36.49	0.006
/E/oral, /I/oral	58.67	37.87	0.0036
/I/nasal, /I/oral	**5.83**	**36.49**	**0.7464**
/ae/nasal, /E/nasal	**31.33**	**39.72**	**0.1177**
/E/nasal, /I/nasal	**5**	**38.41**	**0.7922**
/ae/nasal, /I/nasal	**36.33**	**36.49**	**0.051**
/ae/nasal, /E/oral	**-16.5**	**37.87**	**0.3807**
/ae/oral, /E/oral	**29.83**	**37.87**	**0.1181**
/E/nasal, /I/oral	**10.83**	**39.72**	**0.5817**

Table 20: Speaker G, descriptive results, Embedded List

Speaker H			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	527	141.17	
/ae/oral	789.67	50.92	
/E/nasal	645.83	91.26	
/E/oral	652.5	73.79	
/I/nasal	535.33	63.18	
/I/oral	491.83	50.07	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-262.67	98.56	<.0001
/ae/nasal, /E/nasal	-118.83	98.56	0.0197
/E/nasal, /I/nasal	110.5	102.28	0.0351
/ae/nasal, /E/oral	-125.5	98.56	0.0143
/ae/oral, /E/nasal	143.83	102.28	0.0074
/ae/oral, /E/oral	137.17	102.28	0.0102
/ae/oral, /I/nasal	254.33	102.28	<.0001
/ae/oral, /I/oral	297.83	102.28	<.0001
/E/nasal, /I/oral	154	102.28	0.0044
/E/oral, /I/nasal	117.17	102.28	0.0261
/E/oral, /I/oral	160.67	102.28	0.0031
/E/nasal, /E/oral	**-6.67**	**102.28**	**0.8951**
/I/nasal, /I/oral	**43.5**	**102.28**	**0.3924**
/ae/nasal, /I/nasal	**-8.33**	**98.56**	**0.8642**
/ae/nasal, /I/oral	**35.17**	**98.56**	**0.4723**

Table 21: Speaker H, descriptive results, Embedded List

Speaker I			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	468.17	17.22	
/ae/oral	648.33	22.72	
/E/nasal	523	38.26	
/E/oral	516.83	24.09	
/I/nasal	413.5	17.76	
/I/oral	397.33	24.86	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-180.17	29.64	<.0001
/ae/nasal, /E/nasal	-54.83	29.64	0.0007
/E/nasal, /I/nasal	109.5	29.64	<.0001

/ae/nasal, /I/nasal	54.67	29.64	0.0007
/ae/nasal, /E/oral	-48.67	29.64	0.0022
/ae/nasal, /I/oral	70.83	29.64	<.0001
/ae/oral, /E/nasal	125.33	29.64	<.0001
/ae/oral, /E/oral	131.5	29.64	<.0001
/ae/oral, /I/nasal	234.83	29.64	<.0001
/ae/oral, /I/oral	251	29.64	<.0001
/E/nasal, /I/oral	125.67	29.64	<.0001
/E/oral, /I/nasal	103.33	29.64	<.0001
/E/oral, /I/oral	119.5	29.64	<.0001
/E/nasal, /E/oral	**6.17**	**29.64**	**0.6739**
/I/nasal, /I/oral	**16.17**	**29.64**	**0.2741**

Table 22: Speaker I, descriptive results, Embedded List

Speaker K			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	591.43	77.64	
/ae/oral	793	49.98	
/E/nasal	574.17	107.14	
/E/oral	617.83	22.05	
/I/nasal	592.5	70.15	
/I/oral	514.33	145.78	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-201.57	106.25	0.0005
/ae/oral, /E/nasal	218.83	109.88	0.0003
/ae/oral, /E/oral	175.17	109.88	0.0028
/ae/oral, /I/nasal	200.5	109.88	0.0008
/ae/oral, /I/oral	278.67	109.88	<.0001
/E/nasal, /E/oral	**-43.67**	**104.77**	**0.4014**
/I/nasal, /I/oral	**78.17**	**104.77**	**0.138**
/ae/nasal, /E/nasal	**17.26**	**100.96**	**0.7294**
/E/nasal, /I/nasal	**-18.33**	**104.77**	**0.7233**
/ae/nasal, /I/nasal	**-1.07**	**100.96**	**0.9829**
/ae/nasal, /E/oral	**-26.4**	**100.96**	**0.5972**
/ae/nasal, /I/oral	**77.1**	**100.96**	**0.1293**
/E/nasal, /I/oral	**59.83**	**104.77**	**0.2527**
/E/oral, /I/nasal	**25.33**	**104.77**	**0.625**
/E/oral, /I/oral	**103.5**	**104.77**	**0.0527**

Table 23: Speaker K, descriptive results, Embedded List

Speaker L			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	616.67	29.76	
/ae/oral	626.33	36.41	
/E/nasal	494.17	36.23	
/E/oral	503.5	19.5	
/I/nasal	494	16.33	
/I/oral	418.4	20.31	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/I/nasal, /I/oral	75.6	34.5	0.0001
/ae/nasal, /E/nasal	122.5	32.89	<.0001
/ae/nasal, /I/nasal	122.67	32.89	<.0001
/ae/nasal, /E/oral	113.17	32.89	<.0001
/ae/nasal, /I/oral	198.27	34.5	<.0001
/ae/oral, /E/nasal	132.17	32.89	<.0001
/ae/oral, /E/oral	122.83	32.89	<.0001
/ae/oral, /I/nasal	132.33	32.89	<.0001
/ae/oral, /I/oral	207.93	34.5	<.0001
/E/nasal, /I/oral	75.77	34.5	0.0001
/E/oral, /I/oral	85.1	34.5	<.0001
/ae/nasal, /ae/oral	**-9.67**	**32.89**	**0.5525**
/E/nasal, /E/oral	**-9.33**	**32.89**	**0.5662**
/E/nasal, /I/nasal	**0.17**	**32.89**	**0.9918**
/E/oral, /I/nasal	**9.5**	**32.89**	**0.5593**

Table 24: Speaker L, descriptive results, Embedded List

Speaker M			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	741.5	91.85	
/ae/oral	821.67	82.09	
/E/nasal	698	158.08	
/E/oral	692.5	56.32	
/I/nasal	599.25	143.67	
/I/oral	513.8	35.9	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /I/oral	227.7	139	0.0025
/ae/oral, /E/oral	129.17	119.63	0.0355
/ae/oral, /I/nasal	222.42	133.75	0.0022
/ae/oral, /I/oral	307.87	125.47	<.0001

/E/nasal, /I/oral	184.2	131.05	0.0078
/E/oral, /I/oral	178.7	125.47	0.0072
/ae/nasal, /ae/oral	**-80.17**	**133.75**	**0.228**
/E/nasal, /E/oral	**5.5**	**125.47**	**0.9287**
/I/nasal, /I/oral	**85.45**	**139**	**0.2167**
/ae/nasal, /E/nasal	**43.5**	**139**	**0.5245**
/E/nasal, /I/nasal	**98.75**	**139**	**0.1556**
/ae/nasal, /I/nasal	**142.25**	**146.52**	**0.0565**
/ae/nasal, /E/oral	**49**	**133.75**	**0.4569**
/ae/oral, /E/nasal	**123.67**	**125.47**	**0.0531**
/E/oral, /I/nasal	**93.25**	**133.75**	**0.1631**

Table 25: Speaker M, descriptive results, Embedded List

Speaker O			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	551	37.8	
/ae/oral	711.83	19.81	
/E/nasal	521.6	66.28	
/E/oral	584.2	16.19	
/I/nasal	514.5	51.35	
/I/oral	464.75	24.68	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-160.83	48.12	<.0001
/E/nasal, /E/oral	-62.6	52.71	0.0218
/ae/nasal, /I/oral	86.25	53.8	0.0028
/ae/oral, /E/nasal	190.23	50.46	<.0001
/ae/oral, /E/oral	127.63	50.46	<.0001
/ae/oral, /I/nasal	197.33	48.12	<.0001
/ae/oral, /I/oral	247.08	53.8	<.0001
/E/nasal, /I/oral	56.85	55.91	0.0465
/E/oral, /I/nasal	69.7	50.46	0.0087
/E/oral, /I/oral	119.45	55.91	0.0002
/I/nasal, /I/oral	**49.75**	**53.8**	**0.0684**
/ae/nasal, /E/nasal	**29.4**	**50.46**	**0.2419**
/E/nasal, /I/nasal	**7.1**	**50.46**	**0.7747**
/ae/nasal, /I/nasal	**36.5**	**48.12**	**0.131**
/ae/nasal, /E/oral	**-33.2**	**50.46**	**0.1879**

Table 26: Speaker O, descriptive results, Embedded List

Speaker P			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	738.33	80.98	
/ae/oral	775.17	67.42	
/E/nasal	720.83	82.15	
/E/oral	613.67	40.11	
/I/nasal	707.17	145.21	
/I/oral	502.33	25.67	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/E/nasal, /E/oral	107.17	97.72	0.0327
/I/nasal, /I/oral	204.83	97.72	0.0002
/ae/nasal, /E/oral	124.67	97.72	0.0141
/ae/nasal, /I/oral	236	97.72	<.0001
/ae/oral, /E/oral	161.5	97.72	0.0021
/ae/oral, /I/oral	272.83	97.72	<.0001
/E/nasal, /I/oral	218.5	97.72	<.0001
/E/oral, /I/oral	111.33	97.72	0.0269
/ae/nasal, /ae/oral	**-36.83**	**97.72**	**0.4474**
/ae/nasal, /E/nasal	**17.5**	**97.72**	**0.7171**
/E/nasal, /I/nasal	**13.67**	**97.72**	**0.7771**
/ae/nasal, /I/nasal	**31.17**	**97.72**	**0.5198**
/ae/oral, /E/nasal	**54.33**	**97.72**	**0.2651**
/ae/oral, /I/nasal	**68**	**97.72**	**0.1656**
/E/oral, /I/nasal	**-93.5**	**97.72**	**0.0601**

Table 27: Speaker P, descriptive results, Embedded List

Speaker Q			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	620.2	32.16	
/ae/oral	672.6	23.56	
/E/nasal	559.5	37.56	
/E/oral	576.2	33.98	
/I/nasal	539.67	71.2	
/I/oral	496.17	26.07	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /E/nasal	60.7	51.71	0.0231
/ae/nasal, /I/nasal	80.53	51.71	0.0035
/ae/nasal, /I/oral	124.03	51.71	<.0001

/ae/oral, /E/nasal	113.1	51.71	0.0001
/ae/oral, /E/oral	96.4	54.01	0.0011
/ae/oral, /I/nasal	132.93	51.71	<.0001
/ae/oral, /I/oral	176.43	51.71	<.0001
/E/nasal, /I/oral	63.33	49.31	0.0138
/E/oral, /I/oral	80.03	51.71	0.0037
/ae/nasal, /ae/oral	**-52.4**	**54.01**	**0.0567**
/E/nasal, /E/oral	**-16.7**	**51.71**	**0.5132**
/I/nasal, /I/oral	**43.5**	**49.31**	**0.0814**
/E/nasal, /I/nasal	**19.83**	**49.31**	**0.4164**
/ae/nasal, /E/oral	**44**	**54.01**	**0.1062**
/E/oral, /I/nasal	**36.53**	**51.71**	**0.1587**

Table 28: Speaker Q, descriptive results, Embedded List

D.2. Minimal Triplets Data

Speaker 0			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	510	36.939	
/ae/oral	683.5	20.567	
/E/nasal	518.4	64.458	
/E/oral	597	24.927	
/I/nasal	490	28.601	
/I/oral	451.6	15.773	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-173.5	51.536	<.0001
/ae/nasal, /E/nasal	**-8.4**	**48.589**	**0.7228**
/ae/nasal, /E/oral	-87	51.536	0.0021
/ae/nasal, /I/nasal	**20**	**51.536**	**0.4287**
/ae/nasal, /I/oral	58.4	48.589	0.0208
/ae/oral, /E/nasal	165.1	51.536	<.0001
/ae/oral, /E/oral	86.5	54.324	0.0033
/ae/oral, /I/nasal	193.5	54.324	<.0001
/ae/oral, /I/oral	231.9	51.536	<.0001
/E/nasal, /E/oral	-78.6	51.536	0.0046
/E/nasal, /I/nasal	**28.4**	**51.536**	**0.2647**
/E/nasal, /I/oral	66.8	48.589	0.0094
/E/oral, /I/nasal	107	54.324	0.0005
/E/oral, /I/oral	145.4	51.536	<.0001
/I/nasal, /I/oral	**38.4**	**51.536**	**0.1362**

Table 29: Speaker 0, descriptive results, Minimal Triplets

Speaker 1			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	738.4	103.21	
/ae/oral	672.75	51.253	
/E/nasal	572.4	89.857	
/E/oral	537.4	16.517	
/I/nasal	595.8	81.26	
/I/oral	440	55.444	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	**65.65**	**101.31**	**0.1932**
/ae/nasal, /E/nasal	166	95.516	0.0015
/ae/nasal, /E/oral	201	95.516	0.0002
/ae/nasal, /I/nasal	142.6	95.516	0.0052
/ae/nasal, /I/oral	298.4	95.516	<.0001
/ae/oral, /E/nasal	**100.35**	**101.31**	**0.052**
/ae/oral, /E/oral	135.35	101.31	0.0111
/ae/oral, /I/nasal	**76.95**	**101.31**	**0.1298**
/ae/oral, /I/oral	232.75	101.31	<.0001
/E/nasal, /E/oral	**35**	**95.516**	**0.4561**
/E/nasal, /I/nasal	**-23.4**	**95.516**	**0.6171**
/E/nasal, /I/oral	132.4	95.516	0.0087
/E/oral, /I/nasal	**-58.4**	**95.516**	**0.2186**
/E/oral, /I/oral	97.4	95.516	0.046
/I/nasal, /I/oral	155.8	95.516	0.0026

Table 30: Speaker 1, descriptive results, Minimal Triplets

Speaker 2			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	541	33.682	
/ae/oral	632.75	27.969	
/E/nasal	488	22.825	
/E/oral	543.5	31.459	
/I/nasal	527.6	47.6	
/I/oral	447	10.368	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-91.75	43.421	0.0002
/ae/nasal, /E/nasal	53	40.938	0.0135
/ae/nasal, /E/oral	**-2.5**	**43.421**	**0.906**

/ae/nasal, /I/nasal	**13.4**	**40.938**	**0.5043**
/ae/nasal, /I/oral	94	40.938	<.0001
/ae/oral, /E/nasal	144.75	43.421	<.0001
/ae/oral, /E/oral	89.25	45.77	0.0005
/ae/oral, /I/nasal	105.15	43.421	<.0001
/ae/oral, /I/oral	185.75	43.421	<.0001
/E/nasal, /E/oral	-55.5	43.421	0.0146
/E/nasal, /I/nasal	**-39.6**	**40.938**	**0.0573**
/E/nasal, /I/oral	41	40.938	0.0497
/E/oral, /I/nasal	**15.9**	**43.421**	**0.4557**
/E/oral, /I/oral	96.5	43.421	0.0001
/I/nasal, /I/oral	80.6	40.938	0.0005

Table 31: Speaker 2, descriptive results, Minimal Triplets

Speaker 3			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	647.2	48.122	
/ae/oral	726.25	51.97	
/E/nasal	497.8	46.494	
/E/oral	627	27.722	
/I/nasal	512.4	82.917	
/I/oral	460.6	32.731	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-79.05	71.391	0.0315
/ae/nasal, /E/nasal	149.4	67.308	0.0001
/ae/nasal, /E/oral	**20.2**	**67.308**	**0.5408**
/ae/nasal, /I/nasal	134.8	67.308	0.0004
/ae/nasal, /I/oral	186.6	67.308	<.0001
/ae/oral, /E/nasal	228.45	71.391	<.0001
/ae/oral, /E/oral	99.25	71.391	0.0085
/ae/oral, /I/nasal	213.85	71.391	<.0001
/ae/oral, /I/oral	265.65	71.391	<.0001
/E/nasal, /E/oral	-129.2	67.308	0.0006
/E/nasal, /I/nasal	**-14.6**	**67.308**	**0.6578**
/E/nasal, /I/oral	**37.2**	**67.308**	**0.2647**
/E/oral, /I/nasal	114.6	67.308	0.0018
/E/oral, /I/oral	166.4	67.308	<.0001
/I/nasal, /I/oral	**51.8**	**67.308**	**0.125**

Table 32: Speaker 3, descriptive results, Minimal Triplets

Speaker 5			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	817	110.894	
/ae/oral	834.5	100.792	
/E/nasal	587.6	129.284	
/E/oral	684.2	64.364	
/I/nasal	376.333	38.004	
/I/oral	424.6	9.397	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	**-17.5**	**116.753**	**0.7597**
/ae/nasal, /E/nasal	229.4	110.076	0.0002
/ae/nasal, /E/oral	132.8	110.076	0.0201
/ae/nasal, /I/nasal	440.667	105.389	<.0001
/ae/nasal, /I/oral	392.4	110.076	<.0001
/ae/oral, /E/nasal	246.9	116.753	0.0002
/ae/oral, /E/oral	150.3	116.753	0.0138
/ae/oral, /I/nasal	458.167	112.345	<.0001
/ae/oral, /I/oral	409.9	116.753	<.0001
/E/nasal, /E/oral	**-96.6**	**110.076**	**0.0826**
/E/nasal, /I/nasal	211.267	105.389	0.0004
/E/nasal, /I/oral	163	110.076	0.0054
/E/oral, /I/nasal	307.867	105.389	<.0001
/E/oral, /I/oral	259.6	110.076	<.0001
/I/nasal, /I/oral	**-48.267**	**105.389**	**0.354**

Table 33: Speaker 5, descriptive results, Minimal Triplets

Speaker 6			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	633.2	15.897	
/ae/oral	942.75	151.911	
/E/nasal	637.2	11.323	
/E/oral	674.6	60.418	
/I/nasal	638.8	25.352	
/I/oral	573.8	55.908	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-309.55	91.698	<.0001
/ae/nasal, /E/nasal	**-4**	**86.454**	**0.9246**
/ae/nasal, /E/oral	**-41.4**	**86.454**	**0.3322**

/ae/nasal, /I/nasal	**-5.6**	**86.454**	**0.8946**
/ae/nasal, /I/oral	**59.4**	**86.454**	**0.1686**
/ae/oral, /E/nasal	305.55	91.698	<.0001
/ae/oral, /E/oral	268.15	91.698	<.0001
/ae/oral, /I/nasal	303.95	91.698	<.0001
/ae/oral, /I/oral	368.95	91.698	<.0001
/E/nasal, /E/oral	**-37.4**	**86.454**	**0.3801**
/E/nasal, /I/nasal	**-1.6**	**86.454**	**0.9698**
/E/nasal, /I/oral	**63.4**	**86.454**	**0.1429**
/E/oral, /I/nasal	**35.8**	**86.454**	**0.4005**
/E/oral, /I/oral	100.8	86.454	0.0242
/I/nasal, /I/oral	**65**	**86.454**	**0.1335**

Table 34: Speaker 6, descriptive results, Minimal Triplets

Speaker 7			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	507.6	23.891	
/ae/oral	607.75	32.827	
/E/nasal	498.2	19.486	
/E/oral	504.2	26.129	
/I/nasal	484.6	18.555	
/I/oral	442.8	21.959	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-100.15	33.082	<.0001
/ae/nasal, /E/nasal	**9.4**	**31.19**	**0.5391**
/ae/nasal, /E/oral	**3.4**	**31.19**	**0.8236**
/ae/nasal, /I/nasal	**23**	**31.19**	**0.1408**
/ae/nasal, /I/oral	64.8	31.19	0.0003
/ae/oral, /E/nasal	109.55	33.082	<.0001
/ae/oral, /E/oral	103.55	33.082	<.0001
/ae/oral, /I/nasal	123.15	33.082	<.0001
/ae/oral, /I/oral	164.95	33.082	<.0001
/E/nasal, /E/oral	**-6**	**31.19**	**0.6943**
/E/nasal, /I/nasal	**13.6**	**31.19**	**0.3764**
/E/nasal, /I/oral	55.4	31.19	0.0013
/E/oral, /I/nasal	**19.6**	**31.19**	**0.2065**
/E/oral, /I/oral	61.4	31.19	0.0005
/I/nasal, /I/oral	41.8	31.19	0.0108

Table 35: Speaker 7, descriptive results, Minimal Triplets

Speaker A			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	608	36.354	
/ae/oral	625.667	20.285	
/E/nasal	515.167	53.286	
/E/oral	467.667	45.35	
/I/nasal	524	63.223	
/I/oral	412	44.331	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	**-17.667**	**54.015**	**0.5093**
/ae/nasal, /E/nasal	92.833	54.015	0.0014
/ae/nasal, /E/oral	140.333	54.015	<.0001
/ae/nasal, /I/nasal	84	54.015	0.0034
/ae/nasal, /I/oral	196	54.015	<.0001
/ae/oral, /E/nasal	110.5	54.015	0.0002
/ae/oral, /E/oral	158	54.015	<.0001
/ae/oral, /I/nasal	101.667	54.015	0.0006
/ae/oral, /I/oral	213.667	54.015	<.0001
/E/nasal, /E/oral	**47.5**	**54.015**	**0.0826**
/E/nasal, /I/nasal	**-8.833**	**54.015**	**0.7407**
/E/nasal, /I/oral	103.167	54.015	0.0005
/E/oral, /I/nasal	-56.333	54.015	0.0415
/E/oral, /I/oral	55.667	54.015	0.0438
/I/nasal, /I/oral	112	54.015	0.0002

Table 36: Speaker A, descriptive results, Minimal Triplets

Speaker C			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	697	17.879	
/ae/oral	716.833	39.214	
/E/nasal	605	73.675	
/E/oral	567.833	35.779	
/I/nasal	578	21.643	
/I/oral	500	43.772	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	**-19.833**	**47.824**	**0.4041**
/ae/nasal, /E/nasal	92	47.824	0.0005
/ae/nasal, /E/oral	129.167	47.824	<.0001
/ae/nasal, /I/nasal	119	47.824	<.0001

/ae/nasal, /I/oral	197	47.824	<.0001
/ae/oral, /E/nasal	111.833	49.63	<.0001
/ae/oral, /E/oral	149	49.63	<.0001
/ae/oral, /I/nasal	138.833	49.63	<.0001
/ae/oral, /I/oral	216.833	49.63	<.0001
/E/nasal, /E/oral	**37.167**	**49.63**	**0.1368**
/E/nasal, /I/nasal	**27**	**49.63**	**0.2757**
/E/nasal, /I/oral	105	49.63	0.0002
/E/oral, /I/nasal	**-10.167**	**49.63**	**0.679**
/E/oral, /I/oral	67.833	49.63	0.009
/I/nasal, /I/oral	78	49.63	0.0031

Table 37: Speaker C, descriptive results, Minimal Triplets

Speaker D			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	647.167	38.825	
/ae/oral	640.333	28.296	
/E/nasal	639.667	64.822	
/E/oral	573.833	36.428	
/I/nasal	540.333	94.657	
/I/oral	475.667	34.343	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	**6.833**	**64.54**	**0.8303**
/ae/nasal, /E/nasal	**7.5**	**64.54**	**0.814**
/ae/nasal, /E/oral	73.333	64.54	0.0273
/ae/nasal, /I/nasal	106.833	64.54	0.002
/ae/nasal, /I/oral	171.5	64.54	<.0001
/ae/oral, /E/nasal	**0.667**	**64.54**	**0.9833**
/ae/oral, /E/oral	66.5	64.54	0.0438
/ae/oral, /I/nasal	100	64.54	0.0035
/ae/oral, /I/oral	164.667	64.54	<.0001
/E/nasal, /E/oral	65.833	64.54	0.0459
/E/nasal, /I/nasal	99.333	64.54	0.0037
/E/nasal, /I/oral	164	64.54	<.0001
/E/oral, /I/nasal	**33.5**	**64.54**	**0.2976**
/E/oral, /I/oral	98.167	64.54	0.0041
/I/nasal, /I/oral	64.667	64.54	0.0496

Table 38: Speaker D, descriptive results, Minimal Triplets

Speaker E			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	665	126.521	
/ae/oral	786	93.102	
/E/nasal	726.167	79.174	
/E/oral	724.167	28.407	
/I/nasal	567.833	74.922	
/I/oral	541.667	47.374	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-121	95.802	0.015
/ae/nasal, /E/nasal	**-61.167**	**95.802**	**0.2022**
/ae/nasal, /E/oral	**-59.167**	**95.802**	**0.2169**
/ae/nasal, /I/nasal	97.167	95.802	0.047
/ae/nasal, /I/oral	123.333	95.802	0.0134
/ae/oral, /E/nasal	**59.833**	**95.802**	**0.2119**
/ae/oral, /E/oral	**61.833**	**95.802**	**0.1974**
/ae/oral, /I/nasal	218.167	95.802	<.0001
/ae/oral, /I/oral	244.333	95.802	<.0001
/E/nasal, /E/oral	**2**	**95.802**	**0.9663**
/E/nasal, /I/nasal	158.333	95.802	0.0021
/E/nasal, /I/oral	184.5	95.802	0.0005
/E/oral, /I/nasal	156.333	95.802	0.0023
/E/oral, /I/oral	182.5	95.802	0.0005
/I/nasal, /I/oral	**26.167**	**95.802**	**0.5811**

Table 39: Speaker E, descriptive results, Minimal Triplets

Speaker G			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	546.667	20.422	
/ae/oral	578	32.601	
/E/nasal	510.167	61.294	
/E/oral	503.167	49.155	
/I/nasal	481.167	31.359	
/I/oral	438.167	15.677	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	**-31.333**	**45.367**	**0.1687**
/ae/nasal, /E/nasal	**36.5**	**45.367**	**0.1108**
/ae/nasal, /E/oral	**43.5**	**45.367**	**0.0596**

/ae/nasal, /I/nasal	65.5	45.367	0.0061
/ae/nasal, /I/oral	108.5	45.367	<.0001
/ae/oral, /E/nasal	67.833	45.367	0.0047
/ae/oral, /E/oral	74.833	45.367	0.0021
/ae/oral, /I/nasal	96.833	45.367	0.0001
/ae/oral, /I/oral	139.833	45.367	<.0001
/E/nasal, /E/oral	**7**	**45.367**	**0.7549**
/E/nasal, /I/nasal	**29**	**45.367**	**0.2016**
/E/nasal, /I/oral	72	45.367	0.0029
/E/oral, /I/nasal	**22**	**45.367**	**0.3299**
/E/oral, /I/oral	65	45.367	0.0065
/I/nasal, /I/oral	**43**	**45.367**	**0.0624**

Table 40: Speaker G, descriptive results, Minimal Triplets

Speaker H			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	495.429	55.214	
/ae/oral	780.833	34.574	
/E/nasal	636.667	58.753	
/E/oral	693.25	66.51	
/I/nasal	529.571	88.739	
/I/oral	477	27.58	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-285.405	67.31	<.0001
/ae/nasal, /E/nasal	-141.238	67.31	0.0001
/ae/nasal, /E/oral	-197.821	62.615	<.0001
/ae/nasal, /I/nasal	**-34.143**	**64.669**	**0.2911**
/ae/nasal, /I/oral	**18.429**	**64.669**	**0.5666**
/ae/oral, /E/nasal	144.167	69.85	0.0002
/ae/oral, /E/oral	87.583	65.339	0.0101
/ae/oral, /I/nasal	251.262	67.31	<.0001
/ae/oral, /I/oral	303.833	67.31	<.0001
/E/nasal, /E/oral	**-56.583**	**65.339**	**0.0875**
/E/nasal, /I/nasal	107.095	67.31	0.0027
/E/nasal, /I/oral	159.667	67.31	<.0001
/E/oral, /I/nasal	163.679	62.615	<.0001
/E/oral, /I/oral	216.25	62.615	<.0001
/I/nasal, /I/oral	**52.571**	**64.669**	**0.1078**

Table 41: Speaker H, descriptive results, Minimal Triplets

Speaker I			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	469.167	111.537	
/ae/oral	710	30.588	
/E/nasal	640.167	103.349	
/E/oral	550.667	39.632	
/I/nasal	416	31.95	
/I/oral	404.833	14.511	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-240.833	78.89	<.0001
/ae/nasal, /E/nasal	-171	78.89	0.0001
/ae/nasal, /E/oral	-81.5	78.89	0.0433
/ae/nasal, /I/nasal	**53.167**	**78.89**	**0.1789**
/ae/nasal, /I/oral	**64.333**	**78.89**	**0.1062**
/ae/oral, /E/nasal	**69.833**	**78.89**	**0.0807**
/ae/oral, /E/oral	159.333	78.89	0.0003
/ae/oral, /I/nasal	294	78.89	<.0001
/ae/oral, /I/oral	305.167	78.89	<.0001
/E/nasal, /E/oral	89.5	78.89	0.0275
/E/nasal, /I/nasal	224.167	78.89	<.0001
/E/nasal, /I/oral	235.333	78.89	<.0001
/E/oral, /I/nasal	134.667	78.89	0.0015
/E/oral, /I/oral	145.833	78.89	0.0007
/I/nasal, /I/oral	**11.167**	**78.89**	**0.7745**

Table 42: Speaker I, descriptive results, Minimal Triplets

Speaker K			
Vowel allophone	**Mean**	**Std. Dev.**	
/ae/nasal	586.333	85.897	
/ae/oral	765.571	54.927	
/E/nasal	469.667	53.501	
/E/oral	593.333	64.086	
/I/nasal	537.833	114.629	
/I/oral	527	107.177	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-179.238	96.488	0.0007
/ae/nasal, /E/nasal	**116.667**	**122.634**	**0.0614**
/ae/nasal, /E/oral	**-7**	**100.13**	**0.887**
/ae/nasal, /I/nasal	**48.5**	**100.13**	**0.3291**

/ae/nasal, /I/oral	**59.333**	**105.017**	**0.2565**
/ae/oral, /E/nasal	295.905	119.678	<.0001
/ae/oral, /E/oral	172.238	96.488	0.0011
/ae/oral, /I/nasal	227.738	96.488	<.0001
/ae/oral, /I/oral	238.571	101.551	<.0001
/E/nasal, /E/oral	-123.667	122.634	0.0482
/E/nasal, /I/nasal	**-68.167**	**122.634**	**0.2641**
/E/nasal, /I/oral	**-57.333**	**126.656**	**0.3612**
/E/oral, /I/nasal	**55.5**	**100.13**	**0.2654**
/E/oral, /I/oral	**66.333**	**105.017**	**0.2059**
/I/nasal, /I/oral	**10.833**	**105.017**	**0.834**

Table 43: Speaker K, descriptive results, Minimal Triplets

Speaker L			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	684.6	42.788	
/ae/oral	639.6	31.856	
/E/nasal	480.667	39.998	
/E/oral	469	17.397	
/I/nasal	507	37.101	
/I/oral	389.4	23.234	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	45	44.549	0.0479
/ae/nasal, /E/nasal	203.933	42.653	<.0001
/ae/nasal, /E/oral	215.6	47.252	<.0001
/ae/nasal, /I/nasal	177.6	44.549	<.0001
/ae/nasal, /I/oral	295.2	44.549	<.0001
/ae/oral, /E/nasal	158.933	42.653	<.0001
/ae/oral, /E/oral	170.6	47.252	<.0001
/ae/oral, /I/nasal	132.6	44.549	<.0001
/ae/oral, /I/oral	250.2	44.549	<.0001
/E/nasal, /E/oral	**11.667**	**45.468**	**0.6013**
/E/nasal, /I/nasal	**-26.333**	**42.653**	**0.2148**
/E/nasal, /I/oral	91.267	42.653	0.0002
/E/oral, /I/nasal	**-38**	**47.252**	**0.11**
/E/oral, /I/oral	79.6	47.252	0.002
/I/nasal, /I/oral	117.6	44.549	<.0001

Table 44: Speaker L, descriptive results, Minimal Triplets

Speaker M			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	684	76.047	
/ae/oral	795	45.107	
/E/nasal	566.8	113.663	
/E/oral	659.143	57.153	
/I/nasal	612.167	65.938	
/I/oral	489.333	37.898	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-111	91.885	0.0197
/ae/nasal, /E/nasal	117.2	86.196	0.0095
/ae/nasal, /E/oral	**24.857**	**79.195**	**0.5255**
/ae/nasal, /I/nasal	**71.833**	**82.185**	**0.0842**
/ae/nasal, /I/oral	194.667	82.185	<.0001
/ae/oral, /E/nasal	228.2	95.49	<.0001
/ae/oral, /E/oral	135.857	89.221	0.0042
/ae/oral, /I/nasal	182.833	91.885	0.0003
/ae/oral, /I/oral	305.667	91.885	<.0001
/E/nasal, /E/oral	-92.343	83.35	0.0311
/E/nasal, /I/nasal	**-45.367**	**86.196**	**0.2902**
/E/nasal, /I/oral	**77.467**	**86.196**	**0.0762**
/E/oral, /I/nasal	**46.976**	**79.195**	**0.2345**
/E/oral, /I/oral	169.81	79.195	0.0001
/I/nasal, /I/oral	122.833	82.185	0.0048

Table 45: Speaker M, descriptive results, Minimal Triplets

Speaker O			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	541.833	60.174	
/ae/oral	697.167	23.173	
/E/nasal	557.167	85.378	
/E/oral	585.333	30.349	
/I/nasal	537.333	69.2	
/I/oral	433.333	19.273	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-155.333	63.731	<.0001
/ae/nasal, /E/nasal	**-15.333**	**63.731**	**0.6267**
/ae/nasal, /E/oral	**-43.5**	**63.731**	**0.1736**

/ae/nasal, /I/nasal	**4.5**	**63.731**	**0.8863**
/ae/nasal, /I/oral	108.5	63.731	0.0016
/ae/oral, /E/nasal	140	63.731	<.0001
/ae/oral, /E/oral	111.833	63.731	0.0012
/ae/oral, /I/nasal	159.833	63.731	<.0001
/ae/oral, /I/oral	263.833	63.731	<.0001
/E/nasal, /E/oral	**-28.167**	**63.731**	**0.3739**
/E/nasal, /I/nasal	**19.833**	**63.731**	**0.5299**
/E/nasal, /I/oral	123.833	63.731	0.0004
/E/oral, /I/nasal	**48**	**63.731**	**0.1345**
/E/oral, /I/oral	152	63.731	<.0001
/I/nasal, /I/oral	104	63.731	0.0023

Table 46: Speaker O, descriptive results, Minimal Triplets

Speaker P			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	701.667	48.903	
/ae/oral	776.833	93.247	
/E/nasal	658	42.346	
/E/oral	612.167	59.654	
/I/nasal	625.667	62.317	
/I/oral	515.333	10.746	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-75.167	68.816	0.0333
/ae/nasal, /E/nasal	**43.667**	**68.816**	**0.2049**
/ae/nasal, /E/oral	89.5	68.816	0.0125
/ae/nasal, /I/nasal	76	68.816	0.0316
/ae/nasal, /I/oral	186.333	68.816	<.0001
/ae/oral, /E/nasal	118.833	68.816	0.0014
/ae/oral, /E/oral	164.667	68.816	<.0001
/ae/oral, /I/nasal	151.167	68.816	<.0001
/ae/oral, /I/oral	261.5	68.816	<.0001
/E/nasal, /E/oral	**45.833**	**68.816**	**0.1839**
/E/nasal, /I/nasal	**32.333**	**68.816**	**0.3449**
/E/nasal, /I/oral	142.667	68.816	0.0002
/E/oral, /I/nasal	**-13.5**	**68.816**	**0.6915**
/E/oral, /I/oral	96.833	68.816	0.0074
/I/nasal, /I/oral	110.333	68.816	0.0027

Table 47: Speaker P, descriptive results, Minimal Triplets

Speaker Q			
Vowel allophone	**Mean**	**S.D.**	
/ae/nasal	625	15.126	
/ae/oral	677.833	36.013	
/E/nasal	617.333	29.951	
/E/oral	607.667	13.064	
/I/nasal	603.5	19.542	
/I/oral	508.167	12.465	
Fisher's PLSD comparisons	**Mean Diff.**	**Crit. Diff.**	**P-Value**
/ae/nasal, /ae/oral	-52.833	26.934	0.0004
/ae/nasal, /E/nasal	**7.667**	**26.934**	**0.5654**
/ae/nasal, /E/oral	**17.333**	**26.934**	**0.1987**
/ae/nasal, /I/nasal	**21.5**	**26.934**	**0.1135**
/ae/nasal, /I/oral	116.833	26.934	<.0001
/ae/oral, /E/nasal	60.5	26.934	<.0001
/ae/oral, /E/oral	70.167	26.934	<.0001
/ae/oral, /I/nasal	74.333	26.934	<.0001
/ae/oral, /I/oral	169.667	26.934	<.0001
/E/nasal, /E/oral	**9.667**	**26.934**	**0.4693**
/E/nasal, /I/nasal	**13.833**	**26.934**	**0.3026**
/E/nasal, /I/oral	109.167	26.934	<.0001
/E/oral, /I/nasal	**4.167**	**26.934**	**0.7542**
/E/oral, /I/oral	99.5	26.934	<.0001
/I/nasal, /I/oral	95.333	26.934	<.0001

Table 48: Speaker Q, descriptive results, Minimal Triplets

Appendix E. Vowel Graphs Not Presented in the Main Body

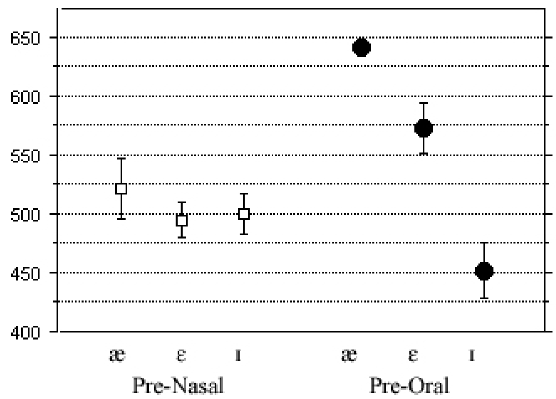

Figure E1: Speaker 0, Embedded List

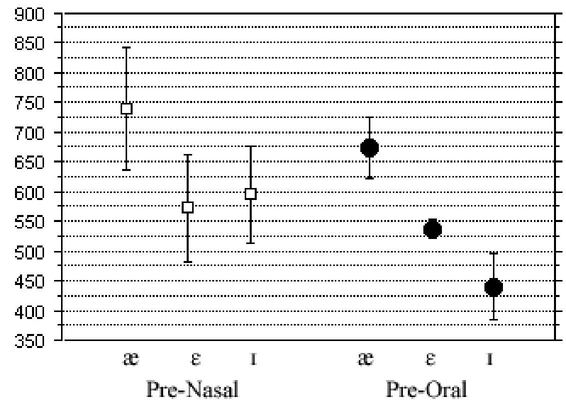

Figure E2: Speaker 1, Minimal Triplets

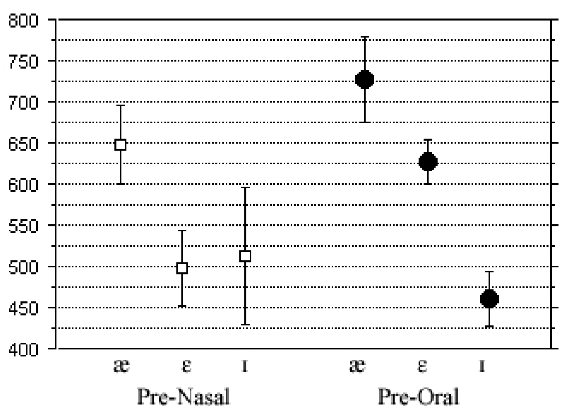

Figure E3: Speaker 3, Minimal Triplets

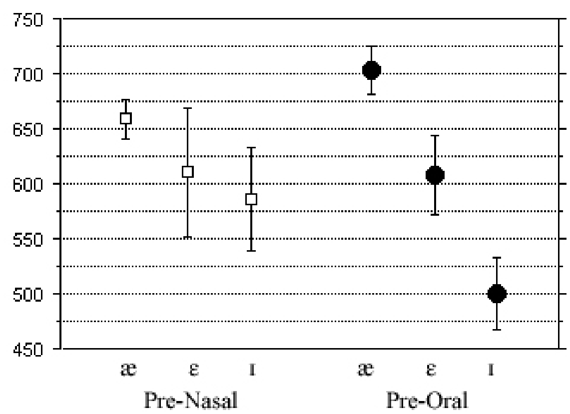

Figure E4: Speaker C, Embedded List

Note that all of these graphs show a Type-A merger. The graphs presented in Appendix E for Speaker 0 and Speaker 1 are mentioned in the discussion, above. Speaker C also shows a Type-A merger, though not as clearly as in her Minimal Triplets. Finally, Speaker 3's Minimal Triplets data were not reproduced in the body, though they are very similar to her Embedded List data.

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