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Vowel Duration in Three American English Dialects

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Abstract

The article reports on an acoustic investigation into the duration of five American English vowels, those found in *hid*, *head*, *had*, *hayed*, and *hide*. We compare duration across three major dialect areas: the Inland North, Midlands, and South. The results show systematic differences across all vowels studied, with the longest durations in the South and the shortest in the Inland North, with the Midlands in an intermediate but distinct position. More generally, the sample differs from and complements other work on this question by including detailed evidence from relatively small, cohesive areas, each within a different established dialect region.

Given the massive body of research on regional and social variation in American English vowels, it is surprising to find a large gap in research on an issue as basic as durational differences. Indeed, duration is the normal starting point for work on vowels in phonetics and speech science, yet in sociolinguistics and dialectology this factor is often still not treated directly in even the most encyclopedic and recent research (see, e.g., Labov, Ash, and Boberg 2006, 36). The present article reports acoustic results from a detailed study of three regions of contemporary American English: westernmost North Carolina (at the heart of the Southern Shift area), central Ohio (Midlands), and south-central and southeastern Wisconsin (Inland North). The results show consistent differences in the length of five vowels within each of these dialects.

In the first section, we review the most relevant work done to date on durational differences across American dialects. The second section presents the method and design of our study, while the third presents the results and analysis. The discussion situates our findings in the context of previous research on the topic. We then note how the regional sampling design employed here complements other current approaches, in particular broader but shallower surveys, and we close with a word on the position of the Midlands among American dialects.

Background

Thomas (2002, 172) provides a succinct summary of the state of the art on acoustic analysis of American English vowels:

> Since the appearance of Labov [Yaeger, and Steiner] (1972), acoustic inquiry into vowel variation and change has grown at a healthy pace…. Virtually all of this inquiry has focused on comparisons of F1 and F2 values. Other components of vowels have received almost no attention from sociolinguists.

While he goes on to note that a few studies "have examined vocalic duration," this has not changed significantly since his words were published. Furthermore, most of those works are limited to narrow issues, particularly Southern English and the status of /aɪ/ monophthongization. Still, some studies have treated regional differences in vowel length, often in the context of rate of speaking.[1] For example, Freiman's (1979) early study begins from the hypothesis that Southerners speak more slowly than Northerners. Ultimately, he concludes that the latitude of a speaker's hometown does not correlate with rate of speaking as measured by words per minute, although:

> It might be true that the individual phonemes pronounced by Southerners are said at a slower rate. However, it seems to me that rate of speaking is more dependent on subject matter, intelligence, and social attitude. [130]

A more recent study, Deser (1990), deals with the speech of several African American families in Detroit, in particular distinguishing a group of "Detroit-like" speakers from a group of "Southern-like" ones. With regard to vowel duration, she concludes:

> Duration also proved to be a reliable dialect measure…. As one possible measure of speech rate, it provided further evidence for the subjective impression that Southern speech is slower, more drawn out, than Northern dialects. [123]

Namely, vowels among her Southern-sounding speakers lasted longer on average than those of Northern-sounding speakers, a pattern which proves "consistent across vowels (and across the voiced/voiceless consonant environment dimension of those vowels) and across speaking styles" (123).

Wetzell (2000) also ties his findings on vowel duration to speech rate, comparing speakers from western North Carolina (Graham County) to speakers from the northeastern United States. Most of his subjects in the latter group come from Philadelphia up through New Jersey on to Long Island, an area basically falling into the Mid-Atlantic region, but including a set of speakers from Rochester (Inland North).[2] He finds (2000, 23) that North Carolina speakers produce longer vowels than Northern speakers, but like Freiman is careful not to draw overly broad conclusions about speaking rate from those results.

Clopper, Pisoni, and de Jong (2005) provide evidence on vowel duration across American dialects in the course of a survey of characteristics of six major regions as identified by Labov, Ash, and Boberg (2006). The main effect of dialect was significant, and a significant dialect-by-vowel interaction arose because the dialect differences were not consistent across all vowels. Considering duration differences for Southern and Northern speakers (corresponding to our North Carolina and Wisconsin speakers, respectively), Clopper, Pisoni, and de Jong found that Southerners produced only two significantly longer vowels than Northerners, /ɛ/ and /ʌ/. These results were interpreted to mean that Southern speakers did not produce generally longer vowels than Northerners (2005, 1665). Midlands speakers pattern with Northerners with regard to /ʌ/.

Some work has also been conducted on areal differences in duration outside the English-speaking world. In their study of regional variation of Dutch vowels, Adank, van Hout, and van de Velde (2007) report a significant main effect of dialect and a significant main effect of gender for vowel duration in Northern Standard Dutch (NSD). Duration of selected vowels varied across four regions in NSD, and females' vowels showed longer durations than males',

[1]Various works have implicitly or explicitly treated vowel duration as an indicator of overall rate of speaking. See, for instance, House (1961) and Crystal and House (1988a, 1988b) on related issues, as well as the popular overview of speech rate in Roach (1998).
[2]We would note that the core area itself appears to be an area of considerable dialectal heterogeneity; see, e.g., Labov, Ash, and Boberg (2006), on the position of New York City and its environs.

which reached statistical significance. In Southern Standard Dutch, the effect of dialect on vowel duration was not significant, while the main effect of gender was again significant, indicating longer durations for females than for males.

All of the American studies point to an important pattern, that "Northern" dialects, whether those of white speakers in the urban northeast or African American speakers in Detroit, produce shorter vowels than "Southern" dialects, whether those of Detroit African Americans with strong affinity to the South or of white speakers in far western North Carolina. While suggestive, these projects invite additional research to confirm and expand on those findings.

Within their limitations—relatively small samples, a focus on other factors with limited attention to duration, and so on—these studies together suggest a durational difference between Northern and Southern varieties of English, usually supporting the view that Southern speech is slower. We test that here with data from three regions, including central Ohio. A contentious issue in American dialectology in recent decades has been the status of the Midlands area, which traditional sources and some recent ones (Benson 2003; Preston 2003) consider a major dialect of American English, while others (most famously Carver 1987 and Davis and Houck 1992) regard it as a simple transition area between North and South. As noted, the only data on duration from the Midlands (Clopper, Pisoni, and de Jong 2005) show this area patterning with the North. Our Ohio results will bear on that discussion.

Our approach here relies on recordings made under laboratory conditions, rather than in traditional sociolinguistic interviews. As detailed below, this was done primarily in order to control for prosodic prominence or emphasis effects as a major source of variation in a vowel's duration (see Jacewicz, Fox, and Salmons 2006 for details and additional references). Although the present stimulus material was read to assure the systematic variation in main sentence stress for all speakers tested, we also collected free speech from the same speakers and will provide analysis of that in future works. At present, we use our experimental work to establish a baseline for such future analyses.

Methods

Speakers

Recordings were obtained from 54 speakers aged 20–34 years. There were 18 speakers (9 male, 9 female) from each dialect area who were born and raised in either central Ohio (the Columbus area: Franklin, Delaware, Union, and adjacent counties), south-central Wisconsin (the Madison area: Dodge and Dane counties), or western North Carolina (the Sylva, Cullowhee, and Waynesville areas: Jackson, Swain, and Haywood counties). All speakers but one had a college-level education. The Ohio and Wisconsin participants reported growing up in a suburban setting, and the North Carolina speakers grew up mostly in rural areas or small towns.

Stimuli

Stimulus materials consisted of a set of sentence pairs which contained the words of the structure /bVts/ and /bVdz/, where V is one of the following target vowels: /ɪ, ɛ, æ, e, aɪ/. The following target words were created: *bits*/*bids*, *bets*/*beds*, *bats*/*bads*, *baits*/*bades*, *bites*/*bides*. The position of the target word within a sentence did not change, nor did its immediate phonetic context. To create several different emphasis conditions for each target word, main sentence stress was systematically varied for each sentence set. In this way, the proximity of the target word to the main sentence stress position determined the level of emphasis of the target word such as high, intermediate, or low (see Jacewicz, Fox, and Salmons 2006 for additional discussion). For each vowel category, the sentence pairs with the following main sentence

stress positions (marked by way of capitalization) yielded three gradient levels of vowel emphasis (high, intermediate, low):

HIGH

Rob said the tall CHAIRS are warm.

No! Rob said the tall BEDS are warm.

INTERMEDIATE

Rob said the SHORT beds are warm.

No! Rob said the TALL beds are warm.

LOW

Rob said the tall beds are COLD.

No! Rob said the tall beds are WARM.

These are only the examples of the vowel /ɛ/ in the word *beds*. A complete set of stimulus materials is given in the appendix. This design allowed us to assess each vowel's duration as a function of multiple factors, such as the position of main stress in a sentence, immediate consonantal context, speaker dialect, and speaker gender. This approach takes into account contextual effects on vowel duration (at both the segmental and suprasegmental levels) and situates the cross-dialectal and cross-gender comparisons in a rigorously controlled phonetic context in which the vowel occurs.

Recording Procedure

The sentence pairs were recorded in random order. Each pair of sentences was recorded three times. A total of 90 sentence pairs were obtained from each subject for subsequent acoustic analysis (5 vowels × 2 consonantal contexts × 3 levels of emphasis × 3 repetitions). Recordings were under computer control using a program written in Matlab, a programming language used for numerical analysis. Sentence pairs were presented in random order on a computer screen and read by a speaker seated in a sound-attenuating booth. The stimuli were recorded directly onto a hard drive disk at a 44.1-kHz sampling rate. A head-mounted microphone (Shure SM10A) was used, placed one inch from the lips. Each speaker was instructed to read the sentences fluently and place the main sentence stress on the capitalized words. The recordings were repeated in case of mispronunciations, wrong placement of the main sentence stress, or disfluent productions.

Acoustic Measurements

Prior to analysis, the tokens were downsampled to 11.025 kHz and pre-emphasized (98%). Vowel onsets and offsets were located by hand from the waveform (with reference to a spectrogram). Vowel onset was located at the zero-crossing before the first positive peak in the periodic waveform and vowel offset was defined as the beginning of the stop closure (location of abrupt decrement in the amplitude of the waveform). The onset and offset locations served as input to a Matlab program, which calculated the overall vowel duration automatically, displaying the onset and offset markings in the waveform for the researcher to examine. A reliability check was performed by a second researcher on all measurements using the same Matlab program with graphical display of vowel onsets and offsets.

Statistical Analysis

Analysis of variance (ANOVA) was used to assess the statistical significance of vowel duration differences. The within-subject factors were vowel, consonantal context, and emphasis

position, and the between-subjects factors were speaker dialect and speaker gender. For all reported significant main effects and interactions, the degrees of freedom for the *F*-tests were Greenhouse-Geisser adjusted in those cases in which there were significant violations of sphericity. Violation of the sphericity assumption in a within-subject factor in an ANOVA can be likened to a violation of the homogeneity of variance assumption in a between-group factor. In addition to the significance values, a measure of the effect size—partial eta squared (η^2)—is also reported. The value of η^2 can range from 0.0 to 1.0 and should be considered a measure of the proportion of variance explained by a dependent variable when controlling for other factors. Post hoc analyses were completed using additional ANOVAs on selected subsets of the data (with appropriate *F*-tests) and *t*-tests.

Results

All main within-subject effects and two-way interactions were significant. There was a significant main effect of vowel ($F(4, 192) = 808.82$, $p < 0.001$, $\eta^2 = 0.944$) and consonantal context ($F(1, 48) = 410.28$, $p < 0.001$, $\eta^2 = 0.895$). These results demonstrate duration differences as a function of vowel quality, the well-known intrinsic property of vowels, with which duration increases progressively with vowel openness (see table 1). Subsequent pairwise comparisons showed that all mean vowel durations differed significantly from one another. It is interesting to note that the vowel /æ/ and not the diphthong /aɪ/ was the longest in the set given that diphthongs are typically longer than single vowel categories.[3] Furthermore, vowels preceding voiced consonants were longer than vowels before voiceless consonants. This widely observed tendency was confirmed once more in the present cross-dialect data. A significant interaction between vowel and consonantal context ($F(4, 192) = 29.29$, $p < 0.001$, $\eta^2 = 0.379$) arose from the fact that the mean duration difference produced by consonant voicing was greater for the diphthong /aɪ/ than for any other vowel.

There was a significant main effect of level of emphasis, that is, prosodic prominence ($F(2, 96) = 242.44$, $p < 0.001$, $\eta^2 = 0.835$). Vowels with high emphasis were on average longer (199 ms) than vowels with intermediate (153 ms) and low emphasis (139 ms). Post hoc analyses revealed that all these mean durations differed significantly from one another. There was also a statistically significant interaction between vowel and emphasis level ($F(8, 384) = 13.56$, $p < 0.001$, $\eta^2 = 0.220$), although the effect size was relatively small. This effect stems from the fact that although for every vowel category, the rank orders of the three levels of emphasis followed the overall pattern (high > intermediate > low), there was some variation among the vowels in terms of whether or not the mean duration of the intermediate level was significantly different from the high or low levels.

In summary, the results for within-subject factors show that vowel duration is sensitive to phonetic effects and varies systematically as a function of vowel quality, consonantal context, and vowel emphasis in a sentence. Of particular interest to this article, however, is whether there are differences in vowel duration coming from the between-subjects factors, speaker dialect and speaker gender.

The effects of speaker Dialect

The main effect of dialect was significant ($F(2, 48) = 15.59$, $p < 0.001$, $\eta^2 = 0.394$). On average, western North Carolina vowels were longest (188 ms) followed by central Ohio (160 ms) and Wisconsin vowels (144 ms), respectively. Scheffé post hoc tests demonstrated that North Carolina vowels were significantly longer than either Ohio or Wisconsin vowels. However, the difference between the latter two was not large enough to reach statistical significance. A

[3]Purnell (2007) provides evidence that /æ/ in Wisconsin behaves more generally as a diphthong.

similar pattern was found in the mean durations for each individual vowel. In particular, for each vowel category, North Carolina vowels were longer than both Ohio and Wisconsin vowels, and Wisconsin vowels were the shortest (see figure 1).

Subtle cross-dialectal differences were revealed by significant two-way interactions involving dialect and each of the within-subject factors. A significant vowel-by-dialect interaction ($F(8, 192) = 7.82$, $p < 0.001$, $\eta^2 = 0.246$) arose from the fact that the pattern of cross-dialectal duration differences was somewhat different for the vowel /æ/ than for the remaining vowels. In particular, one-way ANOVAs and Scheffé post hoc tests indicated that for most vowel categories the North Carolina vowels were significantly longer than either Ohio or Wisconsin vowels, whereas the Ohio and Wisconsin vowels did not differ from each other. However, for the vowel /æ/, the difference between North Carolina and Ohio was not significant.

There was a statistically significant interaction between dialect and emphatic position ($F(3, 71.4) = 3.3$, $p = 0.026$, $\eta^2 = 0.121$), although the effect size was small. Post hoc tests indicated that the duration differences between high and intermediate levels were smaller for Wisconsin vowels than for either Ohio or North Carolina, the duration differences of which did not differ from one another. This resulted in a smaller duration difference between Wisconsin and Ohio vowels for the intermediate level, as illustrated in figure 2. The tendency for North Carolina vowels to be longer than either Ohio or Wisconsin vowels, respectively, was maintained across all levels of vowel emphasis.

There was also statistically significant dialect-by-consonantal context interaction ($F(2, 48) = 6.69$, $p = 0.003$, $\eta^2 = 0.218$), again, with a relatively small effect size. This was obtained because the difference between the mean duration of vowels in voiced and voiceless contexts was somewhat smaller for Wisconsin than for either Ohio or North Carolina. Consonantal context effects were present for each individual vowel category across all three dialects, and, as expected, vowels before voiced consonants were always longer than before voiceless. However, the context-related duration differences for individual vowel categories varied slightly (and unsystematically) across the three dialects, as shown in figure 3. This type of variation gave rise to a significant three-way interaction between dialect, consonantal context, and vowel ($F(8, 192) = 4.3$, $p < 0.001$, $\eta^2 = 0.152$).

We point out again that the effect sizes of the significant interactions described above were relatively small, with η^2 values ranging from 0.121 to 0.246. These results demonstrate that, overall, the effects of these interactions were neither as robust nor as substantial as the main effect of dialect.

Overall, then, the dialectal differences in vowel duration were well manifested across all vowels and did not disappear with the contextual variation such as immediate consonantal context of a vowel or variable stress and emphasis in a sentence. North Carolina vowels were always significantly longer than Wisconsin vowels and, except for /æ/, significantly longer than Ohio vowels. However, although the latter tended to be longer than Wisconsin vowels, the difference between them was not significant.

The effects of speaker Gender

Speaker gender affected vowel duration to a much lesser extent than did dialect. The main effect of gender was not significant ($F(1, 48) = 1.67$, $p = 0.203$, $\eta^2 = 0.034$), although females' vowels were on average slightly longer than males' vowels (168 ms vs. 160 ms).

The gender-related differences in duration of individual vowels across all three dialects are shown in figure 4. For both Ohio and North Carolina, durations of females' vowels tended to

be slightly longer as compared to males', whereas for Wisconsin, females' vowels were either shorter or equal in duration.

Figure 5 shows the durations of individual vowels split by consonantal context, speaker gender, and speaker dialect. As can be seen, the general tendency for vowels to be longer before voiced consonants as opposed to voiceless is maintained across all vowels, all dialects, and both genders. Also apparent is the tendency for North Carolina vowels to have longer durations than Ohio and Wisconsin vowels, respectively. However, the effects of gender are not always manifested in a systematic way. In particular, Ohio and North Carolina females produced longer vowels than males in the /b_dz/ context but not always in the /b_ts/. Moreover, Wisconsin females' vowels were either equal to or shorter than those of Wisconsin males.

Several three- and four-way interactions involving gender were statistically significant, but again, this does not necessarily indicate a substantial effect. In particular, there was a relatively small effect size associated with all the significant interactions involving gender, with η^2 values ranging from 0.089 to 0.170. Speaker gender interacted significantly with other variables such as dialect, consonantal context, vowel category, or degree of vowel emphasis. Such complex interplay of durational differences accounts for very little of the variance and does not explain systematic variation that would interest us here. As a whole, the effects of speaker gender were not strong and the observed longer durations of females' vowels should be regarded as a tendency rather than a true effect.

Discussion

The present results are generally consistent with those on vowel duration reported in earlier work, as reviewed above. In particular, a growing body of research shows that Southern vowels are longer than Northern ones. Our study provides evidence from additional parts of the United States, filling in part of the bigger, national picture.

The general findings from these studies and the present one are consistent: vowel duration is shown to vary across regional varieties. This effect is relatively strong, although it may involve selected vowels or selected regional varieties only. Our samples are by far the largest and most geographically focused reported to date, and they suggest the most consistent duration differences. In the present data, all North Carolina vowels were significantly longer than Wisconsin vowels. The discrepancy between our findings and those of Clopper, Pisoni, and de Jong (2005) on this point almost certainly stems from the selection of speakers. Clopper, Pisoni, and de Jong used 8 speakers for the Northern region who came from a band stretching from New York state westward through Indiana and Illinois to Wisconsin and 8 speakers for the Southern region who grew up in such diverse areas as Indiana (2), South Carolina (1), Alabama (1), Kentucky (2), and Texas (2). In the present study, all 18 Northern speakers came from two adjacent counties in Wisconsin, and all 18 Southern speakers were born and raised in three adjacent counties in western North Carolina. Thus, the results from two highly homogenous regional groups in the North and in the South indicate that Southern speakers do produce longer vowels than Northern speakers.

The effects of speaker gender appear more variable than dialect, although all reports emphasize the tendency for females' vowels to be longer than males'. The main effect of gender was not significant in the Clopper, Pisoni, and de Jong (2005) study, which is again consistent with the present results. The tendency for females' vowels to have longer duration was found in that study as well, although a significant vowel-by-gender interaction brought to light that this was the case for selected vowels only. In the present study, the effects of interactions involving speaker gender were rather weak, and a vowel-by-gender interaction, which would suggest gender-related differences for selected vowels only, was not significant. Given the widespread

expectation that women lead in the vowel changes underway in American English dialects today (like the Northern Cities Shift found in our Wisconsin region and the Southern Shift found in our North Carolina region), even a distinct tendency toward greater vowel duration among female speakers across regions calls for additional study.

Our inclusion of speakers from the Midlands bears on the classification of American dialects, in particular as framed around the Labovian theme of vowel shifts and mergers. We do not yet know whether patterns of durational distinctiveness follow the isoglosses posited for vowel quality in such work. Consider Clopper, Pisoni, and de Jong's (2005) sample for the Midlands, which comes exclusively from central and southern Indiana (eight subjects); northern Indiana provided four Northern speakers (from St. John, Munster, and two from South Bend), while another two representatives of Southern English come from southern Indiana (New Albany, Georgetown). Clopper, Pisoni, and de Jong do not report differences between their Northern and Midlands speakers in duration, noting only that Northern and Midlands speakers both have shorter /Λ/s than do Southerners. In fact, their overall results lead them to conclude (2005, 1672), following a line of research they identify with Davis and Houck (1992), that their "results are consistent with earlier claims in the literature that the Midland dialect region is not a unique dialect, but instead may be a transition area between the North and the South." (See also Carver's [1987, 180–83] section on "The Nonexistent Midland Dialect.")

Other recent work, though, has drawn a sharply different picture of the Midlands (e.g., Murray 1993; Murray and Simon 1999, 2002; and Labov, Ash, and Boberg 2006, 293–96). Murray, Frazer, and Simon (1996) and Benson (2003, 2005, 2006), as well as some of the works just mentioned, provide evidence for distinctive regional patterns in the Midlands in syntax and pragmatics (such as constructions like *the car needs washed* and *the dog needs out*), not characteristic of the North or South. Preston (2003, 250) has also mounted a broad, vigorous defense of the Midlands, but he draws the northern boundary of the South as running north of Indianapolis, leaving only a very narrow band in northern Indiana as Midlands, a view under which most of Clopper, Pisoni, and de Jong's (2005) "Midlands" speakers would be reclassified as "Southern."

Our Ohio results for duration come from an area that is uncontroversially part of the Midlands. These vowels fall partway between patterns for the Inland North and the South, significantly shorter than Southern vowels, with a consistent tendency (though not reaching statistical significance) to be longer than vowels from the Inland North. In that sense and to that extent, our results provide fresh evidence for the distinctiveness of the Midland area, though it is also consistent with the notion of the Midlands as a transitional cline between North and South.

In summary, our results confirm and expand considerably on limited previous work on durational differences in vowels among American English speakers. The main comparative finding in the literature to date has been that Southern vowels tend to be longer than Northern ones. Our study supports this finding with data from new areas, notably central Ohio and southern Wisconsin. Above all, we hope to have shown that vocalic duration warrants continued attention as an areal variable across American English.

Future work from this project will address the general question of speaking rate as well as durational characteristics of spontaneous speech in our speakers. As already noted above, the role of duration as a possible correlate of gender likewise will be treated.

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Appendix

The following sets of sentences were recorded by each speaker. All two-set sentences were randomly presented to the subject in two stimulus lists. The sentences in which the main stress falls on the first and second word position, respectively, served as distracters and were not included in the final analyses.

Vowels before a voiceless consonant in a word:

bits

JANE knows the small bits are sharp.

No! JOHN knows the small bits are sharp.

John FEELS the small bits are sharp.

No! John KNOWS the small bits are sharp.

John knows the SOFT bits are sharp.

No! John knows the SMALL bits are sharp.

John knows the small SCREWS are sharp.

No! John knows the small BITS are sharp.

John knows the small bits are DULL.

No! John knows the small bits are SHARP.

baits

MOM said the dull baits are best.

No! DAD said the dull baits are best.

Dad THINKS the dull baits are best.

No! Dad SAID the dull baits are best.

Dad said the BRIGHT baits are best.

No! Dad said the DULL baits are best.

Dad said the dull HOOKS are best.

No! Dad said the dull BAITS are best.

Dad said the dull baits are WORST.

No! Dad said the dull baits are BEST.

bets

FRANK said the small bets are low.

No! JOHN said the small bets are low.

John THOUGHT the small bets are low.

No! John SAID the small bets are low.

John said the BIG bets are low.

No! John said the SMALL bets are low.

John said the small POTS are low.

No! John said the small BETS are low.

John said the small bets are HIGH.

No! John said the small bets are LOW.

bats

SAM said the small bats are fast.

No! DOC said the small bats are fast.

Doc THINKS the small bats are fast.

No! Doc SAID the small bats are fast.

Doc said the LARGE bats are fast.

No! Doc said the SMALL bats are fast.

Doc said the small BIRDS are fast.

No! Doc said the small BATS are fast.

Doc said the small bats are SLOW.

No! Doc said the small bats are FAST.

bites

JANE thinks the small bites are deep.

No! SUE thinks the small bites are deep.

Sue KNOWS the small bites are deep.

No! Sue THINKS the small bites are deep.

Sue thinks the LARGE bites are deep.

No! Sue thinks the SMALL bites are deep.

Sue thinks the small CUTS are deep.

No! Sue thinks the small BITES are deep.

Sue thinks the small bites are WIDE.

No! Sue thinks the small bites are DEEP.

Vowels before a voiced consonant in a word:

bids

BOB thinks the fall bids are low.

No! TED thinks the fall bids are low.

Ted KNOWS the fall bids are low.

No! Ted THINKS the fall bids are low.

Ted thinks the SPRING bids are low.

No! Ted thinks the FALL bids are low.

Ted thinks the fall SALES are low.

No! Ted thinks the fall BIDS are low.

Ted thinks the fall bids are HIGH.

No! Ted thinks the fall bids are LOW.

bades

(The nonsense word *bade* was explained to the speaker as indicating “a brand of knife, a brand name.”)

TOM says the dull bades are cheap.

No! TED says the dull bades are cheap.

Ted THINKS the dull bades are cheap.

No! Ted SAYS the dull bades are cheap.

Ted says the SHARP bades are cheap.

No! Ted says the DULL bades are cheap.

Ted says the dull FORKS are cheap.

No! Ted says the dull BADES are cheap.

Ted says the dull bades are WEAK.

No! Ted says the dull bades are CHEAP.

beds

TOM said the tall beds are warm.

No! ROB said the tall beds are warm.

Rob THINKS the tall beds are warm.

No! Rob SAID the tall beds are warm.

Rob said the SHORT beds are warm.

No! Rob said the TALL beds are warm.

Rob said the tall CHAIRS are warm.

No! Rob said the tall BEDS are warm.

Rob said the tall beds are COLD.

No! Rob said the tall beds are WARM.

bads

(The speaker was told that *bad* refers to “an error or mistake.” For example, if someone makes an error, he or she might say “my bad” instead of “my mistake.”)

NICK thinks the small bads are worse.

No! MIKE thinks the small bads are worse.

Mike KNOWS the small bads are worse.

No! Mike THINKS the small bads are worse.

Mike thinks the BIG bads are worse.

No! Mike thinks the SMALL bads are worse.

Mike thinks the small GOODS are worse.

No! Mike thinks the small BADS are worse.

Mike thinks the small bads are BEST.

No! Mike thinks the small bads are WORSE.

bides

(The nonsense word *bide* was explained to the speaker as indicating “a small animal, a type of dog.”)

SUE thinks the small bides are cute.

No! JANE thinks the small bides are cute.

Jane KNOWS the small bides are cute.

No! Jane THINKS the small bides are cute.

Jane thinks the SHORT bides are cute.

No! Jane thinks the TALL bides are cute.

Jane thinks the small CATS are cute.

No! Jane thinks the small BIDES are cute.

Jane thinks the small bides are GROSS.

No! Jane thinks the small bides are CUTE.

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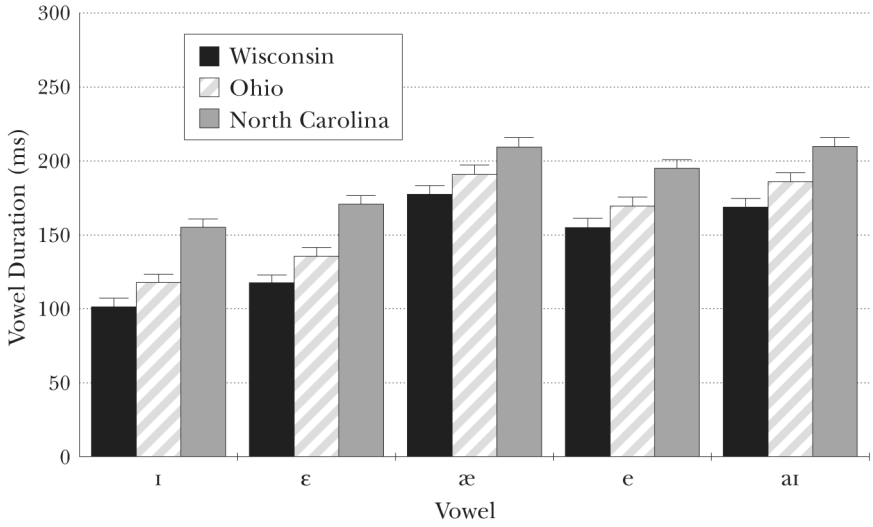

Figure 1.
Mean Durations of Vowels in Wisconsin, Ohio, and North Carolina (error bars indicate one standard error)

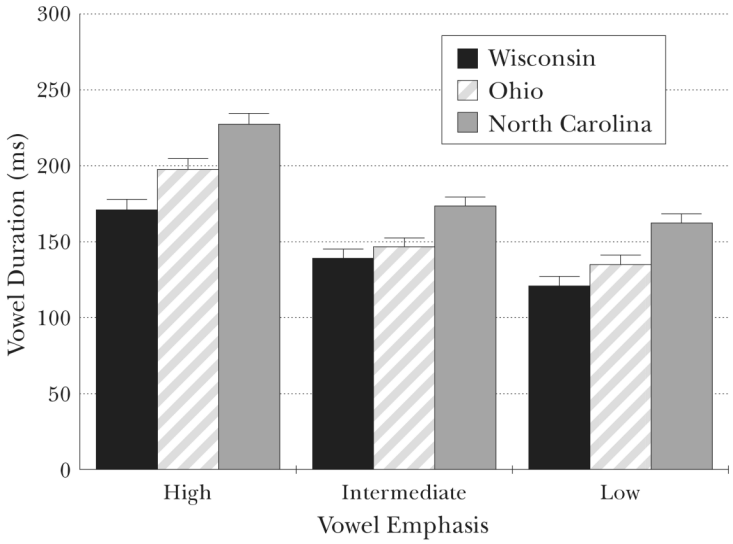

Figure 2.
Mean Vowel Duration as a Function of Vowel Emphasis for Wisconsin, Ohio, and North Carolina (error bars indicate one standard error)

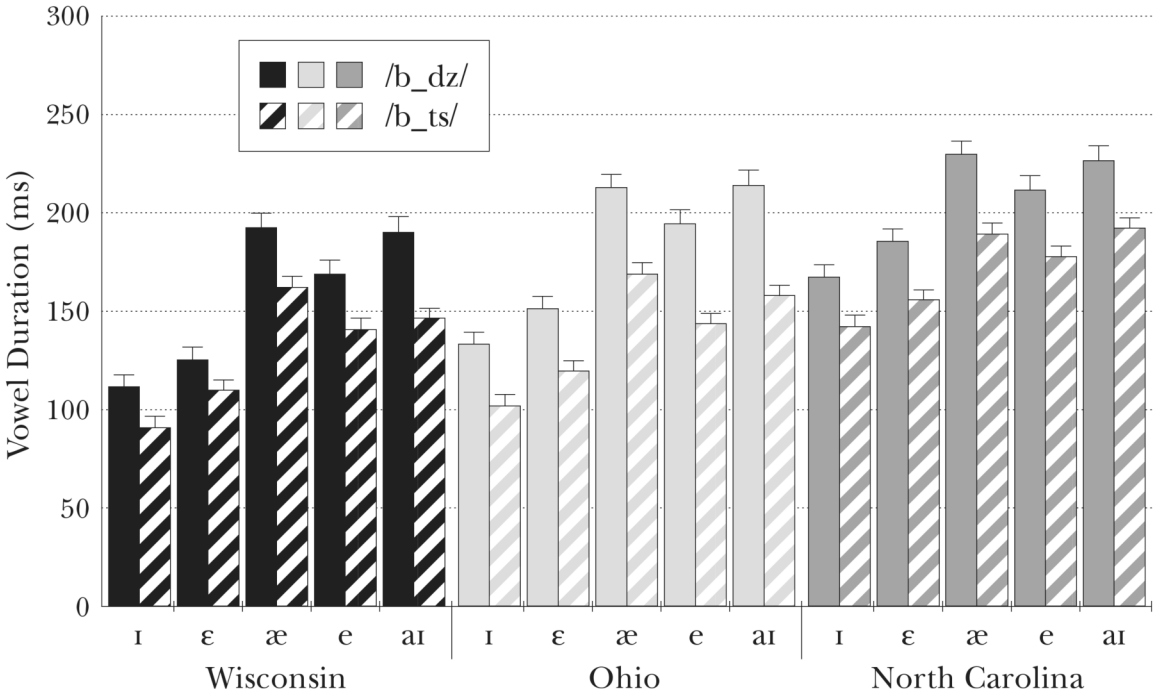

Figure 3.
Mean Durations of Individual Vowels in Two Consonantal Contexts for Wisconsin, Ohio, and North Carolina (error bars indicate one standard error)

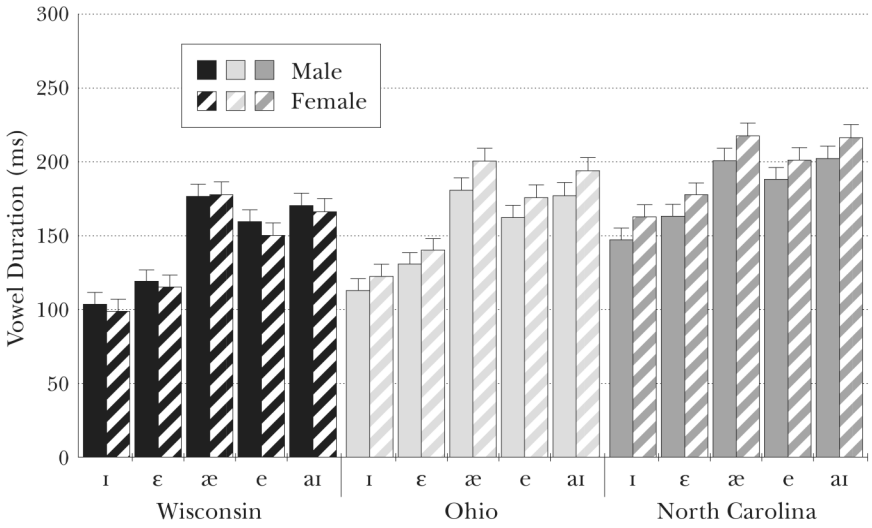

Figure 4.
Mean Durations of Vowels as a Function of Speaker Gender and Speaker Dialect (error bars indicate one standard error)

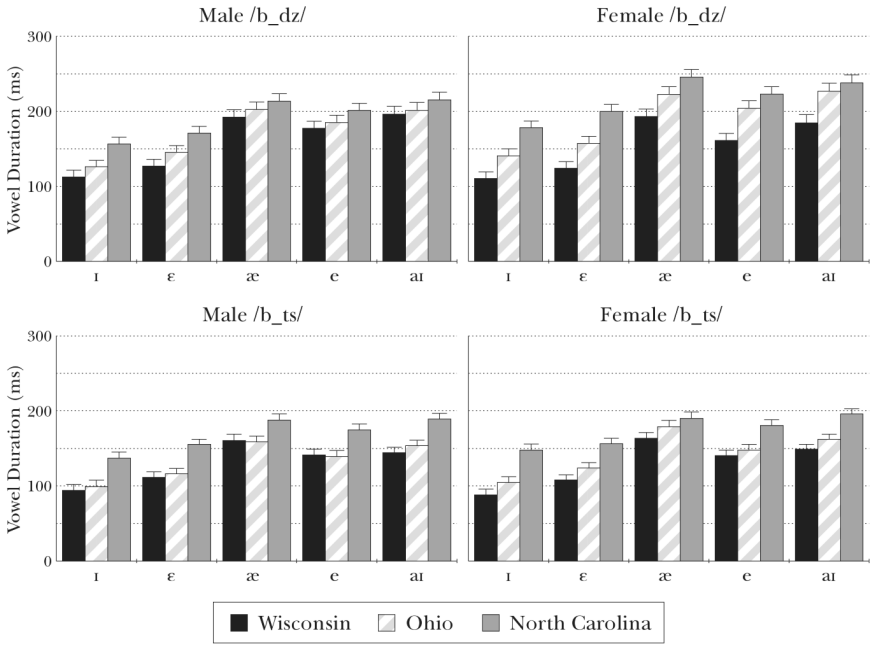

Figure 5.
Mean Durations of Individual Vowels as a Function of Consonantal Context, Speaker Gender, and Speaker Dialect (error bars indicate one standard error)

Table 1

Durations of Vowels in Two Consonant Contexts (mean and one standard deviation in milliseconds)

Vowel	b_dz Context	b_ts Context
/ɪ/	137 (46)	112 (41)
/ɛ/	154 (48)	128 (37)
/æ/	192 (52)	154 (40)
/e/	212 (51)	173 (42)
/aɪ/	210 (56)	166 (37)