

# MORE ON MICHIGAN LISTENERS' PERCEPTIONS OF /ɑ/-FRONTING

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**ABSTRACT:** The Northern Cities Vowel Shift (NCVS) is well advanced in southeastern Lower Michigan and largely absent in Michigan's Upper Peninsula. In a previous study, Plichta and Rakerd found evidence that listeners from Lower Michigan make a perceptual adjustment for NCVS /ɑ/-fronting when given acoustical information about a talker's dialect (a sentence-long speech sample), but listeners from the Upper Peninsula do not. The present study further examines this phenomenon. Here, individual differences regarding listeners' vowel categorization judgments indicate that the /ɑ/-fronting perceptual response is consistently present among young adult residents of Lower Michigan, but much more variable among young adults from the Upper Peninsula. There is also evidence that the perceptual effect for Lower Michigan listeners is robust over a number of different stimulus variations. A word-level difference found here suggests that perceptual cues to /ɑ/-fronting may be provided by both static and dynamic vowel formant features. Finally, listeners' decision reaction times provide new evidence of regional differences in sensitivity to NCVS.

**F**IFTY YEARS AGO, Ladefoged and Broadbent (1957) pointed out that the speech signal conveys three kinds of information simultaneously. There is LINGUISTIC information about the identity of phonetic segments, PERSONAL information about the identity of the talker, and SOCIOLINGUISTIC information about the talker's speech community. Because these information streams co-occur, there is the potential for interaction.

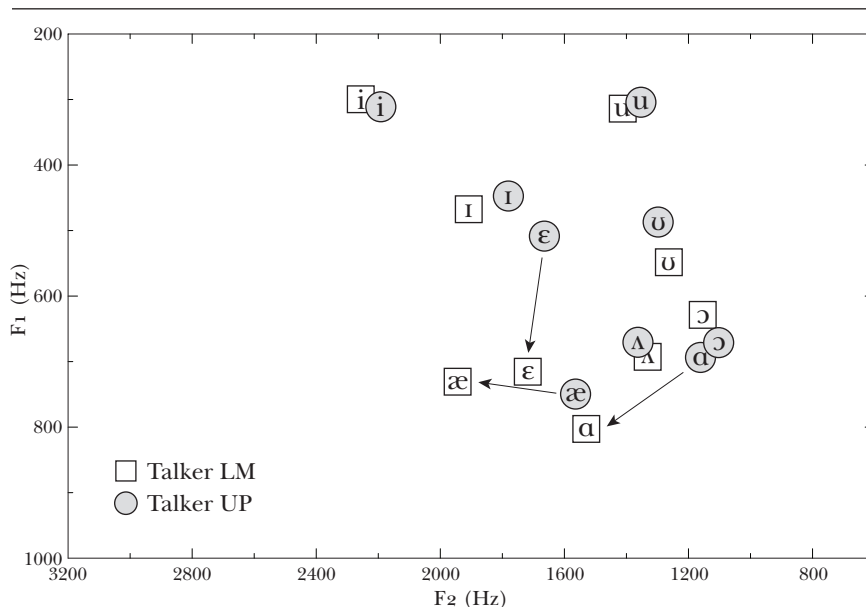
Ladefoged and Broadbent's study found evidence of a perceptual interaction involving personal information and linguistic information. They synthesized multiple versions of a precursor sentence (*Please say what this word is*) with each featuring a unique range of formant frequency variation selected to represent speech produced by a different talker. Listeners then judged the identity of the vowel heard in words presented immediately following each of these precursors. In a number of instances, the perceived vowel was found to vary systematically as the precursor changed, strongly suggesting that the listeners' perceptual processing included a normalization step to adjust for talker-related differences in vowel production.

The present study is concerned with a perceptual interaction that involves linguistic and sociolinguistic information conveyed by vowels. The sociolinguistic variable of interest is the Northern Cities Vowel Shift (NCVS). NCVS is one of the more thoroughly studied ongoing sound changes in the

United States. While some uncertainty remains as to its exact phonological, articulatory-phonetic, and acoustic details, it is commonly agreed that NCVS involves a degree of rearrangement of vowels in the two-dimensional space delimited by F<sub>1</sub> (the “height” dimension) and F<sub>2</sub> (the “frontness” dimension). For example, the vowel /æ/ is believed to be “raised” in NCVS because its F<sub>1</sub> is lower in frequency compared to older variants. Similarly, the vowel /ɑ/ is believed to be “fronted” in NCVS because its F<sub>2</sub> is higher in frequency. The formant frequency data of Peterson and Barney (1952) are sometimes used as a model of the pre-NCVS vowel space (e.g., Evans et al. 1999).

There is evidence that NCVS is well advanced among young adult speakers in the Detroit area of Lower Michigan and nearly absent among young adults in Michigan’s Upper Peninsula (Gordon 2001; Labov, Ash, and Boberg 2006). As an example, figure 1 shows a comparison of the vowel spaces for two young-adult male talkers closely matched in physical size and voice fundamental frequency. One of the talkers, LM, is a lifetime resident of Lower Michigan (the metro Detroit area); the other, talker UP, is a lifetime resident of the Upper Peninsula. Each talker produced 200 vowel tokens in a broad range of consonantal contexts.<sup>1</sup> The figure shows the average first formant (F<sub>1</sub>) and second formant (F<sub>2</sub>) frequency values obtained from these

FIGURE 1  
Vowel Systems of Lifetime Residents of Michigan’s Upper Peninsula (UP)  
and Lower Michigan (LM)



productions. It can be seen that the two talkers' formant values were in good agreement for a majority of the vowels. But they differed substantially with respect to /a/, /ɛ/, and /æ/, with LM's productions shifted in ways consistent with NCVS in each instance.

In a previous investigation (Plichta and Rakerd 2010), we examined the NCVS phenomenon of /a/-fronting, and found evidence that Michigan listeners take dialectal differences like these into account when interpreting cues to /a/ and its near neighbor /æ/. Specifically, we found that the perceived category boundary between /a/ and /æ/ was significantly more fronted when target words were presented at the ends of sentences produced by a talker whose speech was marked by NCVS (talker LM shown in fig. 1) than it was when those same targets were presented at the ends of sentences produced by a talker who showed no evidence of NCVS (talker UP).

A second finding of that investigation was that there was a listener-dependent constraint on this perception. Sensitivity to the dialectal difference between talkers was found to be significant among a group of young-adult listeners who were longstanding residents of Lower Michigan, where they had been widely exposed to NCVS variants. But there was no evidence of sensitivity among a group of young-adult listeners who had resided almost exclusively in the Upper Peninsula, with more limited exposure to speech marked by NCVS.

The present study was conducted with two purposes in mind. The first was to better define the stimulus conditions needed to elicit an /a/-fronting perceptual response from any listener and to better understand the extent to which that response can be expected to depend upon a listener's speech community. We therefore made detailed comparisons among our individual listeners' vowel reports and among the various stimulus conditions of this study. The findings of those comparisons are reported below, first regarding individual differences among the listeners and second regarding sentence-level and word-level factors important to the perceptual effect.

The study's second purpose was to examine data pertaining to /a/-fronting different from those that were considered in our first study and, to our knowledge, different from those that have been considered in any sociolinguistic study of speech perception. Specifically, we examined the time our listeners took to make their vowel judgments. Data regarding reaction times can be informative about perceptual categorization (Ford et al. 1982; Houlihan, Campbell, and Stelmack 1994; Lafond, Lacouture, and Cohen 2009). Reaction times were examined here to learn more about how listeners from Lower Michigan compared to listeners from the Upper Peninsula when categorizing vowels, especially under conditions that invited a perceptual compensation for NCVS.

## METHODS

**PARTICIPANTS.** The participants in this perception study were nine young adults who had resided exclusively in Michigan's Upper Peninsula up to the time of testing and nine who had resided exclusively in the Detroit area of Lower Michigan. All of the participants had normal hearing, and all were native speakers of English.

**STIMULI.** The test stimuli were target words with synthetic vowel nuclei that varied along a continuum from /a/ to /æ/. The acoustical variation was specifically along the dimension of F<sub>2</sub> frequency, with F<sub>2</sub> incremented from 1245 Hz to 1443 Hz, in six steps of 33 Hz each.<sup>2</sup> The synthetic vowels were embedded in an /hVt/ consonantal frame, to produce word items that were heard as either *hot* or *hat*, and in an /sVk/ frame, to produce words heard as either *sock* or *sack*.

**TASK.** Depending on the condition, the target words were presented to participants in citation form, or at the ends of the following sentence carriers spoken by talker LM or talker UP.

1. Bob was positive that he heard his wife, Shannon, say \_\_\_\_\_.
2. Cathy's card was blue and said "pot," while Mary's was black and said \_\_\_\_\_.
3. The key to winning the game of boggle is to know lots of short words like \_\_\_\_\_.
4. It turned out that the most common response to question thirty-two on last week's test was \_\_\_\_\_.

The participants were tested individually, while seated in a quiet room. Their task throughout was to categorize the vowel heard in a target word as either /a/ or /æ/ and to report that vowel categorization decision to a controlling computer by means of a button press. The participants were instructed to respond as promptly as they were able.

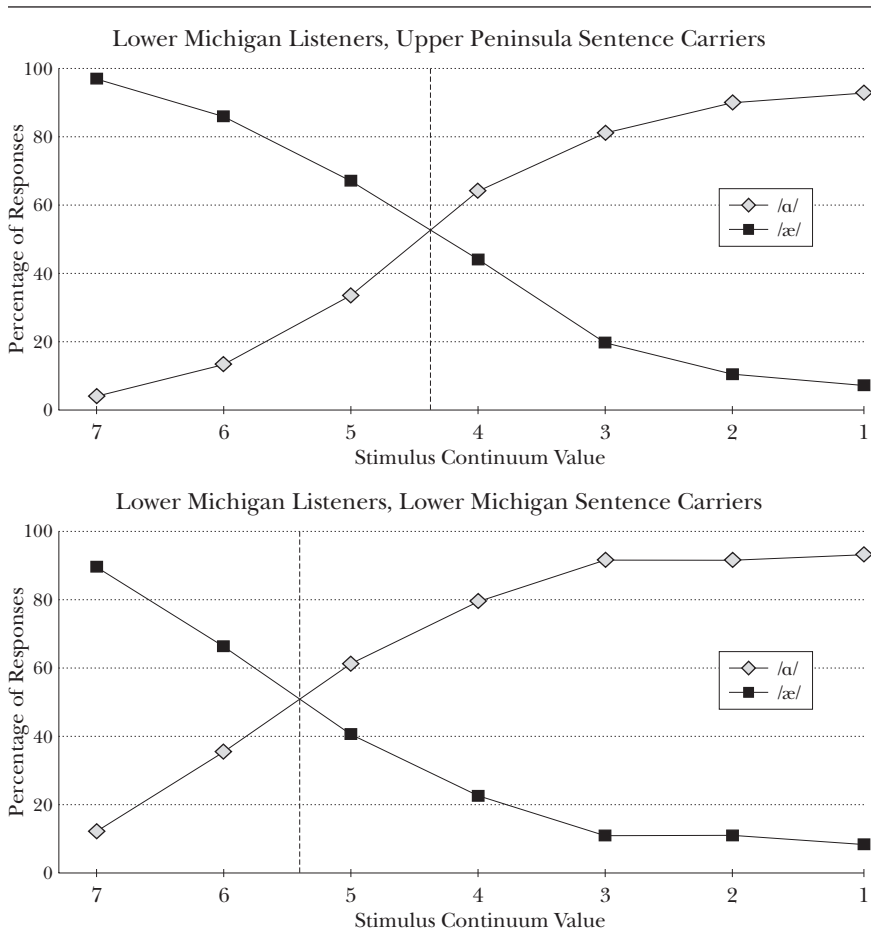
## VOWEL CATEGORIZATION JUDGMENTS

**GROUP DIFFERENCES.** Our first investigation (Plichta and Rakerd 2010) found no difference between the two participant groups when categorizing vowels for target words presented in citation form. But there was a notable difference regarding their categorization of vowels when the targets were presented in sentences, and that difference depended upon the identity of the talker.

Figure 2 shows the response pattern for the Lower Michigan group. The upper panel of the figure gives the percentages of /ɑ/ and /æ/ judgments made by those listeners at each step along the stimulus continuum when they were listening to target words presented in sentence carriers spoken by talker UP. The lower panel gives their results when listening to the words in sentence carriers spoken by talker LM. Note that the seven steps of the stimulus continuum increase from right to left, to agree with vowel space plots like figure 1, which order F2 frequency values in this way to show its relationship to the front-back dimension of vowels.

FIGURE 2

Vowel Categorization Results for Young Adult Listeners from Lower Michigan  
(reported by Plichta and Rakerd 2010)



The crossover point of the /a/ and /æ/ functions provides a best estimate of the vowel category boundary location along the stimulus continuum. That point is marked by a vertical line in each plot. The crossover point shifted for the Lower Michigan listeners, depending upon the regional dialect of the talker. When the talker was from the Upper Peninsula, the crossover occurred at step 4.3. When the talker was from Lower Michigan, the crossover was at step 5.4, a significantly more fronted place along the continuum ( $t(8) = 4.34, p < .01$ ).

Group results for the listeners from the Upper Peninsula are shown in figure 3. When listening to target words presented in sentence carriers spoken by talker UP, these listeners had an /a/-/æ/ crossover at step 4.3 which matched the Lower Michigan listeners' results for this same talker. But the two groups differed appreciably in their responses to sentences produced by talker LM. Whereas the Lower Michigan listeners had a significantly more fronted crossover for talker LM, the Upper Peninsula listeners did not. Instead, their crossover for talker LM was at step 4.5, a point that was very close to and not significantly different from their crossover for talker UP ( $t(8) = 0.96, p > .05$ ).

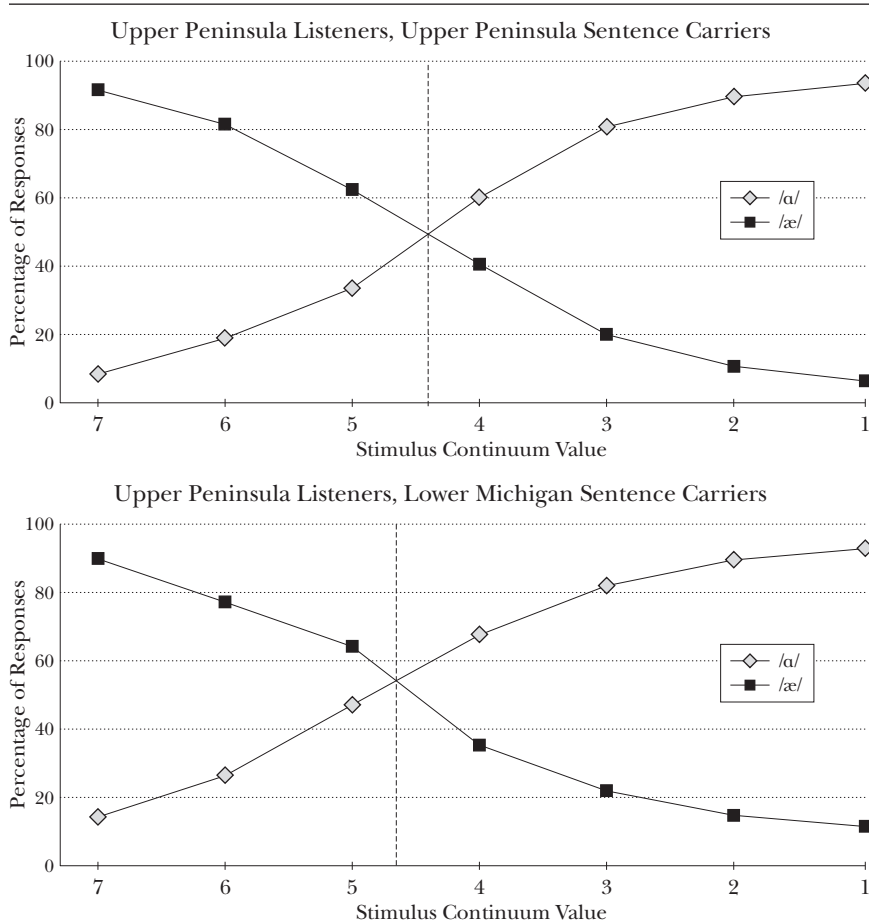
INDIVIDUAL DIFFERENCES. Figures 2 and 3 show that, on average, the listeners from Lower Michigan and the listeners from the Upper Peninsula differed markedly in their sensitivity to NCVS. One goal of the present study was to develop a better understanding of the individual variation that one might expect to see around those averages. Accordingly, a crossover point analysis was conducted here LISTENER BY LISTENER.

The left-hand panel of figure 4 shows the results of that analysis for the nine listeners from Lower Michigan. A circle is drawn around each listener's crossover point when listening to sentences spoken by talker UP, and an arrow is then projected from that circle to the crossover for sentences produced by talker LM. Arrows pointing left represent instances in which an individual's vowel categorizations became more fronted when listening to talker LM, and the longer the arrow's shaft the greater the size of this effect.

The response profiles for the nine listeners from Lower Michigan are notable for their similarity. Every listener exhibited a shift to the left—that is, a shift to a more fronted position when listening to talker LM—and for all but one of the listeners this shift was greater than half a step size along the stimulus continuum. This clearly indicates that the perceptual adjustment for /a/-fronting is widespread among young adults from Lower Michigan.

Individual results for the nine listeners from the Upper Peninsula are shown in the right-hand panel of figure 4. Several of those listeners exhibited shifts much like those of the Lower Michigan group. But there were also sev-

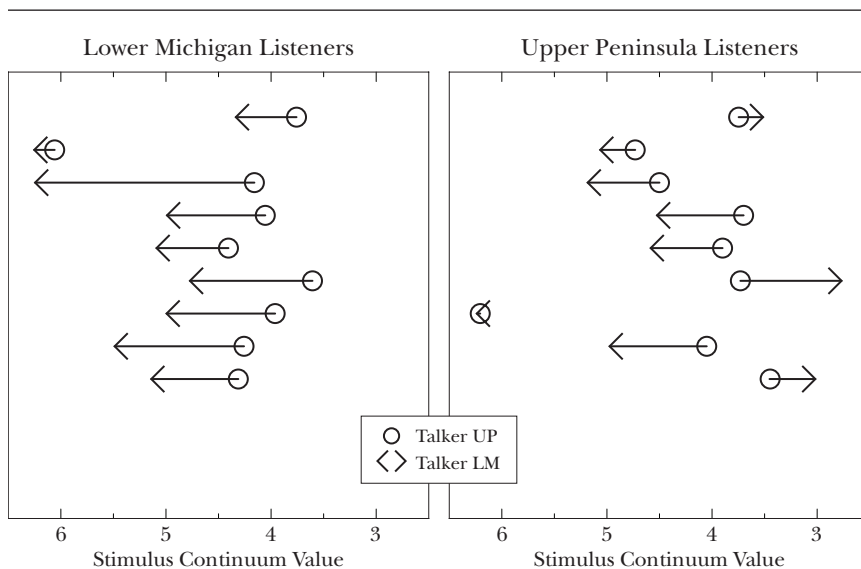
FIGURE 3  
Vowel Categorization Results for Young Adult Listeners  
from Michigan's Upper Peninsula  
(reported by Plichta and Rakerd 2010)



eral listeners who shifted in the opposite direction, and several more whose shifts were negligible in either direction. Hence, the response profiles for the listeners from the Upper Peninsula were quite individualistic.

Variation found in the responses of the Upper Peninsula participants likely warrants further study; however, one can speculate that pronunciation patterns of Lower Michigan, including NCVS, are influencing speech production and perception of at least some of the younger and more socially mobile inhabitants of the region. As noted by Remlinger, Salmons, and von Schneidmeyer (2009), the regional norms established through long-term

FIGURE 4  
Vowel Categorization Results Plotted Separately for Individual Listeners from  
Lower Michigan and Those from the Upper Peninsula



historical processes of settlement and migration are currently undergoing change mainly due to contacts with outsiders and economic processes.

In summary, notable differences between the Lower Michigan and Upper Peninsula listeners were found in their individual vowel categorization responses. The Upper Peninsula listeners exhibited idiosyncratic perceptual shifts. But for the listeners from Lower Michigan the results were highly consistent. Their perceptual shifts were always “fronted” and almost always substantial.

**INDIVIDUAL SENTENCE CARRIERS.** As noted above, talker LM and talker UP each produced four different carrier sentences for the perceptual test. Those sentences all presented a broad sampling of the talker’s vowels, including at least one exemplar of /a/ or /æ/. But the sentences were otherwise free to vary, and they differed in a number of ways: They differed substantially in overall length (the shortest was 10 words, the longest 17 words), in the nearness of an /a/ or /æ/ token to the target word (the most proximate was 2 words away, the furthest was 5 words away), and in the immediate phonetic environment of the target (the preceding word ended variously in a stop consonant, a fricative consonant, or an open vowel).

A crossover point analysis was conducted here to see whether these or any other differences among the sentences may have resulted in some sentences

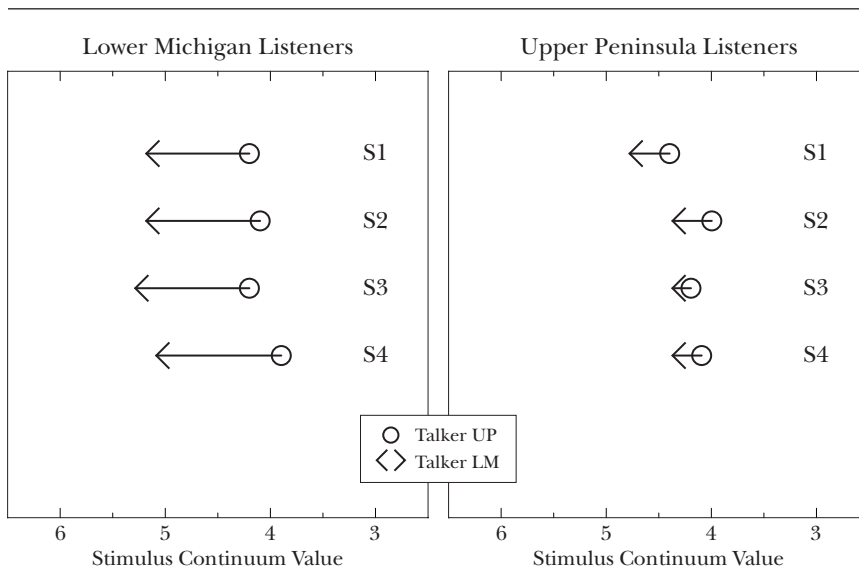


being more effective than others at eliciting a perceptual compensation for NCVS from either the Lower Michigan group or the Upper Peninsula group. A possibility of interest, specifically with regard to the Upper Peninsula listeners, was that they may have had some limited and shared sensitivity to NCVS, too limited to be seen for the study as a whole, but strong enough to be seen here for individual sentence carriers that were especially effective at eliciting an /a/-fronting response.

Results of the crossover point analysis are shown in figure 5. The panel on the left shows the perceptual shift that each of the four sentences elicited from the Lower Michigan listeners; the panel on the right shows the shift elicited from the Upper Peninsula listeners. The results were notably consistent for both groups. All four sentences elicited a substantial /a/-fronting response from the Lower Michigan listeners, as indicated by the sentence arrows each pointing left and extending for at least one step along the continuum. And all four sentences elicited at most a small response from the Upper Peninsula listeners, as indicated by the minimal arrow lengths.

These results support two new conclusions regarding Michigan listeners' perceptual sensitivity to NCVS. The first is that for Lower Michigan listeners the NCVS effect is robust over sentence carrier variations. The effect does not depend in any measurable way on any of the sentence differences

FIGURE 5  
Mean Vowel Categorization Results Plotted Separately  
for the Four Different Sentence Carriers

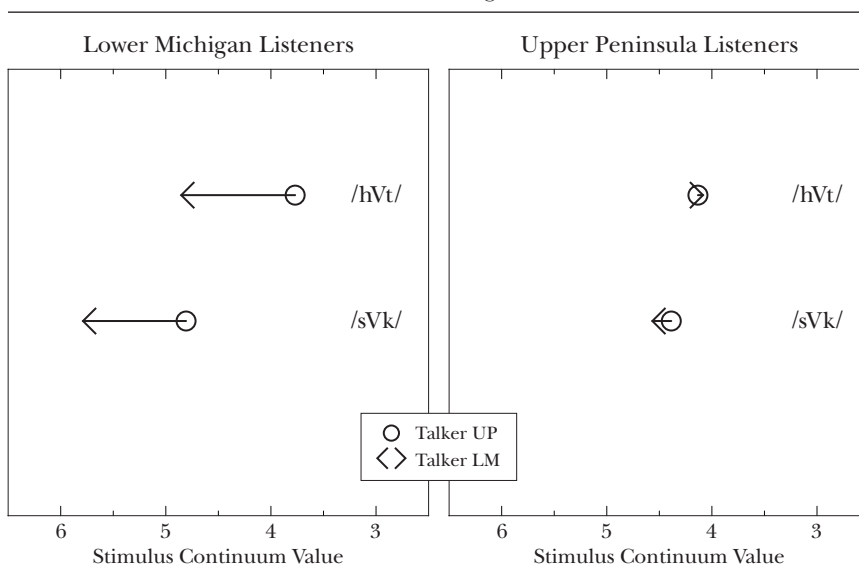


that were noted above. To the contrary, these results suggest that the effect can be elicited fully by any precursor that offers a reasonable sampling of a talker's vowels. An interesting question for future study will be to see how abbreviated such a sampling can be.

A possibility considered here regarding the Upper Peninsula listeners was that they do have some shared sensitivity to NCVS and that one or more of the precursor sentences would therefore elicit a substantial /a/-fronting response from the group. That did not prove to be the case. Instead, the response was found to be minimal in every instance. The general conclusion to be drawn regarding Upper Peninsula listeners is that they show no evidence of shared sensitivity to NCVS, very probably due to their limited exposure to NCVS variants.

**TARGET WORD DIFFERENCES.** Another dimension of stimulus variation concerned the target words. There were two target word series, one that varied from *hot* to *hat* and a second that varied from *sock* to *sack*. The vocalic nuclei of the words in these two series were identical, but there were notable differences in the adjacent consonants. The initial consonants differed in overall power and in their formant transitions; the final consonants differed in release burst spectra. Figure 6 shows the results of a crossover point analysis conducted to compare the two target word frames: /hVt/ and /sVk/.

FIGURE 6  
Mean Vowel Categorization Results Plotted Separately  
for the Two Different Target Word Frames

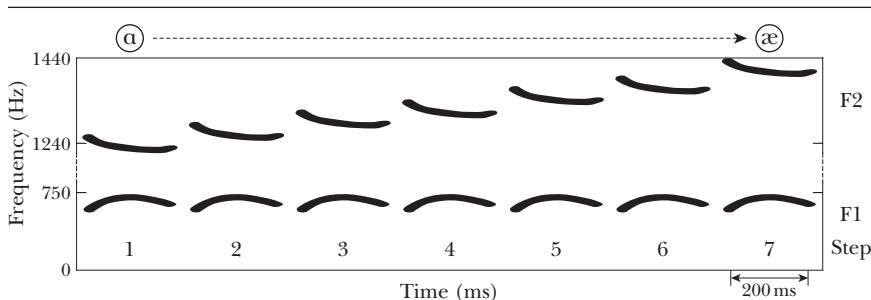


From the point of view of sensitivity to NCVS, the results of this target word analysis were the same as those of the sentence carrier analysis presented earlier (fig. 5). The listeners from Lower Michigan again showed a substantial and general /a/-fronting response, as indicated by the lengthy leftward-projecting arrows for both word frames. And the listeners from the Upper Peninsula again showed no evidence of perceptual sensitivity for either word frame, as evidenced by the fact that the arrows for /hVt/ and /sVk/ were oppositely signed and negligible in length.

But for the Lower Michigan group there was also a second, and unexpected, effect, one that did depend upon the word frame. The Lower Michigan listeners had crossovers for the /sVk/ word frame that were substantially more fronted along the stimulus continuum than were their crossovers for the /hVt/ frame. This word-level effect was present in responses to sentences produced by talker LM and talker UP, and it was substantial—more than one full step along the stimulus continuum—and statistically significant ( $F(1,8) = 19.758$ ;  $p < .01$ ). It was also approximately additive with the /a/-fronting effect of particular interest in this study, as evidenced by the absence of a statistical interaction between these two factors ( $F(1,8) = 0.087$ ;  $p > .05$ ). The Upper Peninsula listeners' responses for the /sVk/ frame were also more fronted than their responses for the /hVt/ frame, but that difference (approximately 0.25 continuum steps) was small compared to the results for the Lower Michigan group.

As noted above, formant frequencies for /hVt/ and /sVk/ were matched at the syllable centers, but formant trajectories differed according to the syllable frame. The trajectories differed considerably at the syllable onset, where /hVt/ had minimal formant transitions and /sVk/ had substantial ones. Figure 7 shows formant track plots for the stimuli in the /sVk/ sequence. All show significant formant movement at the beginning of the vocalic section, with F1 rising and F2 falling. Labov, Ash, and Boberg (2006) report that

FIGURE 7  
Formant Tracks for the Seven Stimuli along the /sVk/ Continuum



productions of /æ/ are frequently diphthongized by speakers of NCVS (their term for this is “Northern Breaking”). Their atlas provides two examples (figs. 13.12 and 13.13), and in both the vowel has a visibly rising F1 and a visibly falling F2 during an extended interval of diphthongal glide, similar formant trajectories to those synthesized here at the onset to /sVk/. Hillenbrand (2003) also found similar formant trajectories in his study of southern Michigan vowel productions. This type of change in formant frequencies over time, often called “tensing,” has recently been confirmed by ultrasound imaging of the articulations of /æ/ (De Decker and Nycz 2006).

Based on these findings, we offer a two-part conjecture to account for the present results: first, the onset transitions synthesized here for /sVk/ provided an inadvertent cue to NCVS /æ/ that biased perceptions toward a more fronted (/æ/-like) location along the stimulus continuum; and second, this cue was salient only for listeners who were regularly exposed to NCVS, namely, members of the Lower Michigan group. It has been known for some time that formant frequency cues to vowel identity can be both static and dynamic (Strange, Jenkins, and Johnson 1983; Verbrugge and Rakerd 1986). The present findings suggest that a listener’s sociolinguistic perceptions may likewise be cued by both static and dynamic formant features. Dynamic changes of F1 and F2 frequency over the first half of the nucleus have been previously found mostly in sociophonetic studies of speech production (e.g., Labov’s “Northern Breaking”). The fact that they seem to be salient in speech perception adds another dimension to the nature of NCVS and offers an interesting opportunity for further research.

#### DECISION REACTION TIMES

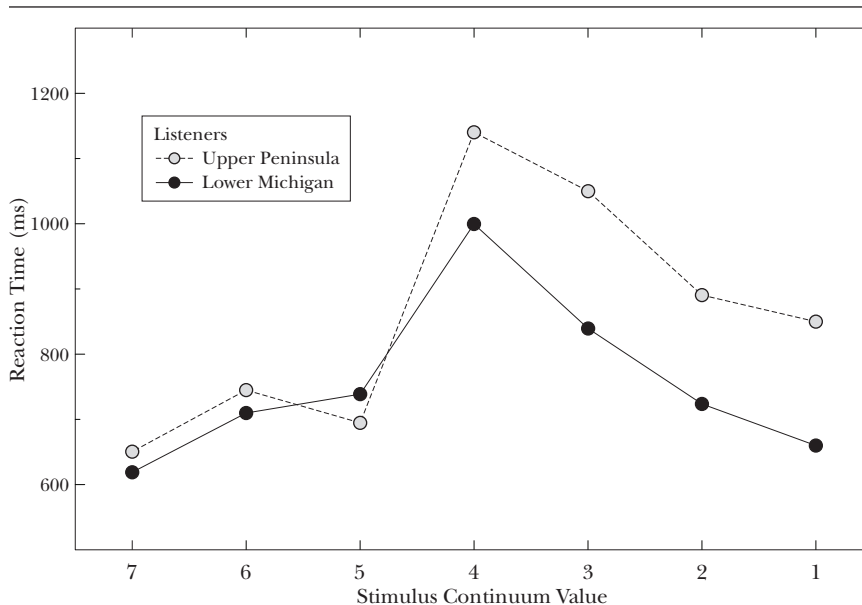
Reaction time data were collected for every listener and for every perceptual judgment. Specifically, the controlling computer recorded the time elapsed from the moment of target word onset to the moment of /a/ or /æ/ response entry. Data of this kind can provide information about perceptual categorization (Ford et al. 1982; Houlihan, Campbell, and Stelmack 1994; Lafond, Lacouture, and Cohen 2009). They were analyzed here to learn more about how listeners from Lower Michigan compared to the listeners from the Upper Peninsula when making their vowel category decisions, especially under conditions that invited a possible perceptual adjustment for NCVS.

TARGET WORDS IN CITATION FORM. As noted above, listeners were asked to categorize the vowels in target words that were presented in citation form. Altogether, the nine listeners in each group made 72 judgments at each step along the stimulus continuum (8 judgments per listener per step, half each

for the /hVt/ and /sVk/ word frames). Figure 8 shows the median reaction time for those judgments, plotted at each step along the stimulus continuum. There are separate plots for the Upper Peninsula listeners (open symbols) and for the Lower Michigan listeners (filled symbols). The shapes of the functions are very similar for the two groups, strongly suggesting that they had comparable sensitivity to the vowels at all points along the continuum.

Reaction times are expected to be low in instances where perceptual decision making is easy and higher in instances where it becomes more difficult. For both listener groups, there were minima in the reaction time functions at the endpoints of the continuum (steps 1 and 7). Presumably these endpoint stimuli were easily identified as tokens of /a/ or /æ/, and listeners therefore responded to them quickly. Both series also show evidence that decision-making became more difficult as the vowel category boundary was approached from both ends of the continuum. Specifically, as the step location got progressively closer to the midpoint of the continuum (step 4), reaction times increased almost monotonically. Finally, both reaction time functions peaked at step 4, indicating that the word category boundary was at or near step 4 for both listening groups.

FIGURE 8  
Median Reaction Time When Making Vowel Categorization Decisions  
Regarding Target Words Presented in Citation Form



TARGET WORDS IN SENTENCE CARRIERS PRODUCED BY TALKER UP. In the main experiment, the participants in each listener group made a total of 288 judgments at each continuum step when listening to targets presented in sentence carriers spoken by talker UP (32 judgments per listener per step, equally distributed over the 4 sentence carriers and 2 target word frames). Figure 9 shows the reaction time results for this condition.

Both listener groups were somewhat faster when reacting to the target words in this sentence context than they were when reacting to the citation form words. This is very likely a practice effect. The citation form word judgments were made first. The present judgments were made over the course of the main experiment, which came later and was extended. These judgments were also interspersed with judgments made in the context of sentences produced by talker LM. Hence the listeners became experienced at the task over time, which very likely speeded their responses.

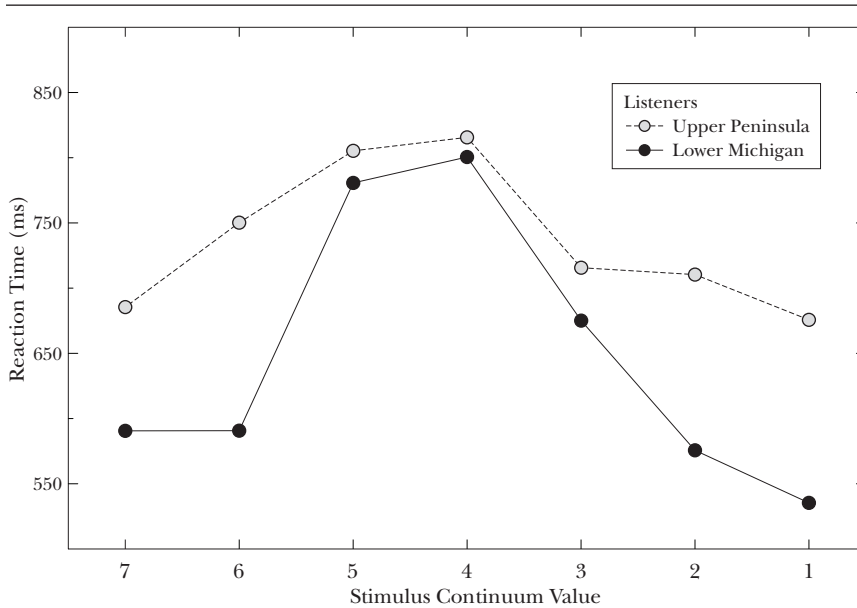
The patterning of the reaction time functions was similar for the two listener groups in this condition, especially near the middle of the stimulus continuum where the functions for both groups peaked. Specifically, the functions: (1) peaked at step 4, (2) declined slightly at step 5, and (3) declined more rapidly at steps above 5 and below 4, reaching minima at the continuum endpoints. An overall interpretation of these results is that for both groups the category boundary occurred somewhere between step 4 and step 5, with reaction times slowing as that boundary was approached from both ends of the stimulus continuum. This is consistent with the conclusion drawn earlier based on an examination of the listeners' overt response judgments. That analysis found that the crossover from /a/ to /æ/ occurred at step 4.3 for both respondent groups when they were listening to targets presented in sentences spoken by talker UP.

TARGET WORDS IN SENTENCES CARRIERS PRODUCED BY TALKER LM. Finally, figure 10 shows the reaction time results for target words presented in sentence carriers produced by talker LM. The overall speed of decision making in this condition was similar to that seen previously for targets presented in sentences produced by talker UP (fig. 9).

The Upper Peninsula listeners showed good evidence of having an /a/-/æ/ category boundary somewhere near the middle of the stimulus continuum in this condition—specifically, at step 4. Hence their boundary location was similarly located at or near step 4 for the citation form word condition, for the talker UP condition, and finally for this condition where the sentences were produced by talker LM.

Results for the listeners from Lower Michigan were quite different. For this group the reaction time peak was considerably further front for talker

FIGURE 9  
 Median Reaction Time When Making Vowel Categorization Decisions Regarding  
 Target Words Embedded in Sentence Carriers Produced by Talker UP

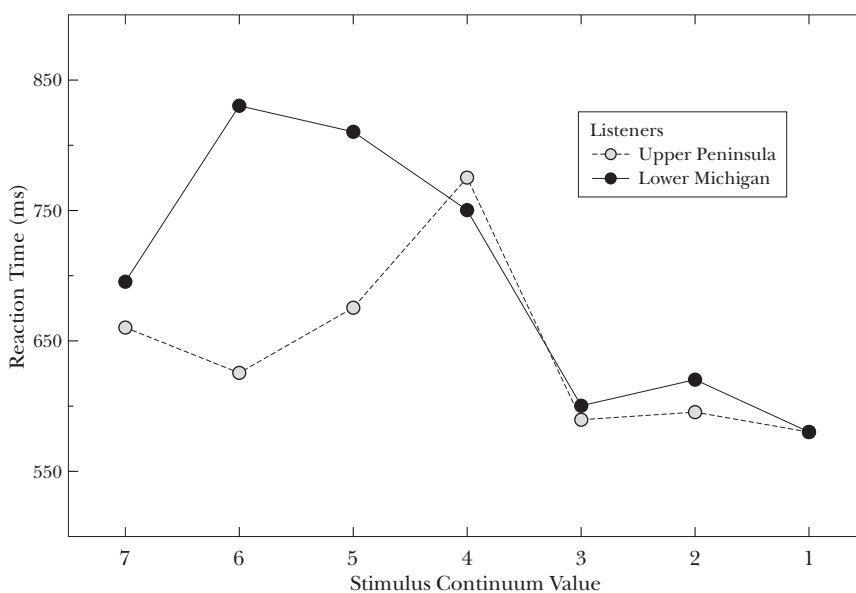


LM than it was for talker UP (and for the citation form words). Reaction times for this group were in fact visibly longer at step 5 than at step 4 (with a difference of 60 msec), and longer still at step 6. This strongly suggests that the Lower Michigan group made a perceptual adjustment for NCVS when listening to the speech of talker LM. Specifically, the evidence indicates that their category boundary became more fronted by at least one and perhaps two steps along the stimulus continuum. Hence, these reaction time results provide new evidence that Lower Michigan listeners are sensitive to NCVS and, specifically, that they make a perceptual adjustment for /a/-fronting when given access to a sentence-length sampling of the talker's vowels.

#### SUMMARY AND CONCLUSIONS

The present study is one of a growing number revealing sociolinguistic influences on vowel perception. In a study also involving listeners from Michigan, Niedzielski (1999) showed that vowel perception can be affected by a listener's beliefs about the nationality of a talker. She presented the same speech sample to two groups of listeners from the Detroit area, telling one group

FIGURE 10  
 Median Reaction Time When Making Vowel Categorization Decisions Regarding  
 Target Words Embedded in Sentence Carriers Produced by Talker LM



that the talker was also from Detroit and telling the other that the talker was from Canada. When both groups were then asked to select vowel exemplars that represented best matches to the vowels that they heard, Niedzielski found that the selections differed markedly across the two groups.

More recently, Hay, Warren, and Drager (2006) demonstrate that perception of diphthongs involved in a merger in progress (as in words *near* and *square*) can be influenced by a variety of talker-dependent and listener-dependent factors, including social class and age information perceived from a photograph of the talker. They argue that their results provide support for a model of speech perception in which exemplars are socially indexed. Studies like these are contributing importantly to our understanding of perceptual dialectology (e.g., Preston 1999).

The present study investigated a perceptual effect involving the Northern Cities Vowel Shift (NCVS), which is well advanced in the Detroit area of Lower Michigan and largely absent in Michigan's Upper Peninsula (Gordon 2001; Labov, Ash, and Boberg 2006). One manifestation of NCVS is fronting of the vowel /a/. In a previous investigation (Plichta and Rakerd 2010), we found evidence that listeners from Lower Michigan made a perceptual adjustment for /a/-fronting when given information about a talker's dialect



(a sentence-long speech sample), but listeners from the Upper Peninsula did not. Here, we further examined this phenomenon. Vowel categorization judgments made by listeners from Lower Michigan and from the Upper Peninsula were examined here to provide information about individual differences regarding sensitivity to NCVS and about stimulus conditions that may be expected to elicit an NCVS perceptual response. Also, an analysis of reaction time data provided new information about listeners' decision making when categorizing vowels and, in particular, about a potential shift in the /a/-/æ/ category boundary when the listeners were exposed to a speech sample marked by NCVS. The findings of the study were as follows:

1. Perceptions of /a/-fronting were found to vary idiosyncratically among young adult listeners from the Upper Peninsula. In contrast, those same perceptions were found to be highly regular among young adults from Lower Michigan. The latter group consistently shifted the /a/-/æ/ category boundary to a more fronted location in the vowel space when exposed to a speech sample produced by a talker who participated in NCVS.

2. The /a/-fronting response by Lower Michigan listeners was found to be elicited approximately equally by sentences that differed in length, in the proximity of prior exemplars of /a/ or /æ/, and in their phonetic details. This indicates that the perceptual effect is quite robust for this listener group and most likely can be elicited by any precursor that offers a reasonable sampling of the talker's vowels.

3. It was conjectured that as a group listeners from the Upper Peninsula do have some limited sensitivity to NCVS and that this would be revealed in their response patterns for individual sentence carriers that were particularly effective at eliciting the /a/-fronting perceptual shift. That conjecture was not supported. To the contrary, this group showed little or no sensitivity to NCVS for any of the sentence carriers tested here and would not be expected to show it for any other eliciting stimulus.

4. There were two target word series (*hot-hat* and *sock-sack*), which differed in their initial and final consonants and in the transitions into and out of those consonants. A comparison of /a/-fronting for these word series again indicated that the perceptual effect is robust for Lower Michigan listeners and essentially absent for Upper Peninsula listeners.

5. A second result regarding the target words was found here. It pertained to the Lower Michigan listeners only. Their /a/-/æ/ boundary for the /sVk/ word frame was found to be more fronted than the boundary for the /hVt/ frame. This word-level difference was approximately additive with the NCVS perceptual effect of primary interest in this study. We hypothesize that the formant transition slopes in the first half of the /sVk/ vowel nucleus provided Lower Michigan listeners with additional NCVS cues (consistent with Labov's

“Northern Breaking”) and thus caused further perceptual shifting of the category boundary toward /æ/.

6. Reaction-time functions for the Lower Michigan and Upper Peninsula listeners were found to be similar at all points along the stimulus continuum for target words presented in citation form, strongly suggesting that the two groups had comparable perceptual representations of /a/ and /æ/ in this context.

7. When the target words were presented at the ends of sentences produced by a talker from the Upper Peninsula (talker UP), the reaction-time functions were again similar for the two listener groups, especially with respect to the positioning of the /a/-/æ/ category boundary. For both groups, the boundary location was near the middle of the stimulus continuum and near to its location for the citation-form presentation condition.

8. Finally, when the target words were presented at the ends of sentences produced by a talker from Lower Michigan (talker LM), the reaction-time functions were substantially different for the two listener groups. For Upper Peninsula listeners, the reaction times showed evidence of /a/-/æ/ categorization similar to that for the other two conditions (i.e., somewhere near the middle of the 7-step stimulus continuum). But for the Lower Michigan listeners, reaction times showed strong evidence of perceptual sensitivity to NCVS, with the /a/-/æ/ category boundary shifted to a significantly more fronted location along the stimulus continuum.

#### NOTES

1. Fifty different monosyllabic words were produced four times each in random order. The word list included multiple instances of each vowel shown in figure 1, with variation in the word-initial and word-final consonants (Plichta 2005).
2. All other synthesis parameters, including the f0 contour (linearly falling from 120 Hz to 100 Hz) and the frequencies of F1 (750 Hz), F3 (2500 Hz), and F4 (3500 Hz), were held constant. The specific F2 values used here were selected on the basis of a pilot study of stimuli spanning a larger range (an 11-step continuum extending from 1175 Hz to 1510 Hz).

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