Shifting Chicago vowels: prosody and sound change

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Abstract

This study investigates the relationship between variation due to prosodic prominence and variation due to sound change. We compare two hypotheses: *under prominence vowels move in the direction of vowel shift*, and *under prominence vowels are hyperarticulated*, and move to positions more peripheral in the vowel space. These hypotheses make competing predictions for two vowels currently undergoing change in Chicago American English, /ɛ/ and /uw/. Labov [1] reports that in the Chicago variety, which participates in the Northern Cities vowel shift, the most recent changes have affected the vowels /ɛ/ and /ʌ/, both of which have been retracting since about 1980. In addition, as in many other contemporary varieties of English, the vowel /uw/ has been reported to be fronting. This fronting is not necessarily part of the general vowel shift. An acoustic analysis of controlled vowel productions from 20 speakers in their twenties shows that prominence effects are consistent with the hypothesis of prominence as local hyperarticulation, but do not generally support the claim that prominence and vowel shift effects are in the same direction. The findings also reveal /uw/ fronting as a change in progress, with greatly more variation in the front/back dimension than for other vowels, in all prosodic contexts. Other effects of prominence on vowel height are discussed as indicators of future vowel changes in this variety.

1. Introduction

Variation in the production of speech sounds can be observed on two time scales. On a long time scale, we may observe differences in the phonetic realization of phonemes over years (in real time) and across generations of speakers (in apparent time), which reflect diachronic sound change. On a short time scale, it is common to observe fine-grained, phonetic differences in phonemes that occur in different phonological contexts or under different speaking conditions, across utterances produced on different occasions by a single speaker. This paper asks about the relationship between variation at these two time scales. We focus on variation in vowel production, examining variation due to prosody (a component of the phonological context) and variation due to recent and ongoing sound change. The immediate goal is to determine if prosodic prominence interacts with vowel shift, such that vowel productions in prominent positions are more advanced along the direction of the shift (i.e., have moved farther along the trajectory of the shift, in acoustic space). Our broader aim is to investigate the role of prosodic variation as a possible source of sound change affecting vowels.

The language we examine is younger-generation Chicago American English. This is an American English variety that participates in the Northern Cities Vowel Shift. The most recent changes within the general reorganization of the vowel space that have been reported for this dialect involve the vowels /ɛ/ (as in *pet*) and /ʌ/ (as in *cut*). Labov [1: 185-195] points out that both of these vowels have acquired a more retracted position starting in the late 1970s and 1980s. In addition, and unrelated to this shift, we are witnessing the fronting of /uw/ (as in *food*), a change that is currently taking place in many English varieties, both in North America and elsewhere. This fronting of /uw/ can be considered to be an independent sound change, and not part of the system of vowel shift that has affected /ɛ/ and /ʌ/, since this vowel moves into a previously unoccupied location in the vowel space of English, that of high central vowels (although, in very advanced stages of fronting, /uw/ may start to encroach upon the domain of /ij/).

Referring to vowel data from speakers of the Northern Cities dialect in Chicago, Labov [1: 195] observes that "the most highly stressed vowels tend to move further in the direction of the change in progress." Labov's remarks are, for the most part, limited to vowels with primary vs, secondary word-level stress, although he makes some reference to emphatic stress. But if we consider the stress effect he observes as an instance of the more general phenomenon of 'strengthening' due to prosodic prominence, then we find that this effect is exactly opposite from the effects of prominence that are normally found in leniting or reductive sound changes [2,3]. In lenition processes we expect the most advanced tokens (most lenited) to occur in the prosodically weakest positions. That is, a lesser degree of prominence should result in more reduction and, therefore, in targets that are further along the lenition path. The vowel shift that is occurring in the Chicago dialect crucially differs from lenition processes in that only stressed vowels are affected. These sound changes, thus, would appear to have a different directionality than lenitions, which may account for current controversies concerning the nature of sound change when no distinctions are made between these two types of changes [4,5].

In this study we ask whether vowel shift, as a sound change that targets *stressed* vowels, is different from other kinds of sound change in terms of its relationship to prosodic variation. Generalizing from Labov's claim about the relationship between stress and vowel shift, we formulate the **Prominence-Shift Hypothesis:** vowels in prominent positions will be more advanced along the direction of the ongoing vowel shift compared to vowels with lesser prominence. Vowels produced in positions with weaker levels of prominence are expected to exhibit smaller displacement due to vowel shift, and/or greater variability in their acoustic realization with some tokens that are advanced in the direction of the shift, and others that are not.

A competing hypothesis about the relationship between vowel shift and prominence comes from the model of prominence effects as enhancing phonological contrasts, by means of local hyperticulation [6]. The **Hyperarticulation Hypothesis** predicts that vowels in prominent position will be located on the periphery of the vowel space, in locations that ideally realize their distinctive place features. These two hypotheses make conflicting predictions in cases where vowel shift is repositioning a vowel away from its idealized location in acoustic space, as with the retraction of the phonologically front vowel /ɛ/ in the Northern Cities Vowel Shift system. Under the Prominence-Shift Hypothesis, this vowel should exhibit greater retraction under prominence, whereas the Hyperarticulation Hypothesis predicts realizations under prominence that are more front, and therefore less advanced along the vowel shift trajectory.

We test the competing predictions of these hypotheses against data from 6 vowels in the speech of young Chicago

speakers: /ij/ (as in *peek*), /ej/ (*mate*), /ɛ/ (*pet*), /ʌ/ (*cut*), /ow/ (*goat*) and /uw/ (*duke*). As mentioned, three of these vowels are reportedly involved in sound change in progress. The other three vowels help define the vowel space. Under the Prominence-Shift Hypothesis, we predict /ɛ/ and /ʌ/ will exhibit backing (lower F2) under prominence, while the Hyperarticulation Hypothesis predicts fronting of /ɛ/ and backing of /ʌ/. For the vowel /uw/, the Hyperarticulation Hypothesis predicts backing under prominence, under the assumption that /uw/ retains its phonological status as a back vowel. Under a strict interpretation, the Prominence-Shift Hypothesis does not offer any prediction about the effect of prominence on /uw/ since that vowel is not part of a chain shift system. But under a more general interpretation of that hypothesis as pertaining to any sound change that targets stressed vowels, we predict greater fronting of /uw/ under prominence. The remaining three vowels that we study, /ij, ej, ow/, are not involved in sound changes in progress reported for this dialect, so the Prominence-Shift Hypothesis offers no predictions. For these vowels, the Hyperarticulation Hypothesis predicts increased fronting of /ij/ and /ej/ under prominence, and backing of /ow/.

2.   Methods

Data on the realization of vowels in different prosodic contexts is obtained from read productions of a set of monosyllabic words, all of which end with either /t/ or /k/. For each of the six test vowels there were five different target words (all nouns), for a total of 30 target words. The complete list is given in (1):

(1) Target vowels

/ɛ/	*bet, check, deck, net, pet*
/ʌ/	*buck, cut, duck, nut, putt*
/ej/	*bait, cake, gate, lake, mate*
/ij/	*beet, leek, peak, seat, sheet*
/ow/	*boat, coke, goat, moat, oak*
/uw/	*duke, root, scoot, spook, suit*

Each target noun was embedded in a noun phrase consisting of Det-Adj-N, which followed the verb and was the verb complement in a meaningful sentence. Example sentences are shown in (2) for the target words *nut*, *bet* and *lane*, respectively.

(2) Sample sentences
The mechanic dropped a tiny <u>nut</u> into the engine.
He made a legal <u>bet</u> with the owner.
The driver merged into a bumpy <u>lane</u> on the highway.

The focus condition of the target word was varied to elicit variation in the phrasal prominence associated with the target word. The contrastive focus condition was used to elicit the most emphatic production of phrasal prominence; the broad focus (new information) condition was used for less emphatic phrasal prominence, and the 'given' (old information) condition was used to elicit the target word with no phrasal prominence. For the 'given' condition, contrastive focus was assigned to the adjective preceding the target noun, so the target noun was in postfocus position. Each focus condition was elicited by a preceding interrogative context sentence for which the target sentence would be an appropriate answer. The context sentence and target sentence were presented on the computer screen, with contrastive focus words in boldface. Examples are given in (3).

(3) Question/Answer pairs for the word ***pun***
Broad Focus condition:
    Q: What happened?
    A: The teacher made a witty pun during the lecture.
Contrastive focus condition:
    Q: Did you say the teacher made a witty joke during lecture?
    A. No, the teacher made a witty **pun** during lecture.
Postfocus condition:
    Q: Did you say the teacher made a boring pun during lecture?
    A. No, the teacher made a **witty** pun during lecture.

Question/answer pairs were presented one at a time on the computer screen in a self-paced PowerPoint presentation. The three question/answer pairs for the same target word were always presented in immediate succession, with the broad focus condition first, followed by contrastive focus and postfocus conditions, in that order. Sentence sets for the 30 target words were randomly ordered but the same ordering was used for all subjects.

Subjects were asked to read the context question silently and the target sentence aloud, with appropriate intonation. Before the participants read the experimental sentences they were given practice examples to verify that they understood the task. The experiment took place in a sound-attenuated booth in the Phonetics and Phonology Laboratory of the University of Illinois. Subjects were recorded using an AKG C520 head-worn condenser microphone and a solid-state digital recorder, with a sampling rate of 44.1 kHz.

Participants in this study were recruited from the undergraduate and graduate student population at the University of Illinois at Urbana-Champaign, were monolingual speakers of American English between the ages of 20-30, and met the requirement of having grown up from early childhood in the Chicago metropolitan area. Participants were paid $8 on completion of the experiment. In this paper we report on data from 20 subjects (10 female, 10 male).

Target vowels were manually segmented based on auditory impression and visual cues from waveforms and spectrograms. F1 and F2 values at 25%, 50% and 75% of the duration of the vowel were automatically extracted using the Praat burg algorithm [7], with the recommended settings for males and female speakers. Outlier formant values were rechecked and errors in formant tracking were manually corrected. All formant values were converted to Bark prior to statistical analysis. We report only on midpoint formants here.

The present study is concerned with differences in the location of vowels in an individual speaker's acoustic space across the three prominence/focus conditions. For this purpose, and to be able to combine speaker data, vowels were normalized within speaker with reference to the center of the speaker's vowel space in each prominence/focus condition. For each vowel token, normalized formant values were calculated by taking the mean F1 (or F2) value over all 30 tokens of the six vowel phonemes occurring in the same prominence/focus condition and subtracting that mean from the observed F1 (or F2) value of the target vowel (all measurements in Bark). Because ANOVA on standard deviations showed no significant differences across prominence/focus conditions for any vowel, standard deviation was not included as a factor in normalization.

Separate ANOVA were conducted for each vowel phoneme category, with normalized formant measures as the dependent variable and prominence/focus condition as the independent variable. For all vowels that showed a significant main effect of prominence, mean formant values were

compared across the prominence/focus conditions to determine the direction of the deviation in F1 and F2 under prominence.

3. Results

3.1. Formant values at vowel midpoint

Table I shows ANOVA results comparing normalized formant measures across prominence/focus conditions for 20 speakers. The three conditions are broad focus (B) contrastive focus (C), and postfocus (P). There are 300 vowel tokens in each target vowel category (5 words × 3 conditions × 20 speakers), with 100 in each of the three prominence/focus conditions. As can be seen, significant differences always involve the C condition, with one marginal difference between B vs. P on F1 for the vowel /uw/. In several cases, there are significant differences between C vs. B *and* C vs. P, while in other cases, the difference is only between C vs. P.

Starting with the vowels that have been reported to be involved in sound changes in progress, the statistical analysis shows that /ɛ, ʌ, uw/ are all lower under contrastive focus than in the other two prominence/focus conditions. There are no effects of prominence/focus on the backness of /ʌ/, while /ɛ/ is fronted and /uw/ is backed under contrastive focus. The backing effects of prominence/focus on /ɛ/ and /uw/ are contrary to the predictions of the Prominence-Shift Hypothesis, since the movement under prominence is contrary to the direction of the change in progress, but the effects confirm the predictions of the Hyperarticulation Hypothesis.

As for the other vowels, /ij, ej, ow/ are all more peripheral under contrastive focus, with /ij, ej/ showing raising and fronting effects of contrastive focus, and /ow/ showing backing and lowering. These effects confirm the predictions of the Hyperarticulation Hypothesis.

Table I. *ANOVA and Scheffe post-hoc results for effects of prominence/focus on normalized F2 and F1 at V midpoint for 20 speakers. Results are marked as significant at p<.05 (*) or p<.01 (**). The direction of the effect in the Contrastive condition relative to the other conditions is shown as fronting, backing, lowering or raising. N=100 in each condition.*

	ɛ		ʌ	
	F2	F1	F2	F1
Prom/foc	.020 *	<.001 **	.317	<.001 **
Post-hoc	C:B* fronting	C:P** C:B** lowering		C:P** C:B** lowering
	ij		ow	
	F2	F1	F2	F1
Prom/foc	.001 **	<.001 **	.008 **	.007 **
Post-hoc	C:B** C:P ** fronting	C:P** C:B** raising	C:P * C:B * backing	C:P* C:B* lowering
	ej		uw	
	F2	F1	F2	F1
By cond.	.001 **	.007 **	.001 **	.014 *
Post-hoc	C:B* C:P** fronting	C:P** raising	C:P** C:B* backing	C:B*, B:P(.054) lowering

Inspection of standard deviations for each vowel as a function of prominence/focus condition shows the vowel /uw/

to be more variable than the other five vowels examined here (Fig. 1). F2 of /uw/ is more variable under all focus conditions, but F1 is more variable only under contrastive focus. These findings show /ij/ to be the most compact vowel category in acoustic space, and /uw/ to be the vowel category with the greatest spread.
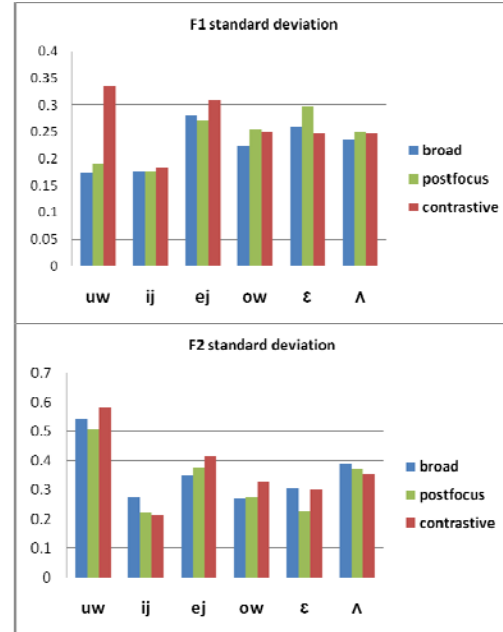

Figure 1. *Standard deviation of F1 (top panel) and F2 (bottom) by vowel for each prominence/focus condition.*

Although there are differences across individual speakers in the details of how prominence/focus affects F1 and F2 of each vowel, we observe that the effects are always in the same direction across speakers. For example, for all speakers who show an effect of contrastive focus on F1 and F2 of /ij/, the effect is one of raising and fronting. No speaker presents an opposing pattern of vowel displacement under contrastive focus, for any vowel. The consistency of the effects across speakers is indicative that we are dealing with a homogenous dialect.

We provide an illustrative vowel plot for a representative speaker in Fig. 2. The contrastive focus vowels (red markers) are more peripheral in the vowel space for all vowels but /uw/. Tokens of /uw/ are highly variable in backness (F2), though other speakers show a slight trend towards increased backness of /uw/ under contrastive focus. The lowering of /ɛ/ and /ʌ/ under contrastive focus is especially remarkable. Notice also that /ɛ/ occupies a very central position, abutting /ʌ/. This is a general characteristic of speakers in this dialect group.

3.2. Vowel duration

The general effect of prominence/focus condition that we observe from formant measure is that vowels are more peripheral under contrastive focus compared to broad or postfocus conditions. These effects may be attributed to the greater duration of vowels under contrastive focus when emphasized, since longer duration allows for a more precise articulation of maximally distinctive acoustic target. In our
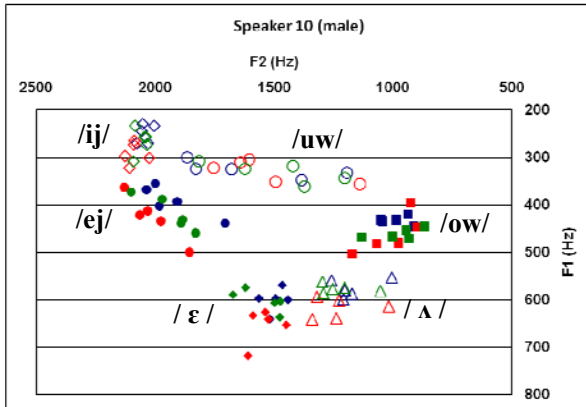
Figure 2. *Vowel plot for a male speaker. F1 and F2 values (Hz) taken from mid point for all tokens. Contrastive focus-red; Broad-blue; Postfocus-green.*

data, there is a significant effect of prominence/focus on vowel duration (F[2,1790]=34.86, *p*<0.001). Planned comparisons show that vowels under contrastive focus are significantly longer than broad focus or post-focus, but broad focus and post-focus durations are not distinct, see Table II. However, it appears unlikely that the effects of prominence/focus on vowel formants can be fully attributed to duration. There is a main effect of vowel type on duration (F[5,1792]=50.62, *p*<0.001), but although /ej/ and /ow/ are significantly longer in mean duration across conditions compared to other vowels (by Scheffé post-hoc *p*<0.001; see Table III), these vowels do not exhibit the greatest effects of prominence/focus on formant values. As can be seen in Fig. 1 above, among the six target vowels, /ej/ and /ow/ are not more variable across prominence/focus conditions than other vowels. Moreover, F2 of the vowel /uw/ exhibits the greatest variance, but /uw/ ranks only third in mean duration among these six vowels.

Table II. *Mean (s.d.) duration (ms.) by prominence/focus condition, pooled over all vowels, all speakers. 600 vowel tokens in each condition.*

	broad	postfocus	contrastive
V duration	120 (27)	121 (28)	133 (33)

Table III. *Mean (s.d.) duration (ms.) by vowel, pooled over prominence/focus conditions and speakers. 300 vowel tokens in each phoneme category.*

	uw	ij	ej	ow	ε	ʌ
V dur	121 (25)	115 (26)	137 (31)	142 (30)	117 (29)	117 (28)

4. Conclusions and discussion

The findings from this study reveal a complex pattern of effects from prominence/focus on vowel formants. Generally, we observe fronting of front vowels and backing of back vowels (except /ʌ/) under contrastive focus, and variable effects on vowel height. Also, all vowels are longer under contrastive focus. These findings support the Hyperarticulation Hypothesis, with prominence effects as local hyperarticulation in the front/back dimension. The findings are not consistent with the predictions from the Prominence-Shift Hypothesis, since we do not observe that prominent vowels have moved farther along the trajectory of the sound change.

One interpretation of these findings is that the failed predictions of the Prominence-Shift Hypothesis applied to /ε/ and /ʌ/ reflect the completion of the vowel shift for these speakers. We observe that all the speakers in our study produce /ε/ as a central vowel, typically abutting /ʌ/. The present locations of the vowels may be their endpoints along the backing trajectory, since any further backing vowels might encroach on the region of the adjacent vowel /ɔ/ (as in *'dog'*). The fact that /ε/ undergoes fronting under contrastive focus is an indication that this now central vowel retains its phonological status as a front vowel.

The results indicate consistent lowering of the back vowels and /ε/ under prominence, and we observe that this lowering effect can be substantial for /ε/ and /ʌ/ for some subjects. If the Prominence-Shift Hypothesis is correct, that is, if the evolving targets of lexically-stressed vowels appear first in the most prominent positions before spreading to positions of lesser prominence, then the lowering effect of prominence seen in our data might presage a future sound change for this vowel system. The next step in the Chicago vowel shift system may be the lowering of /ε/ and /ʌ/. It bears mention that Labov [1:192] notices a similar pattern of lowering for /ε/ under primary stress for one Chicago speaker, a pattern that is contrary to the general model of vowel shift he proposes for Chicago. Our data indicate that this is a robust pattern for at least some young Chicago speakers today.

Finally, these findings confirm the fronting of /uw/ in the speech of young Chicagoans. If the Prominence-Shift Hypothesis applies to this sound change, we expect maximal fronting under contrastive focus. Yet despite the variability of this vowel, not a single speaker shows fronting under contrastive focus. On the other hand, some speakers show backing under contrastive focus. For the remaining speakers, the /uw/ tokens are widely dispersed along the front/back continuum, with the modal value being central. Of course, if the Prominence-Shift Hypothesis is restricted to vowels that are part of a chain shift, then it may simply not apply to /uw/. In this regard we note the same fronting phenomena is taking place in a number of English varieties with very different vowel systems, both in North America (West and South) and elsewhere in England, Australia and New Zealand.

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