Effects of semantic predictability and regional dialect on vowel space reduction

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This study explored the interaction between semantic predictability and regional dialect variation in an analysis of speech produced by college-aged female talkers from the Northern, Midland, and Southern dialects of American English. Previous research on the effects of semantic predictability has shown that vowels in high semantic predictability contexts are temporally and spectrally reduced compared to vowels in low semantic predictability contexts. In the current study, an analysis of vowel duration confirmed temporal reduction in the high predictability condition. An analysis of vowel formant structure and vowel space dispersion revealed overall spectral reduction for the Southern talkers. For the Northern talkers, more extreme Northern Cities shifting occurred in the high predictability condition than in the low predictability condition. No effects of semantic predictability were observed for the Midland talkers. These findings suggest an interaction between semantic and indexical factors in vowel reduction processes.
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I. INTRODUCTION

Temporal and spectral vowel reduction has many sources, including lexical, semantic, and stylistic factors. At the lexical level, unstressed vowels are temporally and spectrally reduced relative to stressed vowels (Fourakis, 1991; Lindblom, 1963), vowels in high frequency words are temporally and spectrally reduced relative to vowels in low frequency words (Munson and Solomon, 2004), and vowels in words with few phonological neighbors (low density words) are temporally and spectrally reduced relative to vowels in words with many phonological neighbors (high density words; Munson and Solomon, 2004; Wright, 1997).

At the semantic level, predictable words are reduced relative to unpredictable words and repeated words are reduced relative to new words. Lieberman (1963) described the results of a series of studies in which talkers were recorded reading meaningful English sentences. The target word in each sentence was either highly predictable (e.g., nine in A stitch in time saves…) or unpredictable (e.g., nine in The number that you will hear is…). Lieberman (1963) found that the unpredictable words tended to be longer in duration, higher in amplitude, and pronounced with what he described as more precise articulation than the highly predictable words. As a result, when the words were excised from the sentence contexts and played back to naïve listeners, the unpredictable words were more intelligible overall than the predictable words. Similarly, Fowler and Housum (1987) found that words that had been used previously in an utterance were temporally reduced compared to words that were used for the first time. Like the unpredictable words in Lieberman's (1963) study, the "old" words in Fowler and Housum's (1987) study were also less intelligible when excised from running speech than the "new" words.

Jurafsky *et al.* (2001) analyzed a corpus of American English telephone conversations and found that function words were more likely to be reduced in both duration and vowel quality when the conditional probability of the target word given the previous word was high. For content words, they also found that duration was inversely correlated with the conditional probability of the target word given the preceding word. In addition, the relative frequency of the target word and the preceding word interacted, such that higher frequency targets were more reduced, whereas targets following high frequency words were less reduced.

Scarborough (2006) explicitly examined the relationship between lexical and semantic factors in vowel reduction and found an additive effect between semantic predictability and lexical neighborhood, such that "easy" words (high frequency words with few lexical neighbors) in high predictability semantic contexts were the most reduced, both spectrally and temporally, whereas "hard" words (low frequency words with many lexical neighbors) in low predictability semantic contexts were the least reduced.

With respect to speaking style, vowels in faster speech are spectrally reduced relative to vowels in slower speech (Fourakis, 1991) and vowels in plain or conversational speech are spectrally and temporally reduced relative to vowels in clear speech (Lindblom, 1990; Picheny *et al.* 1986). Taken together, the lexical, semantic, and stylistic effects on vowel reduction suggest a model of production in which the phonetic targets for individual vowels are hyperarticulated relative to what is typically produced (Johnson *et al.* 1993). According to this account, talkers selectively reduce vowels based on current processing constraints in production and potential listener-oriented constraints, such as noise, native language background, or hearing impairment (Lindblom,

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1990). Thus, high frequency and low density words, semantically predictable words, and casually produced speech all exhibit vowel reduction relative to low frequency and high density words, semantically unpredictable words, and carefully produced speech.

A. Vowel reduction and dialect variation

Several recent studies have obtained evidence for an interaction between vowel reduction processes, such as those described above, and indexical sources of variability. For example, Scarborough (2006) observed a greater effect of lexical neighborhood density on spectral reduction for /o/ than for the other vowels she measured. One possible explanation for her finding is that her talkers were from California and exhibited fronted /o/'s in their speech. It is well documented in the sociolinguistic literature that participants produce more dialect-specific variants in less formal settings, such as interview speech, than in more formal settings, such as reading passages or word lists (e.g., Labov, 1972). This effect of formality on dialect variation is similar to the effect of clear versus conversational speaking styles on vowel reduction, in that both effects may reflect a listener-oriented attempt on the part of the speaker to better approximate a set of hyperarticulated and/or standard variants. Thus, Scarborough's (2006) density × vowel interaction may reflect the effects of both dialect-specific /o/ fronting and lexically induced spectral reduction of the /o/ in low density words.

Similarly, Munson (2007b) observed an interaction between lexical density and gender typicality for the male talkers in his study of vowel space reduction. The effect of gender typicality on vowel space reduction was significant for the male talkers for the easier, low density words, but not for the harder, high density words. Together, Scarborough's (2006) and Munson's (2007b) results suggest that greater indexical variability may be observed under the same conditions in which vowel reduction is typically observed. However, Jacewicz *et al.* (2006) reported more extreme dialect variants in prosodically strong positions compared to prosodically weak positions, suggesting that some nonreduced contexts may also favor indexical marking.

The current study was designed to explore the relationship between the effects of dialect variation and semantic predictability on vowel reduction. Specifically, we examined the degree of Northern Cities vowel shifting across two semantic contexts: high predictability and low predictability. The Northern Cities Chain Shift (NCCS) involves the fronting and raising of /æ/, the lowering and fronting of /ɑ/, the lowering and fronting of /ɔ/, the backing and/or lowering of /ɛ/, the backing of /ʌ/, and the backing of /ɪ/ (Labov, 1998). A schematic of the NCCS is shown in Fig. 1. The NCCS is typically adopted in sequential order, beginning with the raising and fronting of /æ/, as indicated by the numbers in Fig. 1 (Labov *et al.*, 2006). It should also be noted that for some of the vowels, the NCCS and overall vowel reduction processes pull the vowels in different directions in the F1 × F2 space. For example, both the NCCS and vowel reduction can lead to raising of /æ/, but the NCCS produces /æ/ fronting and vowel reduction produces /æ/ backing. Thus, the interaction between the two processes for /æ/ should be reflected along the F2 dimension more than the F1 dimension. The acoustic characteristics and sequential adoption of the NCCS allowed us to explore differences in dialect-specific variants across the two semantic predictability conditions, as well as how the direction of the vowel shifts in the acoustic space affected the interaction between dialect variation and semantic predictability, and how this interaction affected early-adopted vowels in the NCCS compared to late-adopted vowels.

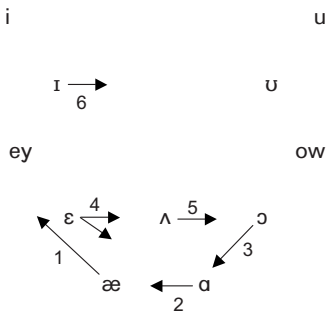

FIG. 1. Schematic of the Northern Cities Chain Shift. Numbers indicate the order in which each component is adopted.

II. METHODS

A. Talkers

Forty female talkers were selected from the Nationwide Speech Project corpus (Clopper and Pisoni, 2006) and the Indiana Speech Project corpus (Clopper *et al.*, 2002). The talkers were all 18–25 year old white native speakers of American English. The talkers were classified into three broad geographical dialects based on their region of origin: Southern, Northern, and Midland. The Southern group included eight women from the Louisville, KY metropolitan area and two women from Texas, for a total of ten Southerners. The Northern group was composed of eight women from the Chicago metropolitan area, and seven women from Northern Indiana: two from South Bend and five from Fort Wayne. Finally, the Midland group included eight women from Central Indiana and seven women from the Evansville area in Southern Indiana. The talkers were selected for recording and assigned to the dialect groups based on residential history. Each of the women had lived in the same dialect region until at least age 18 and both of her parents were also from the same region. Previous acoustic analyses of the vowel productions of a subset of the talkers confirmed dialect-specific differences across the three groups (Clopper *et al.*, 2005). Male talkers were excluded from the study because recordings were available for only five male talkers from each region which did not allow for adequate statistical power for a comparison across gender.

B. Stimulus materials

Four target words for each of four vowels were selected for comparison in two semantic contexts, for a total of 32 tokens per talker. The four vowels were /æ/ and /ɑ/, two of the earliest-adopted vowels in the Northern Cities Chain

Shift, /ʌ/, one of the later-adopted vowels in the NCCS, and /i/, a vowel not involved in the NCCS (see Fig. 1; Labov, 1998). Each of the target words was produced by each of the talkers in sentence-final position in two semantic contexts: high predictability and low predictability. All of the sentences were taken from the Speech Perception in Noise (SPIN) test of Kalikow *et al.* (1977). The high predictability sentences were five to eight words long and were constructed such that the final word in the sentence was predictable from the preceding semantic context. Semantic predictability was confirmed by Kalikow *et al.* (1977) in the development of the SPIN sentences using a sentence completion task. The low predictability sentences were also short meaningful sentences, but the final words were not predictable from the preceding semantic context. The final target words were produced with a pitch accent by all of the talkers. Each target word examined in this study was, therefore, produced in both a highly predictable and an unpredictable context. A complete list of the stimulus materials is shown in the Appendix.

The sentences were recorded as part of a larger corpus that included isolated words, sentences, passages, and interview speech (Clopper *et al.*, 2002; Clopper and Pisoni, 2006). The 16 high predictability sentences in the current study were selected from a larger set of high predictability sentences produced by each talker. The 16 low predictability sentences were selected from a larger set of low predictability sentences produced by each talker. Due to the design of the original corpora, only four utterances per vowel and only one repetition per utterance were available for analysis in the current experiment. All of the materials were digitally recorded directly to a Macintosh Powerbook G3 laptop at a sampling rate of 44.1 kHz and 16 bit resolution in a sound-attenuated booth using a Shure head-mounted microphone (SM10A).

C. Procedure

Three acoustic measurements were obtained from each of the tokens using spectral and waveform views in Praat: vowel duration in milliseconds, first formant frequency (F1) in hertz, and second formant frequency (F2) in hertz. The duration measurements were obtained by hand by the first author (C.G.C.). The formant frequency measurements were obtained at the first-third temporal point, defined as the onset of the vowel plus one-third of the vowel duration, in order to capture the spectral "nucleus" of each vowel. Given that /æ/ is often diphthongal for Northern talkers and /i/ is often diphthongal for Southern talkers, the first-third temporal point was selected to ensure that the measurements reflected the nucleus of each vowel (see Clopper *et al.*, 2005). Formant values were extracted by hand using Praat's standard formant tracking tool with a 25 ms window and a 12th-order LPC analysis. For the small number of stimulus materials for which the 12th-order LPC analysis failed to correctly track the formants, a 10th- or 14th-order LPC analysis was used to extract the formant frequencies. The formant frequency measures were converted to the Bark scale for analysis (Traunmüller, 1990).

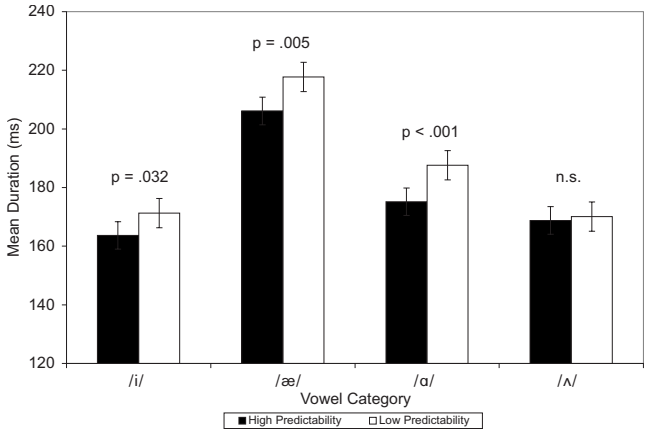

FIG. 2. Mean vowel duration in milliseconds for each vowel in each semantic predictability condition, collapsed across target word and talker dialect. Error bars are standard error.

III. RESULTS

A summary of the duration results is shown in Fig. 2 for each vowel in each semantic predictability condition. For each vowel, a repeated measures analysis of variance (ANOVA) with semantic predictability [high predictability (HP) or low predictability (LP)] as a within subjects factor and talker dialect (North, Midland, or South) as a between subjects factor was conducted. Significant main effects of semantic predictability were obtained for /i/ [$F(1,37)=5.0$, $p=0.032$], /æ/ [$F(1,37)=8.9$, $p=0.005$], and /ɑ/ [$F(1,37)=17.2$, $p<0.001$]. In all three cases, the vowels in the low predictability condition were longer than the vowels in the high predictability condition. The effect of semantic predictability did not reach significance for /ʌ/. Talker dialect was not a significant factor for any of the vowels and none of the semantic predictability × talker dialect interactions were significant. These results confirm an effect of semantic predictability on vowel duration for three of the four vowels across all three talker dialects.

A summary of the spectral analysis is shown in Fig. 3. The filled symbols represent the mean first and second for-

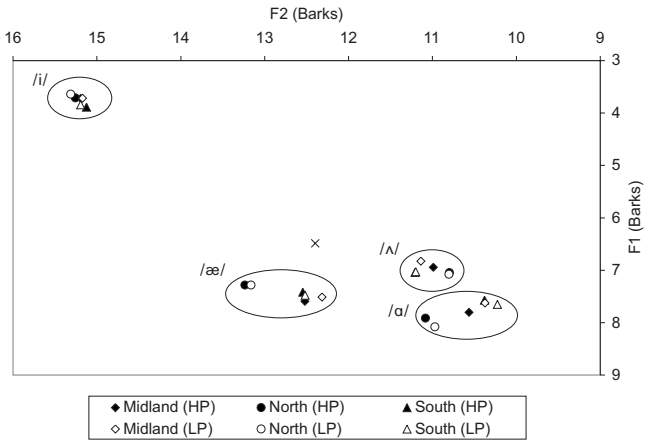

FIG. 3. Mean first and second formant frequencies of /i/, /æ/, /ɑ/, and /ʌ/ in high predictability (filled) and low predictability (open) contexts for the Midland (diamond), Northern (circle), and Southern (triangle) talkers. The grand mean of the vowel space across all talkers and conditions is indicated by the X.

mant frequencies for each of the vowels in the high predictability condition. The open symbols represent the mean F1 and F2 values for the low predictability condition. The grand mean of the vowel space, collapsed across all talkers and semantic predictability conditions, is indicated by the X to provide an indication of the predicted direction of spectral vowel reduction.

An inspection of Fig. 3 suggests that the Northern talkers produced fronted /æ/'s and /ɑ/'s and backed /ʌ/'s compared to the Midland and Southern talkers. Separate repeated measures ANOVAs were conducted on the F1 and F2 measures for each vowel with semantic predictability (HP or LP) as a within subjects factor and talker dialect (North, Midland, or South) as a between subjects factor. The main effect of dialect was significant for the F2 of /æ/ [$F(2,37)=16.4$, $p<0.001$] and the F2 of /ɑ/ [$F(2,37)=10.9$, $p<0.001$]. *Post hoc* Tukey tests revealed that the Northern talkers produced significantly fronted /æ/'s and /ɑ/'s compared to the Midland or Southern talkers (all $p<0.005$), reflecting Northern Cities shifted productions of /æ/ and /ɑ/ for the Northern talkers. The main effect of dialect for the F2 of /ʌ/ did not reach significance.

The series of repeated measures ANOVAs on formant frequency values also revealed a significant main effect of semantic predictability for the F1 of /ɑ/ [$F(1,37)=6.4$, $p=0.015$] and the F2 of /ɑ/ [$F(1,37)=11.1$, $p=0.002$], as well as a significant semantic predictability × dialect interaction for the F1 of /ɑ/ [$F(2,37)=4.0$, $p=0.028$]. None of the other main effects or interactions were significant. For the F1 of /ɑ/, the low predictability variants were produced with a larger F1 than the high predictability variants. For the F2 of /ɑ/, the low predictability variants were produced with a smaller F2 than the high predictability variants. Thus, in both the F1 and F2 dimensions, significant reduction was observed for /ɑ/ in the high predictability condition relative to the low predictability condition. An inspection of Fig. 3 reveals the locus of the semantic predictability × dialect interaction for the F1 of /ɑ/. While the Northern and Southern talkers both produced lower /ɑ/'s in the low predictability condition, the Midland talkers produced lower /ɑ/'s in the high predictability condition. Thus, the reduction of /ɑ/ in the F1 dimension in the high predictability condition was not observed consistently across dialects; unlike the Northern and Southern talkers, the Midland talkers did not exhibit F1 reduction of /ɑ/ in the high predictability context.

Significant effects of semantic predictability were observed for only the F1 and F2 of /ɑ/. However, vowel space reduction and expansion are typically assessed in a two-dimensional space and the analysis of first and second formant frequencies examined each dimension separately. A vowel space dispersion analysis was therefore conducted to explore reduction in the two-dimensional F1 × F2 vowel space. Dispersion was calculated separately for each vowel in each semantic predictability context and was defined as the Euclidean distance in the F1 × F2 Bark space from the target vowel to the average F1 and F2 across all of the vowels analyzed (see Wright, 1997). Overall vowel space dispersion for each semantic predictability condition was defined as the mean of the four individual vowel dispersion measures.

TABLE I. Mean overall vowel space dispersion in Barks for each of the three dialects in the high predictability and low predictability conditions. Standard deviations are shown in parentheses.

Dialect	High predictability	Low predictability	Difference (LP−HP)
Midland	2.19 (0.13)	2.14 (0.13)	−0.05
North	2.24 (0.21)	2.28 (0.20)	0.04
South	2.08 (0.16)	2.15 (0.12)	0.07

The mean overall vowel space dispersion measures for each of the dialects in the high and low predictability conditions are shown in Table I. A repeated measures ANOVA on vowel space dispersion with semantic predictability (HP or LP) as a within subjects factor and talker dialect (North, Midland, or South) as a between subjects factor revealed a significant semantic predictability × dialect interaction [$F(2,37)=5.1$, $p=0.011$]. Neither of the main effects were significant. *Post hoc* paired comparison *t*-tests on vowel space dispersion in each semantic predictability condition for each dialect revealed the locus of the interaction. A significant difference in vowel space dispersion as a result of semantic predictability was observed for the Southern talkers [$t(9)=-2.8$, $p=0.020$]. Semantic predictability did not significantly affect overall vowel space dispersion for the Midland or the Northern talkers.

The significant semantic predictability × dialect interaction in the vowel space dispersion analysis may reflect differences in spectral reduction between the four different vowels included in the analysis. Specifically, the overall measure of vowel dispersion may have been reduced for the Northern talkers because some vowels were spectrally reduced due to semantic predictability while others were spectrally dispersed due to more extreme Northern Cities shifting. To further explore this difference in overall vowel dispersion effects across the three dialects, the individual dispersion measures for each vowel were analyzed. The mean difference in dispersion for each of the vowels between the low predictability and the high predictability conditions is shown in Fig. 4. Positive differences indicate greater dispersion in the low predictability condition than the high predictability condition. Negative differences indicate greater dispersion in the high predictability condition than the low predictability condition.

The Southern talkers, who exhibited an effect of semantic predictability on overall vowel space dispersion, produced /i, æ, ɑ/ with greater dispersion in the low predictability condition than the high predictability condition, but /ʌ/ with less dispersion in the low predictability condition than the high predictability condition. The Northern talkers produced /i, ɑ/ with greater dispersion and /ʌ/ with less dispersion in the low predictability condition than the high predictability condition, similar to the Southern talkers. However, the Northern talkers also produced /æ/ with less dispersion in the low predictability condition than the high predictability condition, unlike the Southern talkers. For the Midland talk-

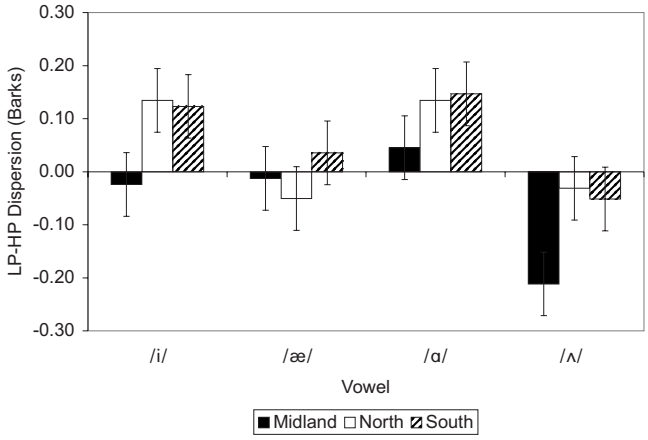

FIG. 4. Mean dispersion difference between the low and high predictability conditions for each vowel for each dialect. Error bars are standard error.

ers, the difference scores for the individual vowels revealed very small differences across the two semantic predictability conditions, with the exception of /ʌ/, which was produced with less dispersion in the low predictability condition than the high predictability condition. A repeated measures ANOVA on the dispersion difference scores with vowel (/ i, æ, ɑ, ʌ/) as a within subject factor and dialect as a between subject factor revealed a significant vowel × dialect interaction [$F(6,111)=7.2$, $p<0.001$]. The main effects of vowel and dialect were not significant. An inspection of Fig. 4 suggests that the Northern dispersion difference for /æ/ is the locus of this interaction: for the Northern talkers, greater dispersion is observed for /æ/ in the high predictability context than the low predictability context. High predictability /æ/'s were more fronted than low predictability /æ/'s for the Northern talkers (see Fig. 3).

IV. DISCUSSION

The duration analysis revealed a significant main effect of semantic predictability for all three dialect groups for three of the four vowels examined. For /i, æ, ɑ/, the vowels were shorter in the high predictability condition than the low predictability condition. In addition, the spectral analysis revealed a significant main effect of semantic predictability for the F1 and F2 of /ɑ/. High predictability /ɑ/'s were raised and fronted relative to low predictability /ɑ/'s for the Northern and Southern talkers, and were fronted, but not raised, relative to the low predictability /ɑ/'s for the Midland talkers. These results are consistent with previous research on the effects of semantic predictability on vowel reduction, which has revealed temporal and spectral reduction in high predictability conditions compared to low predictability conditions (Lieberman, 1963; Scarborough, 2006). The spectral analysis also revealed a significant main effect of talker dialect for the F2 of /æ/ and /ɑ/. The Northern talkers produced more fronted /æ/'s and /ɑ/'s than the Midland or Southern talkers, consistent with the early stages of the Northern Cities Chain Shift (Labov, 1998).

An interaction between semantic predictability and talker dialect was observed in the vowel space dispersion analysis. The effect of semantic predictability on overall vowel space dispersion was observed for the Southern talkers but not the Northern or Midland talkers. The Southern vowels exhibited less dispersion overall in the high predictability condition than the low predictability condition, consistent with previous research on the effects of semantic predictability on vowel reduction (Lieberman, 1963; Scarborough, 2006).

For the Northern talkers, spectral reduction of /i/ and /ɑ/ was accompanied by greater fronting of /æ/ in the high predictability condition (see Fig. 3), leading to the significant vowel × dialect interaction in the individual vowel dispersion analysis and diminishing the effect of semantic context for the Northern talkers in the overall vowel space dispersion analysis. The greater fronting of /æ/ reflects a more extreme production of the Northern Cities shift. These results suggest that vowel production is affected by both semantic constraints, such as predictability, and indexical constraints, such as regional dialect, and that these factors can interact. In particular, the effect of semantic predictability on overall vowel space dispersion is apparently diminished for the Northern talkers due to more extreme Northern Cities /æ/ fronting in the high predictability condition.

This interpretation of the current results is consistent with the findings reported by Munson (2007b) and Scarborough (2006), who observed interactions between lexical constraints, such as word frequency and neighborhood density, and indexical constraints, such as gender prototypicality and regional dialect, on vowel reduction. More extreme indexical variants are produced in the easy processing conditions (e.g., high predictability sentences or low density words) than in the hard processing conditions. These findings suggest that listeners can represent multiple acoustic-phonetic targets for a given vowel category. Specifically, the relatively educated participants in the current study were exposed to local or regional vowel variants (e.g., Northern or Southern) and supraregional standard variants (e.g., General American). For the Northern talkers, the local and standard variants of /æ/ were in competition for production, and the more extreme local variant was produced in the high predictability context relative to the low predictability context. For the Southern talkers, the local and standard variants of the vowels examined were not in competition because both variants of each vowel were phonetically similar, and traditional effects of semantic predictability on vowel space reduction were observed.

The representation of multiple targets for a given vowel category, and competition among those targets in processing, can be accounted for by a class of models, including exemplar theory, in which talkers learn probability distributions of phonemes with some degree of phonetic detail (Pierrehumbert, 2006). These models would predict that the talkers in the current study maintain simultaneous representations of local and standard vowel variants and that those variants are differentially activated under different conditions. Hay *et al.*, (2006) proposed a similar account for the perception of an ongoing sound change in New Zealand, in which listeners maintain multiple acoustic-phonetic representations of a vowel category as it merges with another category.

The activation of the local versus the standard variant across the two semantic predictability conditions may be driven by at least two processing considerations. One possible account of the current results is that the increase in Northern Cities shifting in the high predictability condition reflects a listener-oriented adaptation on the part of the talker. Specifically, talkers choose more shifted variants in the high predictability condition because they know that the listener will be able to access the word easily based on the semantic context. The talker can therefore afford to index social information to the listener without significantly affecting intelligibility. Alternatively, the current results may reflect talker-oriented processing differences in high versus low predictability sentences. For example, the temporal reduction that was observed for all of the talkers may reflect faster lexical retrieval or phonetic implementation processes in the high predictability condition relative to the low predictability condition (Munson, 2007a). In speech perception, some sources of indexical information are processed more slowly than linguistic information and therefore may not affect performance in tasks in which speeded responses are required (McLennan and Luce, 2005). Similar differences in processing lexical, semantic, and indexical information in speech production may account for the interactions in the current study between semantic and indexical factors in vowel reduction. Additional research is needed to explore the effects of semantic predictability and talker dialect on listener-directed speech (such as clear speech) and on speech produced in speeded and nonspeeded production tasks to distinguish between these two accounts of the current data.

Two components of the results require additional comment. First, /ʌ/ did not exhibit either temporal or spectral reduction in the high predictability condition for any of the three dialects. This finding is consistent with Wright's (1997) observation that the lax vowels /ɪ, ɛ, ʌ/ exhibit little to no reduction in low density words compared to high density words, whereas the tense vowels /i, æ, ɑ, ɔ, u/ show greater dispersion in high density words than low density words. Thus, the lack of reduction of /ʌ/ in the current study may reflect more general differences in reduction processes for tense and lax vowels in English.

Second, for the Midland talkers, the effect of semantic predictability on overall vowel space dispersion was not observed. In addition, whereas the Northern and Southern talkers produced raised /ɑ/'s in the high predictability condition, the Midland talkers produced lowered /ɑ/'s in the high predictability condition relative to the low predictability condition, leading to the significant semantic predictability × dialect interaction in the analysis of the F1 of /ɑ/. Thus, in the high predictability condition, the Midland talkers exhibited temporal reduction to the same extent as the Northern and Southern talkers, but they did not produce spectrally reduced vowels and, in the case of /ʌ/, exhibited greater dispersion in the high predictability condition than the low predictability condition. An inspection of the individual data revealed that the dispersion patterns were not due to a single outlier or a geographical subset of the Midland talkers but were observed across the entire group. These findings for the Midland talkers reflect a failure to replicate previous work on the effects of semantic predictability on vowel space reduction (Lieberman, 1963; Scarborough, 2006) and present a challenge to the probabilistic models that can account for the data obtained from the Northern and Southern talkers. However, we know of no other model that would be able to account for this set of findings, so this set of results for the Midland talkers remains a challenge to any account of the effects of linguistic and indexical factors on vowel space dispersion.

Taken together, the results of the current study confirm previously observed significant effects of semantic predictability and regional dialect on vowel production. In addition, significant interactions between semantic predictability and talker dialect were observed, consistent with the results of a growing literature exploring the interactions between lexical and indexical factors in speech production and perception and with a class of probabilistically based models of language processing in which phonological representations are phonetically detailed. Finally, vowel-specific findings suggest that the effects of semantic predictability may be limited to certain classes of vowels (e.g., tense vowels in English).

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APPENDIX

Vowel	High predictability	Low predictability
/i/	The chicken pecked corn with its beak.	She is glad Bill called about the beak.
	The wedding banquet was a feast.	We could consider the feast.
	Watermelons have lots of seeds.	You have considered the seeds.
	Ruth had a necklace of glass beads.	Tom has been discussing the beads.
/æ/	Please wipe your feet on the mat.	Peter has considered the mat.
	Paul hit the water with a splash.	Bob has discussed the splash.
	The cow gave birth to a calf.	She hopes Jane called about the calf.
	The cut on his knee formed a scab.	The boy would discuss the scab.
/ɑ/	Paul was arrested by the cops.	Ruth hopes Bill called about the cop.
	The shepherds guarded their flock.	Paul should have discussed the flock.

Vowel	High predictability	Low predictability
/ʌ/	Tighten the belt by a notch.	The woman considered the notch.
	The plow was pulled by an ox.	The man should discuss the ox.
	The bird of peace is the dove.	Peter could consider the dove.
	The heavy rains caused a flood.	The class should consider the flood.
	Cut the meat into small chunks.	I did not know about the chunks.
	Paul took a bath in the tub.	Miss Smith knows about the tub.

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