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Research Article

Second dialect acquisition and phonetic vowel reduction in the American Midwest

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ABSTRACT

Geographic mobility can lead to the acquisition of new regional dialect features. This second dialect acquisition is highly variable across individuals and is affected by a range of linguistic and social factors. The realization of dialect-specific features is also affected by linguistic variables related to phonetic reduction, but this interaction has been primarily examined with a mix of mobile and non-mobile participants. In the current study, second dialect acquisition by Midwestern American young adults and its interaction with phonetic reduction processes was examined. Relative to lifetime residents of the Northern and Midland regions of American English, some Northern transplants to the Midland region exhibited second dialect acquisition and others exhibited maintenance of Northern dialect features. All talkers showed phonetic reduction due to lexical frequency, phonological neighborhood density, discourse mention, semantic predictability, and speaking style. These phonetic reduction processes only weakly interacted with dialect variation, such that less phonetic reduction was observed overall when it was potentially in conflict with dialect-specific vowel features. Taken together, the results provide additional evidence for substantial individual variation in second dialect acquisition, but limited evidence of an effect of second dialect acquisition on the interaction between dialect variation and phonetic reduction processes.

1. Introduction

Previous research has suggested that dialect-specific variants are enhanced in the same contexts that lead to phonetic reduction, including high-frequency words, words with few phonologically similar neighbors (i.e., low-density words), high-predictability words, second mentions, and more casual speaking styles (Clopper & Pierrehumbert, 2008; Clopper, Burdin, & Turnbull, 2019; Clopper, Mitsch, & Tamati, 2017; Hay, Jannedy, & Mendoza-Denton, 1999; Munson, 2007). Most of the evidence for this alignment between identity-marking and phonetic reduction processes has come from speech produced by talkers from the Midland and Northern dialects of American English, who were recorded in a university setting in the Midland region (Clopper & Pierrehumbert, 2008; Clopper et al., 2017, 2019). Thus, whereas the Midland talkers in these studies were recorded in their local dialect setting, the Northern talkers were not. Moreover, the Midland talkers were lifetime residents of the Midland region, whereas the Northern talkers had lived exclusively in the Northern region prior to age 18 years, but were living in the Midland region, attending university, at the time of the recording. Given that university students exhibit second dialect acquisition as early as their first year of enrollment (Bigham, 2010; Campbell-Kibler, Walker, Elward, & Carmichael, 2014; Evans & Iverson, 2007), the Midland and Northern talkers in the previous work may have critically differed in their productions of dialect-specific features (i.e., features unique to their dialect which are not present in another comparison dialect). That is, the Northern talkers may have produced fewer Northern features, as a result of second dialect acquisition, than lifetime residents of the Northern dialect. The goals of the current study were to address this shortcoming of our previous work and (1) assess the magnitude of second dialect acquisition among Northern students at a university in the Midland dialect region, relative to Northern students at a university in the Northern

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dialect region; and (2) explore how second dialect acquisition might interact with the enhancement of dialect-specific features in contexts that lead to phonetic reduction. To achieve these goals, we first examined evidence of the Northern Cities Shift among Northerners in the North compared to Northerners in the Midland. Having found variation among the Northerners in the Midland, we used k-means clustering to identify groups of talkers who produced Northern vs. Midland vowel features, independent of their residential histories. We then compared the vowel productions of these two talker groups in a range of linguistic contexts to more closely examine the interaction of the Northern Cities Shift and factors leading to phonetic reduction.

1.1. Second dialect acquisition

Much of the early work on second dialect acquisition focused on children and considered factors such as age of acquisition and complexity of the dialect features to be learned (e.g., Chambers, 1992; Payne, 1980). The primary conclusions from this early work were that second dialect acquisition is more successful for younger children than for older children, consistent with a sensitive period for language acquisition, and that "simple" features, such as intervocalic /t d/ flapping, are easier to acquire than "complex" features, such as a phonemic vowel split. For example, Canadian children living in Southern England acquired non-flapped intervocalic /t d/ more easily than the BATH/TRAP vowel split (Chambers, 1992).[1] In this example, acquisition of non-flapped intervocalic /t d/ is described as the simple result of "undoing" the flapping process that is found in Canadian English, on the assumption that Canadian English speakers have access to the underlying /t d/ forms. In contrast, the acquisition of the BATH/TRAP vowel split requires the more complex process of mapping words that share a vowel phoneme in Canadian English to different underlying vowel categories. More recent research, however, has focused on adults, who not only acquire features of a second dialect, despite being outside of the purported sensitive period, but can even acquire complex features, such as phonemic splits (Evans & Iverson, 2007; Johnson & Nycz, 2015; Nycz, 2013a, 2013b, 2019; Sankoff, 2004).

The current focus of second dialect acquisition research is understanding the variability that is observed within and across dialect features and individual talkers (see Nycz, 2015, for a review). The primary finding from this recent work is that second dialect acquisition is gradient (Hazen, 2001). One typical pattern is that features of the first dialect that are not present in the second dialect are lost (Bowie, 2000; Nycz, 2013a; Shockey, 1984; Walker, 2019), leading to a "softening" of the native dialect (Evans & Iverson, 2007). For example, Northern English university students can sometimes acquire the /ʊ ʌ/ split, the lack of which is a feature of varieties of British English spoken in Northern England, after attending university with students from different regions of the U.K. (Evans & Iverson, 2007). At the same time, some features of the second dialect not present in the first dialect are often not acquired (Conn & Horesh, 2002; Sankoff, 2004; Walker, 2019), perhaps reflecting the talkers' social motivation to avoid the appearance of being fake or making fun of the second dialect. In particular, these dialect-specific features of the second dialect that are not acquired are often stereotyped (i.e., they carry overt social meaning; Labov, 1972), either positively as a prestigious variant or negatively as a stigmatized variant, consistent with a social motivation for their lack of acquisition. For example, Americans in the U.K. do not acquire post-vocalic non-rhoticity, a feature of Standard Southern British English that is recognized, but not stigmatized, as a feature of this variety in both the U.S. and the U.K. (Walker, 2019). Dialect-specific features of the second dialect may be acquired, however, when they are not stereotyped, such as Northern Cities /æ/-raising by Appalachians in Michigan (Evans, 2004). In both the loss of first dialect features and the acquisition of second dialect features, the resulting forms are often intermediate between the two dialects (Bigham, 2010; Munro, Derwing, & Flege, 1999; Nycz, 2018; Ziliak, 2012). For example, Canadians in the U.S. produce forms that are acoustically intermediate between the raised Canadian /aʊ aɪ/ variants and the lower U.S. variants (Nycz, 2018).

For virtually all features that have been studied, individual variability is observed across talkers (Conn & Horesh, 2002; Evans & Iverson, 2007; Johnson & Nycz, 2015; Nycz, 2013a, 2013b, 2018; Shockey, 1984). This variability is driven at least in part by social-identity factors, including social networks and attitudes/stances towards the second dialect region (Campbell-Kibler et al., 2014; Evans, 2004; Foreman, 2000; Nycz, 2019). For example, university students from Southern Ohio with social networks comprising mostly other Southern Ohioans are less likely to lose features of their native dialect that are not present in the second dialect than students with more variable social networks (Campbell-Kibler et al., 2014). This maintenance of dialect-specific features, particularly those with salient social meaning (either stigmatized or not), by speakers with strong ties to their local community—what Reed (2020a) calls "rootedness" and which includes, but is not limited to, a lack of desire to move away from a region—is also observed among adults with limited mobility (Reed, 2020b, 2020c), suggesting a crucial role of social-identity factors in the realization of both first and second dialects.

The focus of the current study was second dialect acquisition by Northern American English talkers in the Midland dialect region of the U.S. The Northern dialect is characterized by the Northern Cities vowel shift, which includes the raising and fronting of /æ/, backing and lowering of /ɛ/, and fronting and lowering of /ɑ/ (Labov, Ash, & Boberg, 2006). The Midland dialect, by contrast, is characterized by the lack of both the Northern and Southern American English vowel shifts, as well as by the merger of /ɑ ɔ/ and the fronting of /u/ (Labov, 1998). Despite their differing vowel characteristics, both varieties are perceived as ideologically standard varieties (Campbell-Kibler, 2012; Dossey, Clopper, & Wagner, 2020) and their dialect-specific vowel variants are neither especially prestigious nor stigmatized. This contact between two ideologically standard varieties in a university setting leads to both acquisition of Northern Cities features by Midland talkers in the Midland region (Bigham, 2010) and acquisition of Midland

[1] For clarity, we adopt the lexical set notation (Wells, 1982) here to characterize the two vowel classes in Standard Southern British English corresponding to /æ/ in North American English.

features by Northern talkers in the Midland region (Campbell-Kibler, 2012). The latter aspect of second dialect acquisition, specifically the acquisition of Midland variants of /ɛ æ ɑ/ by Northern talkers in the Midland, was the focus of the current study.

To assess second dialect acquisition by Northern talkers in the Midland dialect region, we focused on the realization of the Northern Cities Shift vowels /ɛ æ ɑ/. We compared the productions of Northern transplants to the Midland to those of lifetime Midland and Northern residents. Second dialect acquisition among the Northern transplants would be realized as less Northern Cities Shifting, most likely involving intermediate vowels between the lifetime Northern and Midland residents. A group-level analysis of the vowel productions of the Northern transplants and the lifetime Midland and Northern residents confirmed Northern Cities Shift features among both groups of Northerners (see Section 3.1). However, the Northern Cities Shift was stronger among the lifetime Northerners than the Northern transplants, consistent with some second dialect acquisition by the Northern transplants. The difference between the lifetime Northerners and the Northern transplants could also reflect, instead or in addition, stronger Northern rootedness for the lifetime Northerners than for the Northern transplants. In the absence of both longitudinal production data for the Northern transplants and ethnographic data related to rootedness for all participants, we cannot distinguish among these possibilities in this work (see Section 5.1). A subsequent k-means clustering analysis to group the full set of talkers by presence vs. absence of Northern Cities Shift features, independent of residential history, revealed substantial individual variation in the production of these features by the Northern transplants, but also by the lifetime Midland and Northern residents (see Section 3.2). We then used these groups of talkers, defined by their use or not of features of the Northern Cities Shift, to explore the interaction between second dialect acquisition and phonetic reduction in vowel production.

1.2. Dialect variation and phonetic reduction

The production of /ɛ æ ɑ/ is variable not only across talkers within the Midland and Northern dialect regions due to the Northern Cities Shift, but also within talkers as a function of linguistic context. In our previous work, we observed more /æ/-raising in low-density words than in high-density words, more /æ/-fronting in high-predictability words than in low-predictability words, more /ɑ/-fronting and -lowering in second mentions than in first mentions, and more /æ/-raising and -fronting in a plain speaking style than in a clear speaking style for Northern transplants in the Midland (Clopper & Pierrehumbert, 2008; Clopper et al., 2017). We interpreted these results as evidence of enhancement of Northern dialect-specific features in contexts that promote phonetic reduction. Moreover, we suggested that this alignment between dialect features and phonetic reduction reflects a listener-oriented process, in which talkers take advantage of "easy" listening conditions (Lindblom, 1990) to mark aspects of their social identity. That is, when talkers expect their listeners to easily understand the content of the message, they can enhance the social-identity information in the acoustic signal without sacrificing effective communication.

We therefore assume two continua of phonetic variation that operate in tandem to produce particular phonetic realizations of target phonemes. The first continuum is related to phonetic reduction and extends from more hypoarticulated (i.e., reduced) forms at one end to more hyperarticulated forms at the other end (Lindblom, 1990). A large number of linguistic factors contribute to where on this continuum a particular token is realized (see e.g., Clopper & Turnbull, 2018, for a review) and we therefore treat position along this continuum as relative and do not assume that any particular linguistic context is privileged as the "default" or "baseline." For consistency, we discuss our results in terms of phonetic reduction, but they could equally be discussed in terms of hyperarticulation. The second continuum is related to dialect variation and extends from more dialect-specific forms at one end to fewer dialect-specific forms at the other end (Labov, 1972). Although this continuum was first defined by Labov (1972) as reflecting the degree of attention that the talker paid to their speech, more recent research has demonstrated variation along this continuum as a function of other factors, such as topic (Walker, 2019) and addressee (Bell, 1984). As in the case of the phonetic reduction continuum, we treat position along this continuum of dialect variation as relative and do not assume that any particular linguistic context is privileged as the "default" or "baseline." For consistency, we discuss our results in terms of enhancement of dialect-specific features, but they could equally be discussed in terms of reduction of dialect-specific features.

We further assume that the dialect-specific features of interest in this study (i.e., the Northern Cities Shift) are not intrinsically related to phonetic reduction.[2] The phonetic reduction variables are expected to lead to vowel centralization for high-frequency, low-density, second mention, high-predictability, and plain speech tokens (Clopper & Turnbull, 2018). Centralization is realized as raising (lower F1) for all three of the target vowels /ɛ æ ɑ/ and as backing (lower F2) for /ɛ æ/ and fronting (higher F2) for /ɑ/. The raising of /ɛ/, backing of /æ/, and raising of /ɑ/ due to phonetic reduction are incompatible with the Northern Cities Shift and therefore provide a locus for observing the predicted interaction between dialect variation and phonetic reduction, because the contexts promoting phonetic reduction also promote enhancement of dialect-specific features. That is, for the raising of /ɛ/, backing of /æ/, and raising of /ɑ/, if dialect enhancement outweighs phonetic reduction, then the effects of the phonetic reduction variables should be in opposite directions for talkers with features of the Northern Cities Shift (NCS) and talkers without features of the Northern Cities Shift (non-NCS). Or, if dialect enhancement competes with phonetic reduction, the effects of the phonetic reduction variables should be greater in magnitude for non-NCS talkers than NCS talkers. In contrast, the backing of /ɛ/, raising of /æ/, and fronting of /ɑ/ are consistent with the Northern Cities Shift and therefore provide a different locus for observing the predicted interaction between dialect

[2] These features of the Northern Cities Shift therefore differ from variables like -ING, in which [ɪŋ] alternates with [ɪn] as a function of formality (i.e., along the phonetic reduction continuum), but also as a function of social factors such as regional background and sexual orientation (i.e., along the dialect variation continuum) in ways that are indexically linked to the formality dimension (Campbell-Kibler, 2007).

Table 1
Summary of the predicted effects of phonetic reduction and enhancement of the Northern Cities Shift (NCS) on F1 and F2 for /ɛ æ ɑ/. Shaded rows indicate vowel formants for which the predicted effects of phonetic reduction and NCS enhancement conflict.

Vowel formant	Phonetic reduction prediction	NCS enhancement prediction
/ɛ/ F1	raising (lower F1)	lowering (higher F1)
/æ/ F2	backing (lower F2)	fronting (higher F2)
/ɑ/ F1	raising (lower F1)	lowering (higher F1)
/ɛ/ F2	backing (lower F2)	backing (lower F2)
/æ/ F1	raising (lower F1)	raising (lower F1)
/ɑ/ F2	fronting (higher F2)	fronting (higher F2)

variation and phonetic reduction. In particular, if the effects of dialect enhancement and phonetic reduction are additive, then the effects of the phonetic reduction variables should be greater in magnitude for NCS talkers than non-NCS talkers. A summary of the predictions for each vowel for each formant for phonetic reduction and enhancement of the Northern Cities Shift is shown in Table 1.

Given that second dialect acquisition is shaped by social-identity factors (Campbell-Kibler et al., 2014; Evans, 2004; Foreman, 2000; Nycz, 2019) and that we have interpreted the alignment of dialect enhancement and phonetic reduction processes as reflecting social-identity marking (Clopper & Pierrehumbert, 2008; Clopper et al., 2017, 2019), the observed individual variation among the Northern transplants in the realization of the Northern Cities Shift led us to reconsider our earlier results suggesting enhancement of dialect-specific features in contexts that lead to phonetic reduction. In particular, all of the Northern talkers in our previous studies on enhancement of the Northern Cities Shift in reduction-promoting contexts were transplants to the Midland region (Clopper & Pierrehumbert, 2008; Clopper et al., 2017, 2019) and may therefore have different social-identity goals than lifetime residents of the Northern region who are recorded in the North. Thus, to assess the effects of second dialect acquisition on the alignment of social-identity marking and phonetic reduction, we examined the realization of Northern Cities Shift features as a function of recording location (North vs. Midland), presence vs. absence of Northern Cities Shift features based on the k-means clustering analysis, and their interactions with linguistic features related to phonetic reduction: lexical frequency, neighborhood density, discourse mention, semantic predictability, and speaking style. We expected to observe the most enhancement of Northern Cities Shift features in reduction-promoting contexts among the talkers who produced those features and were recorded in the Midland, because maintenance of first dialect features in the second dialect region is associated with strong social identity ties with the first dialect (Campbell-Kibler et al., 2014). That is, Northern transplants to the Midland who have strong Northern identities are likely to maintain Northern Cities Shift features in their speech and to enhance those features when the context allows. As in our previous work (Clopper & Pierrehumbert, 2008; Clopper et al., 2017), the results revealed overall patterns of phonetic reduction that were mediated to some degree by talker dialect and varied considerably across vowels and linguistic factors.

2. Methods

2.1. Materials

The materials for this study comprise the Ohio State Stories Corpus (https://u.osu.edu/storiescorpus/). The corpus includes read short stories from each of 45 talkers: 15 lifetime residents (10 female, 5 male) of the Midland dialect region recorded in the Midland region ("Midlanders"), 15 lifetime residents (10 female, 5 male) of the Northern dialect region recorded in the Northern region ("Northerners in the North"), and 15 talkers (10 female, 5 male) recorded in the Midland region who had lived exclusively in the Northern dialect region until at least age 18 years ("Northerners in the Midland"). The talkers recorded in the Midland region comprise the Columbus subcorpus (see Burdin, Turnbull, & Clopper, 2015) and the talkers recorded in the Northern region comprise the Ann Arbor subcorpus. The talkers in the Columbus subcorpus were recruited from the Ohio State University community and recorded in Columbus, OH, in the Midland region. The talkers in the Ann Arbor subcorpus were recruited from the University of Michigan community and recorded in Ann Arbor, MI, in the Northern region. The Midlanders were all lifetime residents of central and/or southern Ohio. The Northerners in the Midland had lived in either northern Ohio (N = 14) or Chicago, IL (N = 1) until at least age 18 years. The Northerners in the North were all lifetime residents of central and/or southern Michigan. Thus, all of the Northern talkers were from the Inland North dialect region, where the Northern Cities Shift is observed (Labov et al., 2006). The talkers ranged in age from 19–29 years (M = 21 years, SD = 2 years). The majority of the talkers (N = 39) identified as white; the remaining talkers identified as Asian (N = 1), more than one race (N = 3), or did not report their race (N = 2).

Each talker was recorded reading a set of 30 short stories in two speaking styles: plain lab speech and clear lab speech. The plain style was elicited by asking the talkers to imagine they were talking to a friend or family member. The clear style was elicited by asking them to imagine they were talking to a non-native or hard-of-hearing listener. All talkers read the full set of short stories in the plain style first, followed by the full set of short stories in the clear style. The stories were constructed to contain 236 mostly monosyllabic target words containing one of six target vowels (/i ɛ æ ɑ ɔ u/), with 34–45 target words per vowel. The target words were selected to vary orthogonally in lexical frequency and phonological neighbor-

hood density, using estimates from the Hoosier Mental Lexicon (Nusbaum, Pisoni, & Davis, 1984). Each target word appeared twice within a single story to elicit first and second mentions. The predictability of the target words in their sentence contexts was quantified in a separate, written cloze task, in which participants were asked to supply the missing word in the sentence with the target word removed. Cloze predictability was defined as the proportion of responses matching the target word. Thus, within each vowel category, the target words were elicited in a fully factorial design with two between-item factors (frequency and density) and three within-item factors (mention, predictability, and style). All talkers were recorded using a Marantz PMD661 digital recorder and Shure SM-10A head-mounted microphone with a 44.1 kHz sampling rate and 16-bit resolution.

2.2. Acoustic analysis

As described by Burdin et al. (2015), the recordings were forced-aligned with the Penn Phonetics Lab Forced Aligner (Yuan & Liberman, 2008). The boundaries for the stressed vowel in each target word were then hand-corrected, following Peterson and Lehiste (1960). Vowel duration and first and second formant frequencies at 20%, 35%, 50%, 65%, and 80% of each target vowel token were estimated from the hand-corrected vowel segmentations. Tokens with non-modal voicing, disfluencies, recording errors, and duration or formant frequency estimates more than 3 standard deviations away from individual talker means by vowel were excluded. F1 and F2 estimates were normalized by talker using z-scores (Lobanov, 1971). A total of 35,647 tokens were included in the analysis, with 5129–6800 tokens per vowel type.

3. Analysis #1: Second dialect acquisition

3.1. Results: Group dialect differences

A preliminary analysis was conducted to identify the features of the Northern Cities Shift in the speech of the talkers in the corpus. A summary of the vowels produced by the three talker groups is shown in Fig. 1. As expected, the Northerners in the North produced backed and lowered /ɛ/, raised and fronted /æ/, and lowered and fronted /ɑ/ relative to the Midlanders, consistent with the Northern Cities Shift, and the Midlanders produced fronted /u/ and greater overlap of /ɑ ɔ/ relative to the Northerners in the North, consistent with the Midland dialect. In addition, the Northerners in the Midland produced /ɛ æ ɑ u/ with mean formant frequencies intermediate between the Northerners in the North and the Midlanders, as well as with distributions of formant frequencies that overlap with both

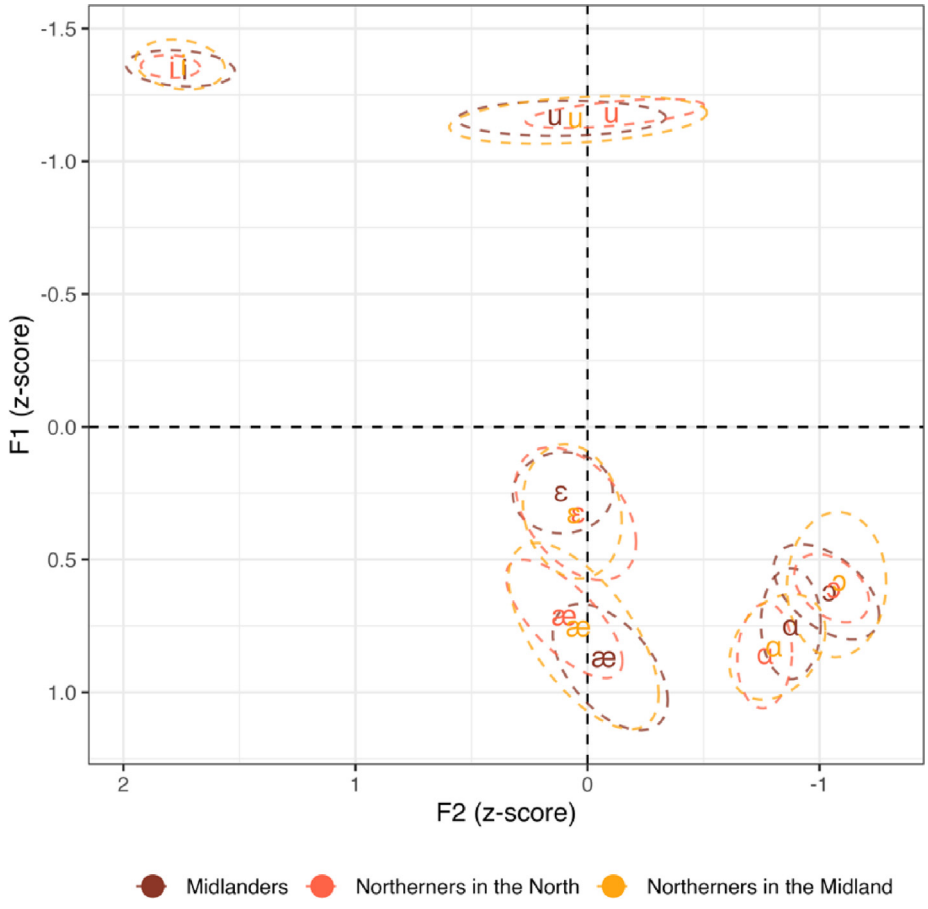

Fig. 1. Partial vowel spaces of the talkers in the Ohio State Stories Corpus, as a function of talker group (Midlanders, Northerners in the North, Northerners in the Midland). Large bold symbols represent group means. Dashed ellipses enclose 95% t-distributions of individual talker means.

Table 2
Summary of the main effects of talker group on F1 and F2 productions of /ɛ æ ɑ u/ in the Ohio State Stories Corpus. Degrees of freedom were estimated using the Satterthwaite approximation.

Vowel	Formant	Main Effect of Talker Group
/ɛ/	F1	$F(2, 44.4) = 3.64$, $p = 0.034$
	F2	$F(2, 46.7) = 2.74$, $p = 0.075$
/æ/	F1	$F(2, 44.7) = 5.12$, $p = 0.010$
	F2	$F(2, 45.7) = 4.75$, $p = 0.013$
/ɑ/	F1	$F(2, 52.5) = 5.37$, $p = 0.008$
	F2	$F(2, 50.8) = 7.79$, $p = 0.001$
/u/	F1	$F(2, 44.8) = 1.41$, $p = 0.254$
	F2	$F(2, 49.9) = 3.29$, $p = 0.046$

Table 3
Summary of the talker group pairwise comparisons for F1 and F2 productions of /ɛ æ ɑ u/ in the Ohio State Stories Corpus. Degrees of freedom were estimated using the Satterthwaite approximation.

Vowel	Formant	Midlanders vs. Northerners in the North	Midlanders vs. Northerners in the Midland
/ɛ/	F1	$t(44.4) = -2.29$, $p = 0.027$	$t(44.4) = -2.38$, $p = 0.022$
	F2	$t(48.6) = 2.25$, $p = 0.029$	$t(44.7) = 1.69$, $p = 0.097$
/æ/	F1	$t(44.7) = 3.10$, $p = 0.003$	$t(44.7) = 2.25$, $p = 0.029$
	F2	$t(46.5) = -3.03$, $p = 0.004$	$t(45.2) = -2.00$, $p = 0.052$
/ɑ/	F1	$t(58.1) = -3.19$, $p = 0.002$	$t(49.9) = -2.30$, $p = 0.026$
	F2	$t(58.7) = -3.94$, $p < 0.001$	$t(52.5) = -2.44$, $p = 0.018$
/u/	F1	$t(45.0) = 1.26$, $p = 0.214$	$t(45.4) = -0.32$, $p = 0.753$
	F2	$t(54.4) = 2.54$, $p = 0.014$	$t(46.0) = 0.97$, $p = 0.338$

the Northerners in the North and the Midlanders. Limited variation in /i ɔ/ was observed across the three talker groups.

Separate linear mixed-effects models were constructed using the *lme4* package in R (Bates, Mächler, Bolker, & Walker, 2015) for each vowel category /i ɛ æ ɑ ɔ u/ to predict z-scored midpoint F1 and F2 estimates with talker group (Midlanders, Northerners in the North, and Northerners in the Midland) as a fixed effect. Talker group was sum-contrast coded. The maximal random effect structure for talkers and target words supported by the data was used in each analysis (Bates, Kliegl, Vasishth, & Baayen, 2015). The *bobyqa* optimizer was used to facilitate model convergence. The main effect of talker group and pairwise comparisons between talker groups were evaluated using the Satterthwaite approximation of degrees of freedom, as implemented in the *lmerTest* package in R (Kuznetsova, Brockhoff, & Christensen, 2017).

A summary of the main effects of talker group is shown in Table 2 and a summary of the talker group pairwise comparisons is shown in Table 3. The full model specifications and output are provided on the Open Science Framework repository for this project: https://osf.io/6jnds/. The analysis revealed significant main effects of talker group for both F1 and F2 of /æ ɑ/, as well as for F1 of /ɛ/ and F2 of /u/. The effect of talker group on the F2 of /ɛ/ was marginal and it was not significant for either F1 or F2 for /i ɔ/ or for F1 of /u/. Pairwise comparisons confirmed significant lowering (higher F1) of /ɛ/, raising (lower F1) of /æ/, and lowering (higher F1) and fronting (higher F2) of /ɑ/ for both groups of Northerners relative to Midlanders, as well as significant backing (lower F2) of /ɛ/ and fronting (higher F2) of /æ/ for Northerners in the North relative to Midlanders. The Northerners in the Midland did not differ significantly from the Northerners in the North for any of the vowel formants. This pattern of results is consistent with Northern Cities Shifting among the Northern talkers relative to the Midland talkers, as well as with stronger evidence of the Northern Cities Shift among Northerners in the North than Northerners in the Midland. The Midland talkers also exhibited fronting (higher F2) of /u/ relative to Northerners in the North, consistent with greater /u/-fronting in the Midland than in the North (Labov et al., 2006; cf. Clopper et al., 2019).

3.2. Results: Individual talker clustering

The analysis in Section 3.1 broadly confirmed the presence of the Northern Cities Shift among the Northern talkers in the Ohio State Stories Corpus, with stronger evidence of the shift among Northerners in the North than Northerners in the Midland. This differential evidence of the shift among the two Northern groups is potentially consistent with second dialect acquisition of the Midland dialect by some of the Northerners in the Midland. As noted in Section 1.1, this difference may also reflect stronger Northern rootedness among Northerners in the North than some of the Northerners in the Midland, given that a component of rootedness is a lack of a desire to move away from an area, which the Northerners in the Midland did, but the Northerners in the North did not, with the result potentially being differences in the degree of the Northern Cities Shift prior to the former group's relocation to the Midland. Our production data are insufficient to distinguish between these two alternative interpretations (see Section 5.1).

To examine potential individual talker differences in second dialect acquisition by Northerners in the Midland, as well as to more accurately divide the talkers into groups who showed evidence of the Northern Cities Shift or not in their vowel productions, we conducted a k-means clustering analysis of the full set of 45 talkers. The input to the model comprised by-talker mean z-scored midpoint F1 and F2 values for the vowels implicated in the Northern Cities Shift that were shown in the analysis in Section 3.1 to distinguish the talkers by dialect: /ɛ æ ɑ/. A two-cluster solution was constructed to capture talkers with and without the features of the Northern Cities Shift. The distance metric used in the k-means clustering analysis was Euclidean distance in a six-dimensional space, with one dimension for each of the two formants for each of the three vowels. To identify the clusters, the distances in this six-dimensional space between individual talkers and their assigned cluster center, defined as the mean over all talkers in the cluster, were minimized. Given that the formant frequencies were z-scored, each of the six dimensions were on the same scale and both formants for all vowels therefore contributed equally to the distance metric, and, by extension, cluster assignment.

In the resulting solution, cluster 1 included one Midlander, 12 Northerners in the North, and six Northerners in the Midland, and cluster 2 included 14 Midlanders, three Northerners in the North, and nine Northerners in the Midland. Thus, 80% of the Northerners in the North were assigned to cluster 1 and all but one of the Midlanders were assigned to cluster 2. The Northerners in the Midland were more evenly divided between the two clusters, with six talkers in cluster 1 with the Northerners in the North and nine talkers in cluster 2 with the Midlanders. A visual inspection of the vowel spaces of the talkers in the two clusters in Fig. 2 confirms that the clusters

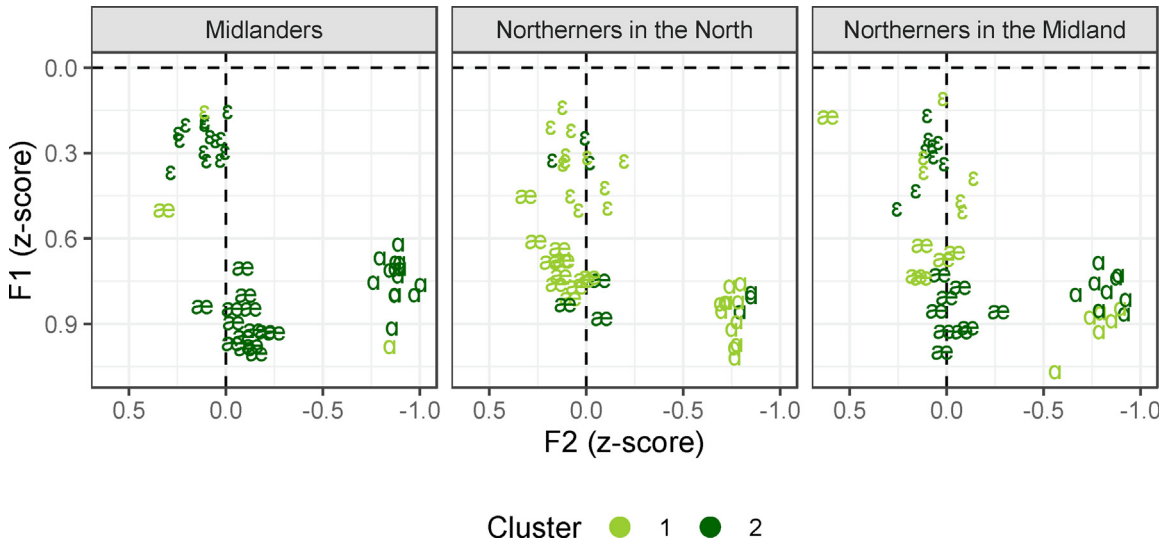

Fig. 2. Partial vowel spaces of the talkers in the Ohio State Stories Corpus, as a function of talker group (Midlanders, Northerners in the North, Northerners in the Midland) and k-means cluster assignment (1, 2). Symbols represent individual talker means.

capture talkers with features of the Northern Cities Shift (cluster 1, lighter symbols), including raised and fronted /æ/, lowered and fronted /ɑ/, and, to a lesser extent, lowered and backed /ɛ/, and those without (cluster 2, darker symbols). Thus, the results suggest two clusters of talkers defined by the presence vs. absence of the Northern Cities Shift in their vowel productions. That is, cluster 1 comprises NCS talkers and cluster 2 comprises non-NCS talkers.[3] The results further suggest second dialect acquisition of the Midland dialect by some Northerners in the Midland, although lifetime residents of both regions also exhibit individual variation in vowel production.

3.3. Discussion

The results of the analysis of overall group differences in Section 3.1 confirm the presence of the Northern Cities Shift among the Northern talkers, including both the Northerners in the North and the Northerners in the Midland, relative to the Midlanders. In particular, both groups of Northerners exhibit significant /ɛ/-lowering, /æ/-raising, and /ɑ/-fronting and -lowering relative to the Midlanders. The Northerners in the North further exhibit significant /ɛ/-backing and /æ/-fronting relative to the Midlanders. The difference between the two Northern groups was not significant for any of the vowel formants. Thus, as a group, the Northerners in the Midland pattern more similarly to the Northerners in the North and show some significant differences from the Midlanders, consistent with the Northern Cities Shift.

At the same time, the evidence for the Northern Cities Shift is weaker among the Northerners in the Midland than the Northerners in the North, for whom more vowel formant differences from the Midlanders were significant (see Table 3). The results of the clustering analysis of the individual talkers in Section 3.2 suggest that the weaker overall effects reflect second dialect acquisition by some of the Northerners in the Midland, but not others. In particular, 60% (9 of 15) of the Northerners in the Midland were assigned to the non-NCS cluster, whereas 40% (6 of 15) were assigned to the NCS cluster. The Northerners in the Midland who were assigned to the NCS cluster are those who produced the most /ɛ/-lowering, /æ/-raising, and /ɑ/-lowering, consistent with the Northern Cities Shift, whereas the Northerners in the Midland who were assigned to the non-NCS cluster produced vowels that are less consistent with the Northern Cities Shift and more consistent with the Midland dialect (see Fig. 2). This distribution of the Northerners in the Midland further supports our interpretation of the two clusters as reflecting the presence vs. absence of Northern Cities Shift features.

The clustering analysis also revealed variation in the presence of the Northern Cities Shift features among the Northerners in the North and the Midlanders. Three of the Northerners in the North were assigned to the non-NCS cluster and one Midlander was assigned to the NCS cluster. As shown in Fig. 2, the Northerners in the North who were assigned to the non-NCS cluster produced lower and backer /æ/ and higher and backer /ɑ/ than the Northerners in the North assigned to the NCS cluster, consistent with the Midland vowel pattern. Likewise, the single Midlander assigned to the NCS cluster produced higher and fronter /æ/ and lower and fronter /ɑ/ than the other Midlanders, consistent with the Northern Cities Shift. Thus, the lifetime residents of the two regions also exhibited individual variation in their production of Northern vs. Midland vowel features.

Together the results of these two analyses provide evidence for second dialect acquisition among some of the Northerners in the Midland, alongside variation in the presence of Northern Cities Shift features within each of the two lifetime resident groups. The variation observed among the Northerners in the Midland aligns with the previous literature on second dialect acquisition by adults, which consistently reveals individual

[3] Alternatives to k-means clustering were explored, including hierarchical clustering and linear discriminant analysis. The specific assignment of individual talkers to clusters varies somewhat across analyses, reflecting the continuous variation observed in the vowel spaces. That is, talkers on the edges of the clusters are variably assigned across analyses. However, all analyses produce clear groups of NCS and non-NCS talkers. The alternative analyses are available on the Open Science Framework repository for this project: https://osf.io/6jnds/.

variation (Conn & Horesh, 2002; Evans & Iverson, 2007; Johnson & Nycz, 2015; Nycz, 2013a, 2013b, 2018; Shockey, 1984). The variation observed within the other two groups aligns with our previous work on /u/-fronting in the Ohio State Stories Corpus, in which the magnitude of /u/-fronting did not neatly align with regional dialect boundaries (Clopper et al., 2019). This variation within the lifetime resident groups is also consistent with previous claims about the permeability of the North-Midland dialect boundary (e.g., Davis & Houck, 1992; Thomas, 2010), as well as with claims about within-region variation reflecting social-identity factors, such as rootedness (e.g., Reed, 2020a, 2020b, 2020c) and local orientation (D'Onofrio & Benheim, 2020).

4. Analysis #2: Dialect variation and phonetic reduction

4.1. Results

The final analysis in this study explored the interaction between dialect variation and phonetic reduction in the speech of the talkers in the Ohio State Stories Corpus. Recall from Section 1.2 that the motivation for the study was to observe the interaction between (1) the Northern Cities Shift, (2) recording location, and (3) variables related to phonetic reduction. Given the variability that we observed in the production of the Northern Cities Shift within and across talker groups, we used the cluster assignments from the k-means clustering as the factor representing talker dialect—that is, whether or not the talker produced features of the Northern Cities Shift. In addition, we considered the location of the recording, in the Midland or the North, as well as the interactions of both k-means cluster and recording location with a set of variables related to phonetic reduction (Clopper et al., 2019; cf. Clopper & Pierrehumbert, 2008; Clopper et al., 2017).

Separate linear mixed-effects models were constructed using the *lme4* package in R (Bates, Mächler et al., 2015) for each vowel category /ɛ æ ɑ/ to predict z-scored midpoint F1 and F2 estimates with k-means cluster, recording location, and five phonetic reduction variables (log lexical frequency, neighborhood density, mention, log cloze predictability,[4] and style) as fixed effects, as well as all two- and three-way interactions involving k-means cluster and recording location. No interactions among the phonetic reduction variables were considered (cf. Burdin et al., 2015). Vowel duration was included as a covariate to capture the potential correlation between vowel duration and vowel space expansion (Moon & Lindblom, 1994; cf. Clopper et al., 2017; Fourakis, 1991). The k-means cluster and recording location variables were treatment coded with the NCS cluster and North as the reference levels, respectively. The other categorical fixed effects (mention and style) were sum-contrast coded and the continuous predictors (lexical frequency, neighborhood density, cloze predictability, and duration) were centered. Thus, the coefficients in the model output for the phonetic variables are interpretable as simple effects of phonetic reduction for talkers with features of the Northern Cities Shift recorded in the North. The maximal random effect structure for talkers and target words supported by the data was used in each analysis (Bates, Kliegl, Vasishth, & Baayen, 2015). The *bobyqa* optimizer was used to facilitate model convergence. All main effects and all interactions among categorical predictors were evaluated using the Satterthwaite approximation of degrees of freedom, as implemented in the *lmerTest* package in R (Kuznetsova et al., 2017). Interactions between categorical and continuous predictors were evaluated using treatment contrasts with releveling. Given the unbalanced cells of the k-means cluster × recording location interaction, we examined Variance Inflation Factors (VIF) for each model with all categorical predictors sum-contrast coded. The maximum VIF was less than 2.6 for all models and this degree of collinearity among predictors was deemed acceptable.

A summary of the significant main effects and interactions from the linear mixed-effects models is shown in Table 4 and significant pairwise comparisons and simple effects are reported in the main text. The full model specifications and output are provided on the Open Science Framework repository for this project: https://osf.io/6jnds/. The effects of frequency, density, mention, predictability, and style are shown separately for each k-means cluster group for each recording location in Figs. 2–6, respectively. For ease of comparison across the figures, frequency, density, and predictability are shown in these figures as binary variables, based on a median split, although the analysis was conducted using continuous variables. In all five figures, lighter symbols represent the tokens that are expected to be reduced (high-frequency, low-density, second mention, high-predictability, plain speech) relative to the tokens represented by the darker symbols (low-frequency, high-density, first mention, low-predictability, clear speech).

The analysis revealed significant main effects of k-means cluster for both F1 and F2 of /æ ɑ/, further confirming the interpretation of the clusters as reflecting presence (cluster 1) vs. absence (cluster 2) of features of the Northern Cities Shift. In addition, recording location was not a significant main effect for either formant for any of the vowels, further confirming the interpretation of the clusters as reflecting individual talker productions, largely independent of recording location. However, the interaction between k-means cluster and recording location was significant for F1 of /æ ɑ/. In both cases, pairwise comparisons revealed that the k-means cluster effect was significant for the Midland recordings (/æ/: $t = -6.63$, $p < 0.001$; /ɑ/: $t = 4.68$, $p < 0.001$), but not for the Northern recordings. Thus, the differences in vowel productions between talkers with and without features of the Northern Cities Shift are smaller in the North than in the Midland, as might be expected, given the greater homogeneity of the talkers recorded in the North (i.e., all lifetime residents of the North) than the talkers recorded in the Midland (i.e., both lifetime residents of the Midland and recent Northern transplants).

The analysis also revealed numerous significant main effects consistent with phonetic reduction, as well as some significant interactions between k-means cluster, recording location, and the phonetic reduction variables. The duration covariate was significant in the predicted direction (i.e., shorter vowels are centralized) for both F1 and F2 of /ɛ ɑ/ and for F1 of /æ/. The effects of the phonetic reduction variables (lexical frequency, neighborhood density, mention, predictability, and style) were more variable across formants and vowels, but

[4] Cloze predictability values of 0 were changed to 0.01 prior to log-transformation to avoid undefined values (Clopper, Turnbull, & Burdin, 2018).

Table 4
Summary of the significant main effects and interactions in the mixed-effects models examining dialect variation and phonetic reduction in the Ohio State Stories Corpus. Significant F-statistics are shown with Satterthwaite approximation of degrees of freedom in parentheses (all $p < 0.05$).

	F1 /ɛ/	F2 /ɛ/	F1 /æ/	F2 /æ/	F1 /ɑ/	F2 /ɑ/
Cluster			26.28(1, 50)	18.00(1, 46)	10.72(1, 59)	7.06(1, 55)
Duration	579.07(1, 2598)	18.38(1, 4591)	363.45(1, 2248)		30.34(1, 3185)	45.76(1, 2059)
Frequency					8.13(1, 29)	21.17(1, 19)
Density		6.74(1, 41)			5.53(1, 28)	9.41(1, 20)
Mention			22.51(1, 55)			6.02(1, 35)
Predictability				19.37(1, 75)		4.28(1, 35)
Style	87.67(1, 45)	31.72(1, 45)	57.16(1, 57)		26.48(1, 60)	15.90(1, 50)
Cluster × location			5.08(1, 45)		4.45(1, 45)	
Cluster × density	14.33(1, 5731)					6.16(1, 35)
Cluster × predictability					9.28(1, 156)	
Location × frequency						4.43(1, 54)
Location × density		4.63(1, 57)			11.75(1, 4800)	11.84(1, 57)
Location × predictability					13.45(1, 4763)	
Cluster × location × density				6.32(1, 6374)		
Cluster × location × style		4.76(1, 44)				

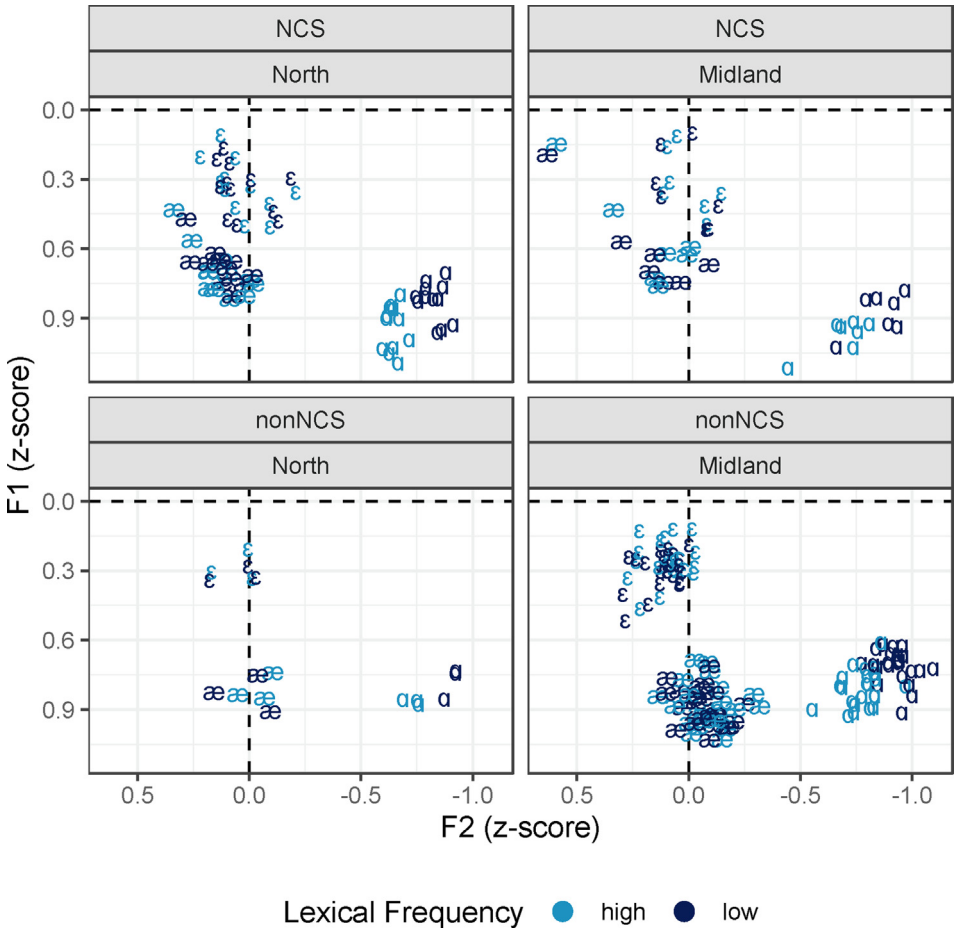

Fig. 3. Effect of lexical frequency on vowel formant frequencies for each k-means cluster (NCS, nonNCS) and recording location (North, Midland). Symbols represent individual talker means. High and low frequency are defined by a median split of the continuous measure.

were generally in the expected direction for phonetic reduction when they were observed.

As shown in Fig. 3, higher frequency target words led to fronter /ɑ/ tokens ($B = 0.084$, $t = 4.61$, $p < 0.001$), consistent with both phonetic reduction and the Northern Cities Shift, but also to lower /ɑ/ tokens ($B = 0.057$, $t = 2.85$, $p = 0.008$), contrary to phonetic reduction patterns, but consistent with the Northern Cities Shift. In addition, the effect of frequency on /ɑ/-fronting interacted significantly with location. Post-hoc analyses confirm a significant positive effect of frequency for both recording locations. The effect is larger in the Northern recordings ($B = 0.093$, $t = 5.05$, $p < 0.001$) than in the Midland recordings ($B = 0.074$, $t = 3.91$, $p < 0.001$), consistent with enhancement of the Northern Cities Shift among talkers recorded in the North.

As shown in Fig. 4, lower density target words led to backer /ɛ/ tokens ($B = 0.008$, $t = 2.60$, $p = 0.013$), consistent with both phonetic reduction and the Northern Cities Shift, and higher /ɑ/

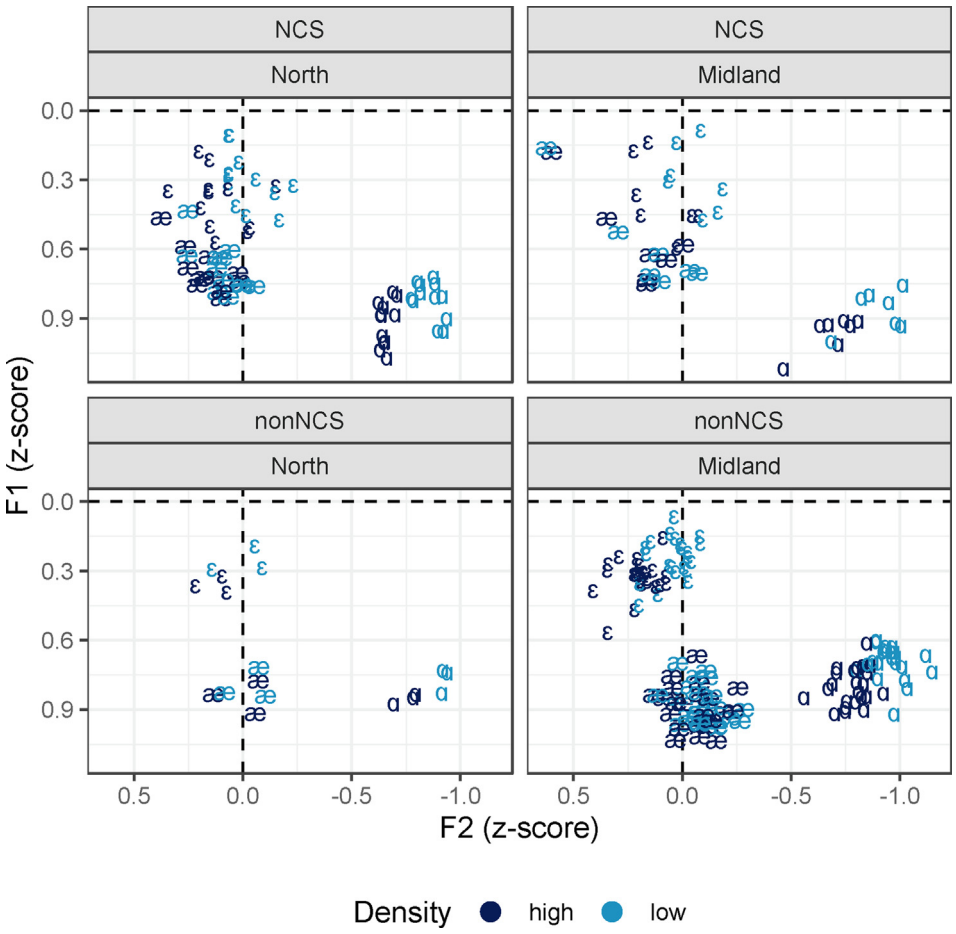

Fig. 4. Effect of neighborhood density on vowel formant frequencies for each k-means cluster (NCS, nonNCS) and recording location (North, Midland). Symbols represent individual talker means. High and low density are defined by a median split of the continuous measure.

tokens ($B = 0.005$, $t = 2.35$, $p = 0.026$), consistent with phonetic reduction. However, lower density target words also led to backer /ɑ/ tokens ($B = 0.006$, $t = 3.07$, $p = 0.006$), contrary to both phonetic reduction and the Northern Cities Shift. Density was also involved in numerous interactions with k-means cluster and recording location. Post-hoc analyses revealed some of these interactions to be relatively uninformative to our research questions. For the F1 of /ɛ/, the interaction between cluster and density was significant. However, post-hoc analyses revealed a non-significant negative effect of density for the NCS cluster ($B = -0.002$, $t = -0.721$, *n.s.*) and a non-significant positive effect of density for the non-NCS cluster ($B = 0.001$, $t = 0.376$, *n.s.*), leading to the significant interaction. Given that the effect of density was not significant for either cluster, this result will not be discussed further. For the F2 of /æ/, the three-way interaction between k-means cluster, recording location, and density was significant. Post-hoc analyses revealed a positive effect of density, consistent with phonetic reduction, for both clusters from both recording locations. However, this effect only reached statistical significance for the NCS cluster recorded in the North ($B = 0.006$, $t = 2.37$, $p = 0.023$) and the non-NCS cluster recorded in the Midland ($B = 0.005$, $t = 2.14$, $p = 0.038$). This finding likely reflects differences in statistical power across the four cells of the design, as the non-NCS cluster recorded in the North includes only three talkers and the NCS cluster recorded in the Midland includes only seven talkers.

The remaining interactions provided greater insight into our question regarding the combined effects of dialect variation and phonetic reduction on vowel production. For the F2 of /ɛ/ and the F1 of /ɑ/, a significant interaction between location and density was observed. Post-hoc analyses revealed significant positive effects of density for both locations for the F2 of /ɛ/, consistent with the main effect observed in the analysis. The effect was smaller for the Northern recordings ($B = 0.007$, $t = 2.23$, $p = 0.032$) than the Midland recordings ($B = 0.009$, $t = 2.89$, $p = 0.006$). Similarly, for the F1 of /ɑ/, post-hoc analyses revealed a significant effect for density consistent with phonetic reduction for the Midland recordings only ($B = 0.006$, $t = 3.13$, $p = 0.004$). Thus, for both vowel formants, the effect of density was larger for the Midland recordings than the Northern recordings. Given that most of the Midland recordings involve non-NCS talkers (i.e., 23 of 26) and most of the Northern recordings involve NCS talkers (i.e., 12 of 18), the interaction for the F1 of /ɑ/ can be taken as weak evidence of the expected interaction, in which the magnitude of phonetic reduction is reduced for Northern talkers when phonetic reduction and dialect enhancement are in competition. However, for the F2 of /ɛ/, the interaction is contrary to the predicted pattern, given that both phonetic reduction and the

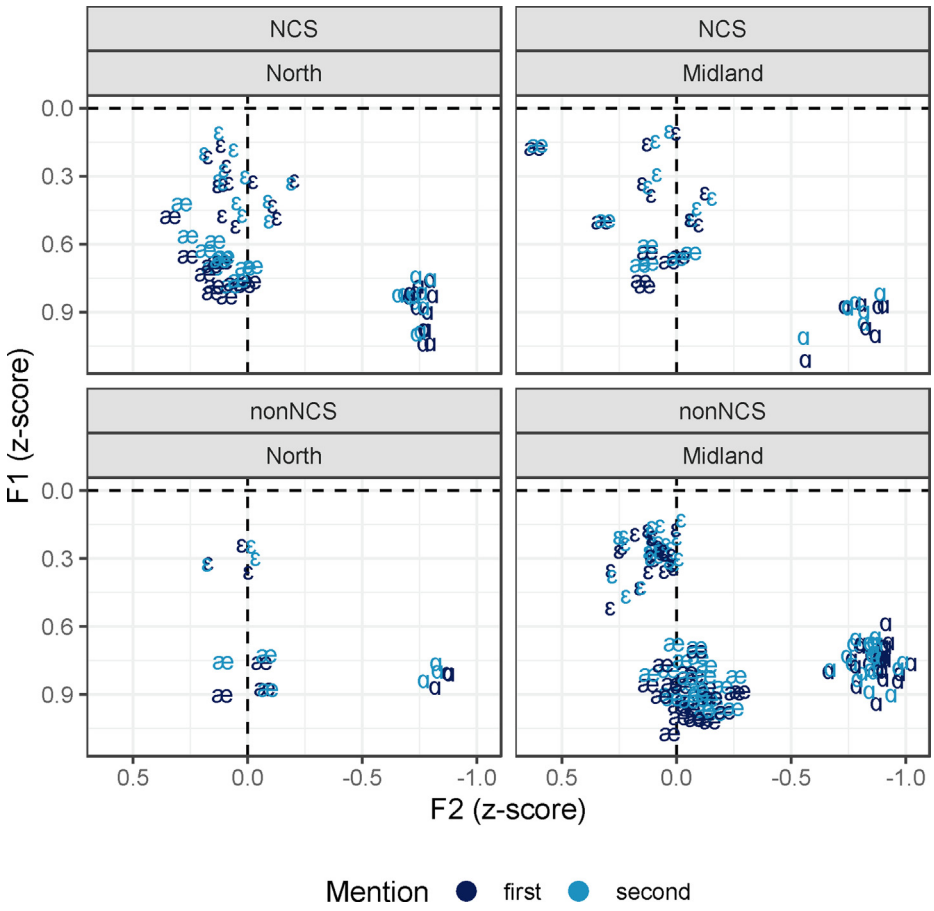

Fig. 5. Effect of discourse mention on vowel formant frequencies for each k-means cluster (NCS, nonNCS) and recording location (North, Midland). Symbols represent individual talker means.

Northern Cities Shift predict backing of /ɛ/ and should therefore lead to a larger effect in the North than in the Midland.

Finally, for the F2 of /ɑ/, significant interactions were observed between k-means cluster and density and between location and density. Post-hoc analyses revealed significant positive effects of density for both clusters. The effect was larger for the NCS cluster (B = 0.007, t = 3.26, p = 0.004) than the non-NCS cluster (B = 0.004, t = 2.49, p = 0.019). The larger effect for the NCS cluster than the non-NCS cluster was expected, given that the predictions of phonetic reduction and Northern Cities Shifting align for the F2 of /ɑ/. However, as noted above, the overall effect of density on the F2 of /ɑ/ is inconsistent with both phonetic reduction and the Northern Cities Shift. Post-hoc analyses of the location × density interaction further confirm that the effect of density is significant in the unexpected direction for both recording locations. The effect is larger in the Midland recordings (B = 0.007, t = 3.72, p = 0.001) than in the Northern recordings (B = 0.004, t = 2.23, p = 0.037). Although the effect of location on the magnitude of the density effect is similar to what was observed for the F2 of /ɛ/ and the F1 of /ɑ/, the result is unexpected in the context of the k-means cluster interaction, in which the density effect was stronger for the NCS cluster (who were mostly recorded in the North) than for the non-NCS cluster (who were mostly recorded in the Midland). Apart from these unexpected findings for the F2 of /ɑ/, the interactions demonstrate more robust density effects among talkers recorded in the Midland than those recorded in the North, suggesting greater phonetic reduction when the local dialect does not conflict with phonetic reduction processes.

As shown in Fig. 5, second mentions of target words led to higher /æ/ tokens (B = 0.031, t = 4.75, p < 0.001) and fronter /ɑ/ tokens (B = −0.016, t = −2.46, p = 0.019), consistent with phonetic reduction and the Northern Cities Shift. No significant interactions involving discourse mention emerged in the analysis, suggesting that these effects were similar in magnitude across the two talker clusters and the two recording locations.

As shown in Fig. 6, higher predictability target words led to fronter /ɑ/ tokens (B = 0.018, t = 2.07, p = 0.046), consistent with phonetic reduction and the Northern Cities Shift, but also to fronter /æ/ tokens (B = 0.022, t = 4.40, p < 0.001), contrary to phonetic reduction patterns, but consistent with the Northern Cities Shift. In addition, the interactions between cluster and predictability and between location and predictability were significant for the F1 of /ɑ/. Post-hoc analyses revealed a significant negative effect of predictability, consistent with phonetic reduction, for the NCS cluster only (B = −0.018, t = −2.27, p = 0.030), contrary to the predicted interaction between dialect variation and phonetic reduction. That is, given that phonetic reduction and the Northern Cities Shift conflict for the F1 of /ɑ/, the NCS cluster should exhibit a smaller effect of predictability than the non-NCS cluster. In contrast, for the interac-

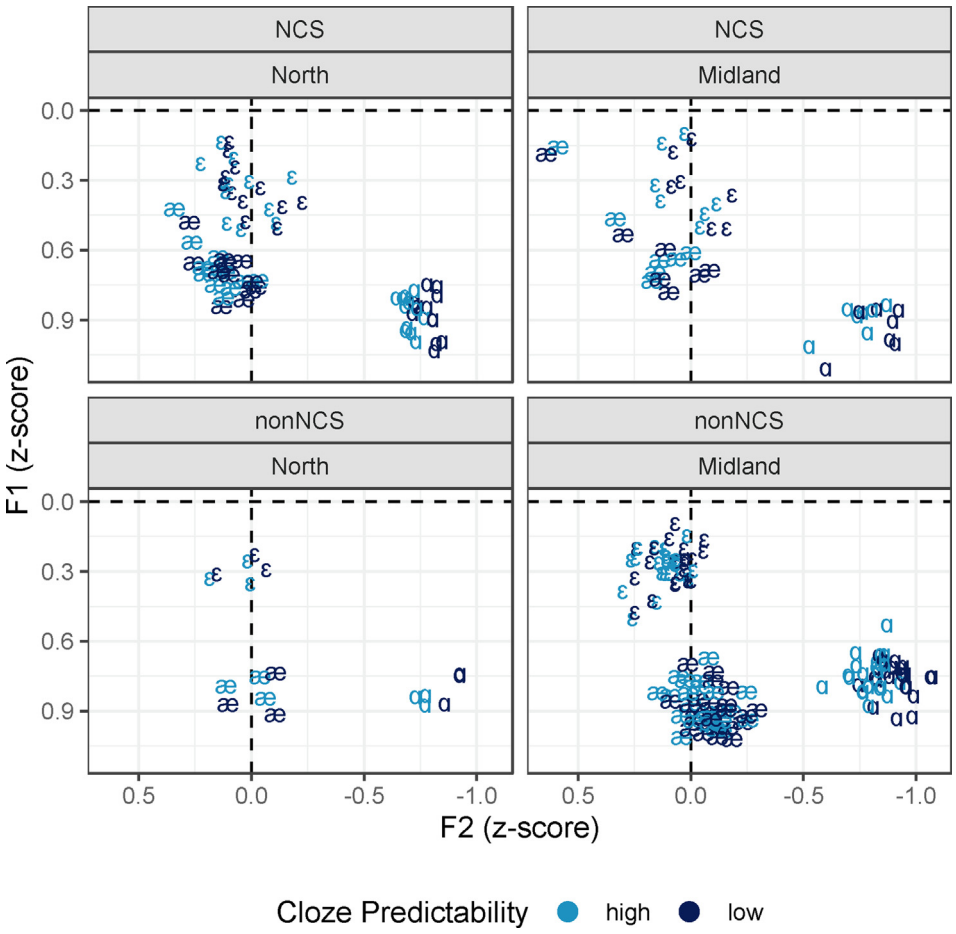

Fig. 6. Effect of cloze predictability on vowel formant frequencies for each k-means cluster (NCS, nonNCS) and recording location (North, Midland). Symbols represent individual talker means. High and low predictability are defined by a median split of the continuous measure.

tion involving location, post-hoc analyses revealed significant effects of predictability consistent with phonetic reduction for the Midland recordings only ($B = -0.017$, $t = -2.18$, $p = 0.033$). On the one hand, this interaction with location can be taken as weak evidence of the expected pattern, as in the parallel result in the location × density interaction for the F1 of /ɑ/, in which the magnitude of phonetic reduction is reduced for Northern talkers when phonetic reduction and dialect enhancement are in competition. On the other hand, however, the location × predictability interaction appears to conflict with the cluster × predictability interaction, in which the effect is stronger for the NCS cluster (who were mostly recorded in the North) than for the non-NCS cluster (who were mostly recorded in the Midland). This apparently mismatching pattern of interactions is parallel to the results observed for density for the F2 of /ɑ/.

As shown in Fig. 7, the plain style led to higher and backer /ɛ/ (F1: $B = 0.072$, $t = 9.36$, $p < 0.001$; F2: $B = 0.029$, $t = 5.63$, $p < 0.001$), higher /æ/ ($B = 0.077$, $t = 7.56$, $p < 0.001$), and higher and fronter /ɑ/ (F1: $B = 0.061$, $t = 5.15$, $p < 0.001$; F2: $B = -0.028$, $t = -3.99$, $p < 0.001$) tokens, consistent with phonetic reduction. For the F2 of /ɛ/, an interaction between k-means cluster, location, and style was also observed. Post-hoc analyses revealed a significant effect of style for both clusters recorded in the Midland (NCS: $B = 0.041$, $t = 2.06$, $p = 0.046$; non-NCS: $B = 0.066$, $t = 5.92$, $p < 0.001$), but only for the NCS cluster recorded in the North ($B = 0.094$, $t = 6.16$, $p < 0.001$). As noted above, the non-NCS cluster recorded in the North included only three talkers, so the lack of a significant effect of style for this group may reflect insufficient statistical power.

4.2. Discussion

The analysis of the interactions between dialect variation and phonetic reduction in the Ohio State Stories corpus involved the consideration of the effects of five linguistic variables on the first two formants for each of three vowels for four talker groups, defined by their dialect features in production and the location where they were recorded. Unsurprisingly, given previous work on this topic (Clopper & Pierrehumbert, 2008; Clopper et al., 2017), the analysis revealed a variable pattern of main effects and interactions across the six vowel formants we considered. The main effects of style and duration on phonetic reduction were the most robust and consistent across vowels, with less consistent effects for lexical frequency, neighborhood density, mention, and predictability.

A summary of the significant results and how they align with the predictions associated with phonetic reduction and enhancement of the Northern Cities Shift is shown in Table 5.

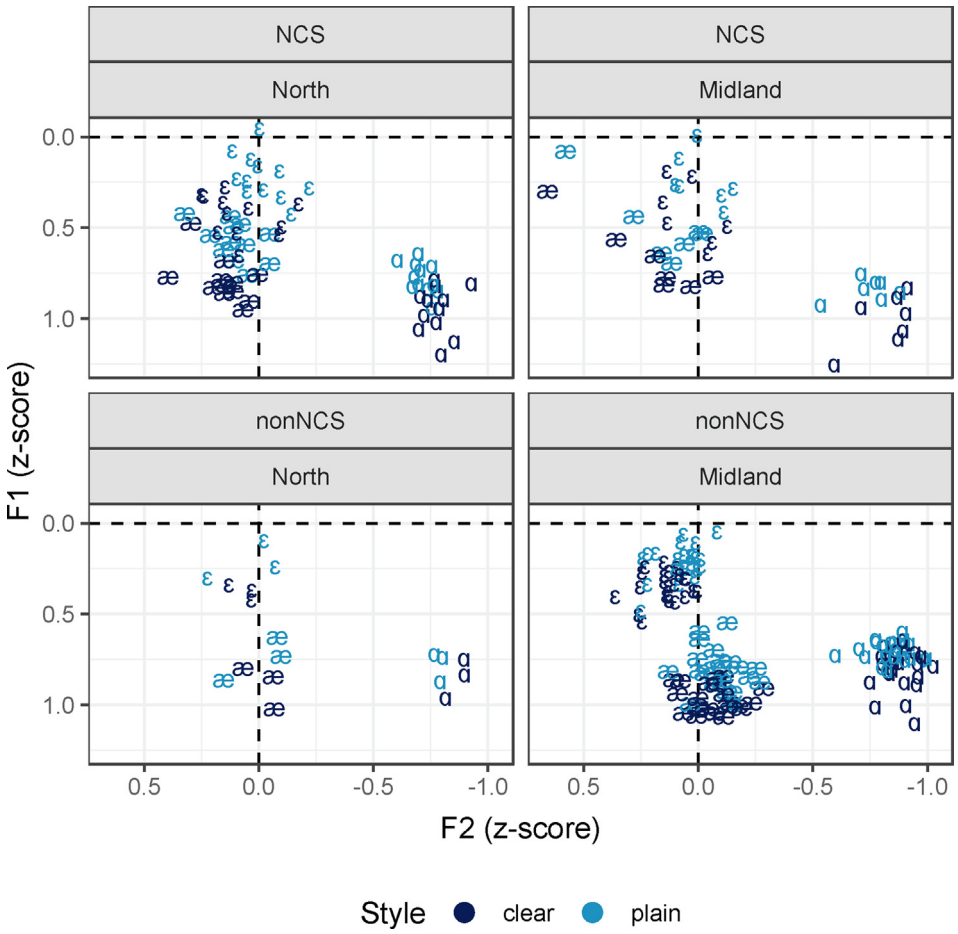

Fig. 7. Effect of style on vowel formant frequencies for each k-means cluster (NCS, nonNCS) and recording location (North, Midland). Symbols represent individual talker means.

Table 5
Summary of the significant effects of phonetic reduction and enhancement of the Northern Cities Shift (NCS) on vowel production in the Ohio State Stories Corpus. Shaded rows indicate vowel formants for which the predicted effects conflict (see Table 1).

Vowel formant	Phonetic reduction effects		NCS enhancement effects		Other effects	
/ɛ/ F1	*raising*	style				
/æ/ F2	*backing*	density	*fronting*	predictability		
/ɑ/ F1	*raising*	style density predictability	*lowering*	frequency		
/ɛ/ F2	*backing*	density style	*backing*	density style		
/æ/ F1	*raising*	mention style	*raising*	mention style		
/ɑ/ F2	*fronting*	predictability style frequency mention	*fronting*	predictability style frequency mention	*backing*	density

Given previous work (Clopper & Pierrehumbert, 2008; Clopper et al., 2017), we expected the phonetic reduction variables to predict centralization in the vowel space (i.e., phonetic reduction) and enhancement of the NCS. The first three rows of the table are shaded and show the effects that were observed when the phonetic reduction and Northern Cities Shift enhancement predictions are in conflict (see Table 1), whereas the last three rows of the table show the effects that were

observed when the phonetic reduction and Northern Cities Shift enhancement predictions align. In terms of overall numbers, more significant effects of the phonetic reduction variables were observed when the predictions align than when they conflict. This difference is broadly consistent with the proposal that productions of vowel variants along the dialect variation and phonetic reduction continua covary, leading to stronger effects when they are in alignment. An inspection of Table 4 further suggests larger overall effect sizes for frequency and density among the vowel formants for which the predictions align relative to those for which they conflict, but the same pattern is not observed for predictability and style. Within the set of vowel formants for which the predictions conflict (i.e., the shaded rows in Table 5), more significant effects were observed that are consistent with phonetic reduction than with enhancement of the Northern Cities Shift. Given that the talker set included fewer talkers overall with features of the Northern Cities Shift (N = 19) than talkers without (N = 26), it is not surprising that phonetic reduction produced stronger effects overall than dialect enhancement in this corpus.

The interactions between the phonetic reduction variables and the two talker-related variables (k-means cluster and recording location) generally revealed weaker evidence of phonetic reduction for the Northern recordings than the Midland recordings, except for the frequency effect on the F2 of /ɑ/, for which the effect was stronger for the Northern recordings than the Midland recordings. Given that the talkers recorded in the North were more likely to exhibit features of the Northern Cities Shift than talkers recorded in the Midland, this pattern of interactions is also broadly consistent with the proposal that dialect enhancement and phonetic reduction processes operate along covarying continua in vowel production, leading to stronger effects of phonetic reduction when it aligns with dialect-specific features and weaker effects of phonetic reduction when it conflicts with dialect-specific features.

As shown in Table 5, all but one of the results of this analysis were consistent with phonetic reduction and/or the Northern Cities Shift. The density effect for the F2 of /ɑ/, however, was unexpected. Whereas both phonetic reduction and the Northern Cities Shift predict fronting of /ɑ/ in low-density words, the low-density words in this corpus were produced with backed /ɑ/ relative to high-density words (see Fig. 4). Although numerous studies have demonstrated phonetic reduction for low-density words relative to high-density words (e.g., Munson & Solomon, 2004; Scarborough, 2010; Wright, 2004), these studies have examined words produced in isolation. In contrast, one study examining spontaneous speech has revealed phonetic reduction in high-density words relative to low-density words (Gahl, Yao, & Johnson, 2012). The words in the current study were produced in read short stories, which could arguably be more similar to spontaneous speech than isolated read words, if connected speech is the critical dimension of variation. However, speaking style cannot be the sole explanation for the unexpected direction of the density effect for the F2 of /ɑ/ in the current study, given that other vowel formants that we examined, including the F2 of /ɛ æ/ and the F1 of /ɑ/, showed phonetic reduction in low-density words relative to high-density words. The unexpected result likewise does not likely reflect a misrepresentation of /ɑ/ as a back vowel that is fronted under phonetic reduction, given that high-frequency, second mention, high-predictability, and plain style tokens were all fronted relative to low-frequency, first mention, low-predictability, and clear style tokens, consistent with fronting as the realization of phonetic reduction for /ɑ/. Thus, the explanation may lie at the very narrow intersection of density effects for /ɑ/, perhaps related to specific minimal pairs involving the target words and either /æ/ or /ɔ/ (see Clopper & Tamati, 2014) or to lexical idiosyncrasies involving the phonemic specification of some target words (e.g., whether the target word *dog* contains /ɑ/ or /ɔ/ for individual talkers), especially for Midlanders who have overlapping acoustic categories for /ɑ ɔ/ (see Fig. 1).

The effect of density on the F2 of /ɑ/ also presents a puzzle with respect to the significant interactions involving k-means cluster and recording location. The interactions suggested a stronger effect of density for the NCS cluster than the non-NCS cluster and for the Midland recordings than the Northern recordings. A similar pattern of interactions was observed for the effect of predictability on the F1 of /ɑ/. Given that most of the Northern recordings were of NCS talkers and most of the Midland recordings were of non-NCS talkers, the two interactions appear to be in conflict. However, an inspection of Figs. 4 and 6 suggests that the locus of both interactions is the relatively smaller effects of density on the F2 of /ɑ/ and predictability on the F1 of /ɑ/ for the non-NCS talkers recorded in the North.[5] Although this interpretation would be more strongly supported by a significant three-way interaction involving both k-means cluster and recording location, the small number of non-NCS talkers recorded in the North may have limited our ability to observe those interactions.

5. Discussion

The first goal of the current study was to assess the magnitude of second dialect acquisition among Northern American students at a university in the Midland American dialect region. The results of the first series of analyses revealed significant group differences in the realization of the Northern Cities Shift between Northern talkers and Midland talkers, but no significant group differences between the Northerners in the North and the Northerners in the Midland. However, the analysis also revealed considerable individual talker variability within each group, suggesting second dialect acquisition by some of the Northern talkers in the Midland. The second goal of the current study was to explore how second dialect acquisition interacts with the enhancement of dialect-specific features in contexts that lead to phonetic reduction. The results of the second analysis revealed the expected effects of phonetic reduction on vowel realization across talker groups, but only indirect evidence of the expected interactions between dialect variation and phonetic reduction.

5.1. Second dialect acquisition

Previous research has demonstrated that university students exhibit second dialect acquisition as early as their first

[5] We considered the possibility that the interactions may be driven by the NCS talker in the Midland with a very fronted and lowered /ɑ/ (see Figs. 4 and 6), but models constructed with that talker excluded revealed the same pattern of interactions as the models with the full dataset.

year on campus (Bigham, 2010; Campbell-Kibler et al., 2014; Evans & Iverson, 2007). The results of the current study provide additional evidence for second dialect acquisition by university students. In particular, although as a group, the Northerners in the Midland patterned with the Northerners in the North and produced significant differences in vowel formants from the Midlanders, consistent with the Northern Cities Shift, the evidence of the Northern Cities Shift was weaker overall among the Northerners in the Midland than the Northerners in the North. In addition, the k-means clustering analysis revealed that, individually, 60% (9/15) of the Northerners in the Midland were more similar to the Midlanders than to the Northerners in the North, consistent with acquisition of the Midland dialect. This finding that some, but not all, of the Northern transplants in the Midland exhibit second dialect acquisition is also consistent with the previous literature, which reveals near-universal individual variation in the magnitude of second dialect acquisition within populations with similar residential histories (Conn & Horesh, 2002; Evans & Iverson, 2007; Johnson & Nycz, 2015; Nycz, 2013a, 2013b, 2018; Shockey, 1984).

One possible alternative explanation for our results is that the individual variation that we observe reflects social-identity factors related to rootedness and connection with the local community. The Northern talkers in the corpus were not—and cannot—be assigned randomly to the two subgroups (i.e., Northerners in the North and Northerners in the Midland). That is, all of the Northerners in the Midland chose to move to the Midland to attend university, whereas all of the Northerners in the North chose to stay in the North to attend university. It is possible, therefore, that the Northerners in the Midland who produced fewer features of the Northern Cities Shift, also produced fewer features of the Northern Cities Shift prior to moving to the Midland region because they were less rooted in the North (Reed, 2020a, 2020b, 2020c) or had a less-local orientation to the North (D'Onofrio & Benheim, 2020). That is, the results may not reflect second dialect acquisition, but cultural identification with the Northern region. Cultural identification may be especially relevant for our data, given that the Northerners in the Midland were almost all from Ohio and were attending university in their home state, albeit in a different dialect region. The Northerners in the Midland may therefore have had varying degrees of affiliation with the Northern region specifically vs. Ohio or the American Midwest more generally. Since we do not have earlier recordings from any of the talkers and did not collect information about the talkers' connection to the Northern or Midland regions, our data cannot directly address this possibility. Longitudinal data tracking second dialect acquisition over time, as well as ethnographic data on rootedness and other place-based orientations, is critical for advancing our understanding of variation in second dialect acquisition.

We also observed individual variation within the two lifetime-resident talker groups (i.e., Northerners in the North and Midlanders) and this variation was smaller in magnitude than what we observed among the Northerners in the Midland. Thus, although variation in all three of the talker groups was observed and may reflect social identity and rootedness to the local community to some extent, it seems unlikely that rootedness provides the primary explanation for the Northerners in the Midland, because they vary so much more than the two lifetime resident groups in their realization of the Northern Cities Shift. In addition, in comparison to previous work on rootedness in Appalachia (Reed, 2020a, 2020b, 2020c), the relative lack of enregisterment of the Northern dialect (Campbell-Kibler, 2012) and the lack of robust regional identities corresponding to the Midland-Northern dialect boundary (Dossey et al., 2020) also weaken the argument in favor of rootedness as the central explanation for our results. Thus, consistent with current perspectives (see Nycz, 2015, for a review), our results suggest that second dialect acquisition is quite flexible, involving substantial variation across individuals. Further research is needed to understand the sources of this individual variation, both within the Midwestern American university student population we considered in this study and within other mobile populations of varying social and regional backgrounds.

5.2. Dialect variation and phonetic reduction

Our own previous research has suggested that dialect-specific features are enhanced in the same contexts in which phonetic reduction is observed (Clopper & Pierrehumbert, 2008; Clopper et al., 2017). The results of the current study reveal the expected patterns of phonetic reduction due to lexical frequency, phonological neighborhood density, discourse mention, cloze predictability, and speaking style, although the most consistent effects were observed for speaking style. The results provide less direct evidence for the expected interaction between dialect variation and phonetic reduction, although this interaction can be observed in the general patterns in Table 5. In particular, numerically fewer significant effects of the phonetic reduction variables were observed when enhancement of the Northern Cities Shift and phonetic reduction were in conflict than when they were not.

In our statistical analysis, we considered interactions between the k-means cluster, the recording location, and the phonetic reduction variables. The k-means cluster factor was intended to capture dialect variation (i.e., NCS vs. non-NCS) and its interaction with recording location was intended to capture differential identity marking of the NCS in the Midland and the North, due to second dialect acquisition. The significant interactions mostly involved recording location instead of k-means cluster, however, and generally revealed greater phonetic reduction in the Midland recordings than in the Northern recordings. The one exception to this pattern was the location $\times$ frequency interaction for the F2 of /ɑ/, which revealed more fronting of /ɑ/, consistent with both phonetic reduction and the Northern Cities Shift, for high frequency words in the Northern recordings than in the Midland recordings. One possible explanation for the recording location effects on phonetic reduction is that they are the result of differences in the two environments, including the physical recording location, the recruitment process, and the experimenter. We find this explanation unlikely, however, because the interactions involving recording location are observed across phonetic reduction variables and include both style, which talkers explicitly control and therefore might be expected to vary with the experimenter or other variables related to the recording setting, as well as neighborhood density, which talkers likely do not have good intuitions about and therefore are less likely to manipulate explicitly in response to the environment.

Given the unbalanced cells of the recording location × k-means cluster design, including just three talkers in the non-NCS cluster who were recorded in the North, but 14 talkers in the non-NCS cluster who were recorded in the Midland, we propose that it is more likely that the recording location variable and its associated interactions reflect talker dialect. That is, recordings in the North largely correspond to NCS talkers and recordings in the Midland largely correspond to non-NCS talkers. Even with this assumption that recording location reflects talker dialect, however, the observed interactions do not provide clear evidence for dialect enhancement in reduction-promoting contexts. Rather, they suggest less phonetic reduction overall among NCS talkers than among non-NCS talkers, somewhat independently of whether the Northern Cities Shift conflicts with phonetic reduction processes for a particular vowel formant. No clear patterns regarding the three-way interaction between second dialect acquisition, dialect enhancement, and phonetic reduction were observed.

The focus of our study was the phonetic realization of vowel targets in the acoustic F1 × F2 space, which allowed for specific predictions about alignment vs. conflict between enhancement of the Northern Cities Shift and phonetic reduction (see Table 1). Much of the other previous research examining the interaction between phonetic reduction and social variation has likewise focused on phonetic variation and vowel production (Clopper & Pierrehumbert, 2008; Clopper et al., 2017, 2019; Hay et al., 1999; Munson, 2007). An open question is how productions along the dialect variation and phonetic reduction continua might vary for other kinds of variables, including both vowel variables involving contrasts such as BATH/TRAP and consonant variables of all kinds. We predict that alignment vs. conflict of the two continua would emerge as a predictor of the realization of variables such as -ING and intervocalic /t d/ flapping, where one variant can be straightforwardly interpreted as more reduced relative to the other variant. The predictions for variables without such straightforward connections to reduction processes are less clear.

5.3. Enhancement of social-identity marking in second dialect acquisition

In our previous work (Clopper & Pierrehumbert, 2008; Clopper et al., 2017), we proposed that talkers take advantage of "easy" listening situations to produce more socially marked forms. From a listener-oriented perspective (e.g., Lindblom, 1990), we argued that, for example, when producing a high-frequency word, talkers can take the "risk" of producing a more fronted /ɑ/ that might be unfamiliar or otherwise more difficult for the listener to process, because the overall processing load for the listener is relatively low. In the context of second dialect acquisition in the current study, we expected this social-identity marking in reduction-promoting contexts to be strongest for the Northern transplants who showed limited second dialect acquisition (i.e., talkers in the NCS k-means cluster who were recorded in the Midland). This prediction was based on the assumptions that limited second dialect acquisition reflects a strong Northern identity and that the Midland recording location would elicit stronger marking of that identity when the linguistic context allowed.

The analysis summarized in Table 5 does not provide strong evidence of greater social-identity marking in reduction-promoting contexts overall. Moreover, we observed essentially no evidence in support of our specific prediction that Northern transplants with NCS features would differ significantly from the other talkers in their realization of dialect features across linguistic contexts. Given that recording location emerged as a more robust predictor of vowel realization in interaction with the linguistic factors than k-means cluster or the k-means cluster × recording location interaction, the results could be interpreted as showing that social-identity marking across linguistic contexts is similar for transplants and lifetime residents of the two dialect regions and that second dialect acquisition does not play a robust role in this process. However, we do not want to over-interpret our null results, especially given the unbalanced cells of our k-means cluster × location recording design, as discussed above.

Indeed, a potential alternative to our prediction about the relationships among second dialect acquisition, social-identity marking, and phonetic reduction is that the Northern transplants who showed limited second dialect acquisition (i.e., who resisted acquiring the local Midland dialect) might also be less likely to exhibit listener-oriented sensitivity to difficult linguistic contexts. That is, they may produce robust NCS features regardless of the context as a strong index of their Northern identity. In contrast, the Northern transplants who show evidence of second dialect acquisition might be more responsive to linguistic context. These talkers have both vowel systems available in their phonetic repertoire, to a certain extent, and can switch between them as needed to balance communicative need with social-identity marking. However, observing statistically significant shifts in this population might be difficult, given that they may not produce vowels with robust NCS features in general when the recording takes place in the Midland region.

Thus, rather than concluding that second dialect acquisition does not affect the enhancement of social-identity marking in reduction-promoting contexts, we need to consider other ways of examining this question. In this study, we chose to rely on highly-controlled read speech samples produced in a laboratory under non-interactive conditions with an artificial manipulation of speaking style (i.e., imagine your interlocutor is X) and an orthogonal manipulation of our linguistic variables (lexical frequency, neighborhood density, discourse mention, semantic predictability, and speaking style). Although this approach is quite common in the literature (Smiljanic & Bradlow, 2009) because of the control it affords over the speech that is produced, previous work has demonstrated variability in speaking style effects with real vs. imagined interlocutors (Scarborough, Brenier, Zhao, Hall-Lew, & Dmitrieva, 2007) and in phonological density effects in read vs. spontaneous speech (Gahl et al., 2012). Thus, to the extent that we believe that these results reflect talkers' attention to the needs of their listeners, data from more ecologically-valid tasks are necessary. This ecological validity extends beyond just moving towards interactive tasks and includes considering speech in noise between interlocutors of different ages and social backgrounds (Hazan et al., 2018; Tuomainen, Taschenberger, Rosen, & Hazan, 2021).

For example, an interlocutor with a specific regional background may be critical for observing second dialect effects of this kind. Regional background of the imagined interlocutor was not manipulated in our study, but perhaps second dialect effects would emerge if we asked our Northern transplants to interact separately with both other Northern transplants and lifetime Midland residents. Alternatively, these effects might emerge if we asked our Northern transplants to interact separately with both Northerners in the North and Midlanders in the Midland. We suggest that these comparisons might lead to differences among the Northern transplants as they engage with interlocutors who represent their first and second dialects, respectively (cf. Campbell-Kibler et al., 2014; see also Kim, Horton, & Bradlow, 2011). Whereas the Northern transplants who have not acquired features of the Midland dialect might show limited interlocutor effects, the Northern transplants who have acquired features of the Midland dialect might produce more Northern features in reduction-promoting contexts when talking to other transplants or when in the North, but fewer Northern features in reduction-promoting contexts when talking to Midlanders or when in the Midland. This kind of result would allow us to draw theoretical connections among second dialect acquisition, listener-oriented accounts of variation, and interactive phonetic accommodation by acknowledging the potential difficulty of cross-dialect communication and its role in second dialect acquisition.

5.4. Conclusion

Adult Northern transplants to the Midland dialect region exhibit variation in second dialect acquisition, with evidence of loss of Northern Cities Shift features among some talkers and maintenance of Northern Cities Shift features among others. This result provides further evidence for second dialect acquisition by adults, confirming continued adaptability in speech production into adulthood (Evans & Iverson, 2007). The variability that we observed across talkers in the magnitude of second dialect acquisition is consistent with contemporary research and likely reflects social-identity factors that we did not assess (Campbell-Kibler et al., 2014; Evans, 2004; Foreman, 2000; Nycz, 2019). Future longitudinal studies, similar to Evans and Iverson's (2007) work, are needed to disentangle the role of place-related factors, including mobility and rootedness, in second dialect acquisition.

Northerners in the Midland, as well as comparison groups of Northerners in the North and Midlanders in the Midland, produce phonetic reduction in high-frequency, low-density, second mention, high-predictability, and plain speech tokens relative to low-frequency, high-density, first mention, low-predictability, and clear speech tokens. This phonetic reduction process weakly interacts with dialect, such that fewer significant effects of phonetic reduction are observed overall when phonetic reduction conflicts with the Northern Cities Shift and the effects of phonetic reduction are smaller for talkers in the Northern region than talkers in the Midland region. These findings only weakly support the proposal that dialect-specific features are enhanced in reduction-promoting contexts (Clopper & Pierrehumbert, 2008; Clopper et al., 2017). Future studies using interactive tasks are needed to more directly examine the relative effects of phonetic reduction and social-identity marking in speech production, for both first and second dialects.

CRediT authorship contribution statement

Cynthia G. Clopper: Conceptualization, Methodology, Formal analysis, Data curation, Visualization, Writing – original draft, Writing – review & editing, Funding acquisition. **Rachel Steindel Burdin:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Visualization, Writing – review & editing. **Rory Turnbull:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Visualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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