Variation and stability of American Norwegian /r/ in contact

David Natvig
University of Oslo

Sound patterns in heritage languages are often highly variable, potentially with influences from majority languages. Yet, the core phonological system of the heritage language tends to remain stable. This article considers variation in the phonetic and phonological patterns of /r/ in American Norwegian heritage language speakers from neighboring communities in western Wisconsin, in the Upper Midwestern United States. Drawing on acoustic data from speakers born between 1879 and 1957, I examine the distribution of four rhotic allophones, including an English-like approximant, over time. These data reveal an increase of approximants that is structured within the Norwegian phonological system and its processes. Furthermore, analyzing these changes with the proposed modular framework provides clarity for how heritage language sound systems do and do not change under contact and contributes to our understanding of the asymmetric phonetic and phonological heritage language patterns.

Keywords: Heritage language bilingualism, Norwegian, phonology, rhotics

1. Introduction

Rhotics are a robustly heterogeneous set of sounds, varying across manners and places of articulation (e.g., Ladefoged & Maddieson, 1996, pp. 215–245; Lindau, 1985). They have also been shown to be sources of cross-linguistic influence (CLI) among bilingual children (Kehoe, 2018; Lléo, 2018) and heritage language (HL) speakers (Amengual, 2016; Henriksen, 2015; Kim & Repiso Puigdelliura, 2019; Kupisch, 2020). In Germanic, rhotics are highly variable synchronically and diachronically (Howell, 1991; Natvig & Salmons, 2020; Schiller, 1999), including from CLI-induced patterns in the Wisconsin German HL (Salmons, 2016). As is increasingly the norm in work on sound change, I consider language-internal change and 'external' motivations, e.g., CLI and other socially contextualized variation, as integrated factors in language contact (Dorian, 1993). This

https://doi.org/10.1075/lab.20085.nat | Published online: 15 April 2021
Linguistic Approaches to Bilingualism issn 1879-9264 | e-issn 1879-9272

article systematically explores the variation of rhotics in another Upper Midwestern HL – American Norwegian (AmNo) – focusing on /r/ distributions among speakers born between 1879 and 1957 from neighboring Coon Valley and Westby, in western Wisconsin. These variations illustrate how the phonological structures of languages in contact shape contact-induced change.

AmNo speakers acquired the language in a naturalistic setting, normally at home from family members and peers, but it was not the language of the wider majority, regionally or nationally, i.e., a HL following Rothman (2009). Records from Coon Valley and Westby indicate that both Norwegian and English were spoken for at least three generations. Many children in these communities continued to learn Norwegian as their home language at least until the 1930s and 1940s, when the majority of the contemporary speakers were born. These speakers are now the last generation of Norwegian HL-speakers in their communities.

US Census records for Coon Valley and Westby from 1910, the first with questions about specific language knowledge, show a fairly low degree of Norwegian monolingualism. For example, approximately 16% (176/1092) of Coon Valley[1] and 13% (83/649) of Westby residents 10 years of age and older reported speaking Norwegian without knowledge of English. Although it is unclear what knowing English meant for the census enumerators or the residents, over 80% of the population of both districts reported knowledge of English, demonstrating that these communities supported Norwegian-English bilingualism for decades. Because this bilingualism shapes the outcomes of the HL acquisition and change over continuing generations (Putnam, Kupisch & Pascual y Cabo, 2018), I examine not only variation and differential outcomes for a particular type of sound, rhotics, but also how those changing patterns affect the phonological system.

Over the course of the 78-year span of birth years investigated here, Coon Valley and Westby underwent community-wide shift to English. It is therefore likely that English influences on AmNo sound patterns, as well as other linguistic domains, increase during this period. This article focuses on those patterns for /r/ against the background of general findings of HL sound systems, namely that "while heritage speakers may retain their native phonology, the phonetic values of both vowels and consonants are affected, thus contributing to a non-native accent" (Benmamoun, Montrul & Polinsky, 2013, p. 137). In this case, what might be considered 'accented' form of the HL here consists of the use of an English-like [ɹ], what I refer to as *r-approximation*, because it involves a potential change in the surface form of the Norwegian /r/ phoneme from a tap or trill to an approximant (see Section 2.2).

1. Here Coon Valley consists of two enumeration districts at the time: Coon Township and Coon Valley.

I apply the modular phonological framework in Natvig (2019) to examine the impact of r-approximation on the AmNo phonological system, focusing on change over time. Previous work has shown variable influence of English [ɹ] in AmNo (Hjelde, 1996), but this is the first to examine the distribution of that variation across phonological environments and in the context of the broader sound system. The results anchor ordered variation, i.e., structured heterogeneity (Weinreich, Labov & Herzog, 1968, pp. 187–188) within formal phonological structure, specifically with patterns from language contact and bilingualism. Although the increased use of one language may introduce new phonetic variants into the other, it occurs in accordance with the comparatively resilient phonological categories and processes of the contacting languages (Polinsky, 2018, p. 115). These patterns shed light on the mechanisms in which new sounds enter language's phonology through contact, which then may be distributed throughout the community (e.g., Salmons & Purnell, 2020), as well as the potential that those sounds have for advancing structural changes.

2. Background

In this section, I review relevant findings on HL phonetics and phonology generally and rhotics specifically (2.1) and discuss Norwegian rhotic phonology (2.2). I then present my theoretical and analytical framework for the sound system (2.3) and language contact (2.4), and lay out my hypotheses for potential contact-induced effects on the AmNo phonology (2.5).

2.1 HL phonology and rhotic variation

Typically, phonology appears to be a stable domain in HL grammar, although speakers often sound different from monolingual or homeland speakers (Polinsky, 2018, p. 114). HL speakers may sound like majority language monolinguals, and the extent to which they have an 'accent' in the HL is likely attributable to the length and variety of continued exposure to it (Kupisch, Barton, Hailer, Klaschik, Stangen, Lein & van de Weijer, 2014). Although simultaneous bilingualism has been shown to both accelerate (Lléo, Kuchenbrandt, Kehoe & Trujillo, 2003) and decelerate (Kehoe, 2002) the rate of acquisition of HL sound patterns, phoneme discrimination studies indicate that speakers appear to master the core phonological grammar (e.g., Oh, Au, Knightly & Jun, 2003).

Many of the enduring effects on HL sound systems occur as outcomes of CLI, either as convergence of gradient phonetic targets toward those of the majority language (e.g., Godson, 2004) or as a change in an articulatory gesture, as with

German-Spanish bilinguals' use of German uvular /r/ in Spanish (Kehoe, 2018). However, the effects of CLI and change on the HL sound system appear to be constrained, even if they are commonly attested (Benmamoun et al., 2013, p. 137; Polinsky, 2018, pp. 116–122; Polinsky & Scontras, 2020, p. 10).

In terms of HL rhotics, investigations find both variability of surface forms and maintenance of abstract contrasts. A considerable amount of this work investigates the Spanish tap-trill distinction, where /r/ and /ɾ/ contrast intervocalically (Hualde, 2005). For Henriksen (2015), there is no consistent pattern based on occlusions between the tap and the trill. However, two generations of bilingual Spanish speakers maintain the contrast via segment length. Accordingly, this pattern reveals differences in phonetic properties, not in the phonological ones. Furthermore, Amengual (2016) finds that English-dominant heritage Spanish speakers pattern with Spanish-dominant heritage speakers for /ɾ/ but, with regard to /r/, they pattern with L2 learners. Again, the contrast appears to be stable, but with variable surface realizations. Finally, Kim and Repiso Puigdelliura (2019) investigate the effects of language dominance on the rates and degrees of lingual constriction of tap productions, finding that dominance is an indicator for the distribution of variable forms (Kim & Repiso Puigdelliura, 2019, p. 22). These results suggest that heritage speakers with a range of different bilingual outcomes exploit the variation available in the language, but they may do so differently than monolinguals (Kupisch, 2020). The effects of HL bilingualism on rhotics we generally find is in phonetic properties and the relative distribution of the available surface forms, and not a change in phonemic representations.

2.2 Norwegian rhotics: Patterns and acoustics

For eastern Norwegian dialects, from which the AmNo varieties investigated here descend (Johannessen & Laake, 2012), the prototypical /r/ phone is an alveolar tap or trill, the latter often occurring in emphatic speech (Kristoffersen, 2000, p. 24, fn. 21). Both taps and trills are possible /r/ forms in comparable dialects and their occurrence in AmNo demonstrates the acquisition of Norwegian, not English, sound patterns. They are therefore considered here as belonging to the same articulatory category ([ɾ/r]), either as a single contact or multiple closures in the spectrogram (Ladefoged & Maddieson, 1996, pp. 218–231). Additionally, /r/ undergoes two variable alternations in codas: (1) deletion (Kristoffersen 2000, pp. 311–315) and (2) retroflexion, where coronals following /r/ coalesce as a retroflex or postalveolar (Kristoffersen, 2000, pp. 96–97). Retroflexion is also triggered by the retroflex flap phoneme /ɽ/, such that *gul* [gʉːɽ] 'yellow' when modifying a neuter noun occurs as *gult* [gʉːʈʰ] (Kristoffersen, 2000, p. 96).[2] In these and similar varieties, /ɽ/ and /r/ contrast pre- and post-vocalically – *bra* [bɾɑː] 'good' vs. *blad* [bɽɑː] 'magazine' and *tar* [tʰɑːɾ] 'takes' vs. *tal* [tʰɑːɽ] 'number' – but their opposition is opaque following retroflexion: *vart* [ʋɑʈʰ] 'became' vs. *valt* [ʋɑʈʰ] 'chosen'. Accordingly, any change surface-level /r/ and /ɽ/ contrast in AmNo can only be observed outside of these environments. Both r-deletion and r-triggered retroflexion vary along linguistic, geographical, stylistic, and social parameters (Johannessen & Vaux, 2013).

The relevant Norwegian /r/ patterns are as follows: tap or trill in onsets, variation between tap/trill and deletion in codas, and an additional variable retroflexion process in codas where /r/ precedes a coronal. All are properties of the pre-immigration varieties in question (Haugen, 1969, p. 433; Ross, 1907, pp. 37–73), and I am unaware of any reports of an approximant [ɹ] variant in this dialect area. The AmNo /r/ allophones investigated here are presented in Figure 1.[3] For the tap in (1), *berre* 'just, only' there is a clear closure following the [æ]. In (2) *var* 'was' demonstrates r-deletion in coda positions, with no evidence of vibration or formant movement indicative of the other allophones.[4] Both (3) and (4) involve retroflexion, indicated by a third formant (F3) decrease in the preceding vowel (Hamann 2003, p. 78). The adverb *borte* 'away' in (3) has a short fall in F3 ([Ø↓F3]) during the transition between the [ʊ] and [ʈʰ] and *hjern'n* (<hjernen>) 'the brain' in (4) has a clearly perceptible approximant [ɹ], shown in the F3 decrease (Ladefoged & Maddieson, 1996, p. 234) that occurs over nearly the entire length of [æ].[5] In order to distinguish between the short F3 fall and r-deletion in (3), i.e., [Ø↓F3], and r-approximation in (4), I categorize the former when the drop occurs over less than half of the duration of the vowel and [ɹ] as an F3 decrease over more than half of vowel duration.[6] Although there may be additional low-level acoustic properties that indicate an underlying /r/, these tokens

2. The retroflex flap is not distinctive in Norwegian orthography.

3. Participants W_41, b. 1895 (1–2); W_05, b. 1936 (3–4); see Section 3.1.

4. There may be some ambiguity regarding whether /r/ exists in the phonological forms of *var* 'was/were' and *er* 'am/is/are', with deletion being the result of a diachronic rather than synchronic process. Although instances without final /r/ are common in the data, non-rhotic variants are not categorical and /r/ evidence is present among all age groups (see Appendix, Figure A1). This is consistent with a synchronic phonological process (see Cavirani & van Oostendorp, 2019, for discussion of related issues).

5. I use the symbol for the alveolar approximant [ɹ] throughout because of its use in descriptions of English, but the retroflex approximant [ɻ] may also be appropriate (for both languages).

6. Vowel midpoint is used as a criterion to base the distinction between these forms on acoustics rather than perception. Future studies may uncover different parameters for the boundary between a formant change at the transition and an approximant.

lack the features of the other major rhotic forms and patterns. I now turn to a discussion of the theoretical framework I adopt for analyzing these variants.

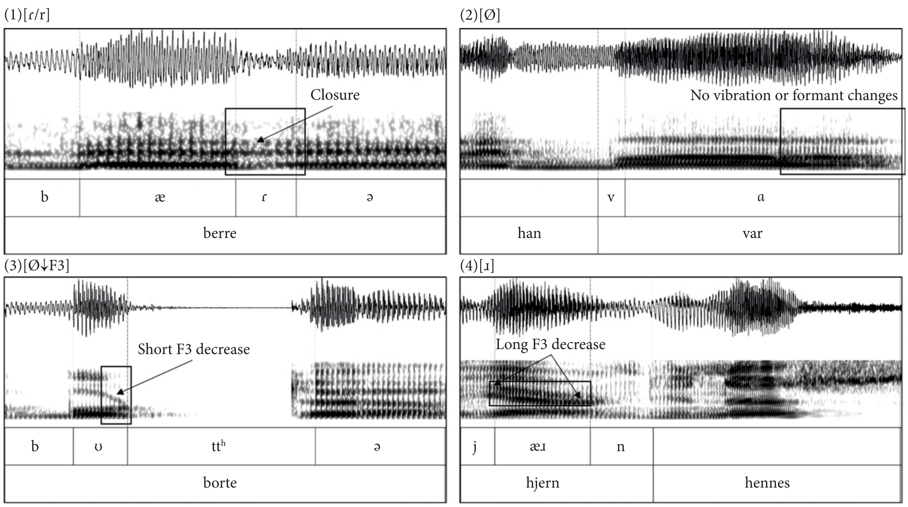

Figure 1. Spectrograms of four r-types: [ɾ/r], [Ø], [Ø↓F3], and [ɹ]

2.3 The modular sound system in contact

To account for HL phonetic and phonological asymmetries, particularly with respect to potential CLI on rhotic variation, I adopt the modular framework in (1), consisting of the three separate, yet interconnected levels of representation (Natvig, 2019; Purnell & Raimy, 2015).

(1)	Phonological:	Abstract categories (contrasts)
	Phonetic-Phonological:	Categories completed with gestures, enhancements (articulations)
	Phonetic:	Implementation of gestures (continuous features)

Phonological representations comprise features that distinguish language-specific contrasts (Avery & Rice, 1989; Dresher, 2009; Dresher, Piggott & Rice, 1994; Rice, 2009) based on the phonologically active patterns in the language (Avery & Idsardi, 2001; Dresher, 2009; Iverson & Salmons, 1995). Therefore, a phoneme is not a sound, per se, but the collection of its contrastive, or "phonologically relevant", properties (Trubetzkoy, 1969, p. 36). I adopt privative feature contrasts, where underspecified oppositions are marked by the presence vs. the absence of a distinctive feature (for arguments see Avery & Idsardi, 2001; Iverson & Salmons, 1995; Natvig, 2020).

Operations at the Phonetic-Phonological level of representation render phonemic categories pronounceable by adding articulatory gestures, either as completions of contrastive features or as enhancements (Avery & Idsardi, 2001; Natvig, 2019; Purnell & Raimy, 2015). Enhancements are variable features that increase the salience of phonological contrasts (Stevens, Keyser & Kawasaki, 1986). Lip-rounding on English /ʃ/, for example, enhances its place of articulation contrast with /s/ (Keyser & Stevens, 2006).

Finally, gestures are converted into continuous variables in the speech signal and in real time at the Phonetic level of representation, relating either to contrastive, specified features in the phonology (active features) or to categories lacking positive phonological content (here, enhancements). Gestures that correspond to the implementation of phonological contrasts have been shown to be less prone to variability than non-contrastive properties (Hall, 2011; Tanner, Sonderegger & Stuart-Smith, 2020).

With respect to rhotic phonological features, I assume that for both AmNo and English, /r/ is consistent with the Germanic pattern: unspecified for place and manner (Natvig & Salmons, 2020). A critical difference is that AmNo contrasts the /ɽ, r/ phonemes (Haugen, 1969, p. 433), whereas /l/ and /r/ are contrastive in English. For both, /r/ is specified as [consonant, sonorant]; Norwegian /ɽ/ is [consonant, sonorant, retroflex], whereas English /l/ is [consonant, sonorant, lateral] (Natvig, 2020). Furthermore, because English lacks both a conditioned retroflex process and, in the relevant region of the US, coda r-deletion, the potential influence it may have on AmNo is in the implementation of /r/ as an approximant [ɹ] phone. Table 1 illustrates the levels of representation and their properties of English /l, r/ and AmNo /ɽ, r/. For AmNo, the /ɽ/ allophones [ɽ] and [ɹ] are in free variation, the latter of which is an approximant variant from English contact (Hjelde, 1996), and [ɾ/r], [Ø], [Ø↓F3], [ɹ] are possible surface forms of /r/.

Distinctive features at the Phonological level of representation mark privative contrasts, shown here with ‘ ✓ ’ for the presence of phonological features. The English lateral-rhotic and Norwegian retroflex-coronal contrasts are respectively labeled [lateral]~Ø and [retroflex]~Ø at the Phonetic-Phonological level. For AmNo, this node describes the completion of a retroflex articulation for /ɽ/, but the coronal completion for the unspecified /r/ phones [ɾ/r]. The [Ø↓F3] and [ɹ] allophones of /r/ are the result of [retroflex] enhancement, the inherited Norwegian process (see Natvig, 2020, pp. 19–23). Finally, an [aperture] gesture is a manner completion for the flap, tap, and trill allophones [ɽ, ɾ, r], which is deleted (or not implemented) for approximants. Phonetic-Phonological-level gestures are then implemented at the Phonetic level of representation as continuous variables, described in italics. Here, the [retroflex] feature for [ɹ] lowers the preceding vowel’s third formant. The null allophone [Ø] is the result of a contextualized

Table 1. Modular representation of English /l, r/ and AmNo /ɽ, r/ phonemes and their allophones

English

Level of representation		/l/	/r/
Phonological	[consonant] [sonorant] [lateral]	✓ ✓ ✓	✓ ✓
Phonetic-Phonological	[consonant] [sonorant] [lateral]~Ø	[aperture] [sonorant] [lateral]	~~[aperture]~~ [sonorant] [retroflex]
Phonetic		*alveolar lateral*	*long F3 decrease*
IPA		[l]	[ɹ]

American Norwegian

Level of representation		/ɽ/		/r/		
Phonological	[consonant] [sonorant] [retroflex]	✓ ✓ ✓		✓ ✓		
Phonetic-Phonological	[consonant] [sonorant] [retroflex]~Ø	[aperture] [sonorant] [retroflex]	~~[aperture]~~ [sonorant] [retroflex]	[aperture] [sonorant] [coronal]	~~[aperture]~~ ~~[sonorant]~~ ~~[coronal]~~	~~[aperture]~~ [sonorant] [retroflex]
Phonetic		*retroflex flap*	*F3 decrease*	*alveolar tap/trill*	*deletion*	*F3 decrease*
(IPA)		[ɽ]	[ɹ]	[ɾ/r]	[Ø]	[Ø↓F3], [ɹ]

deletion rule and is not implemented in the phonetics. The allophonic variation in AmNo /r/ therefore occurs through enhancement and the implementation of those gestures.

2.4 Stability and variability in phonetic and phonological contact

The present model makes predictions about CLI patterns in a contact scenario. According to Van Coetsem (1988), some linguistic structures are more or less susceptible to transfer from the less dominant language (borrowing) and to transfer from the more dominant language (imposition) than others, what he refers to as the "stability gradient" of language (p. 25). Howell (1993, p. 189) schematizes the stability gradient as in Table 2. On the left are structures that are less stable and more prone to transfer from the less dominant to the more dominant language (borrowing). The right side shows structures that tend to be more stable and prone to transfer from the more to less dominant language (imposition). These are tendencies and real patterns of CLI are also influenced by additional sociolinguistic factors. Furthermore, the domains on each side of the gradient in Table 2 are not necessarily equally stable. A great deal of work on HL inflectional morphology, for example, has revealed that this domain is less stable than both phonology and syntax (see Polinsky, 2018, Chapter 5), showing that distinct linguistic domains are affected differently across a range of contact and bilingual scenarios.

Table 2. Stability gradient, with affected domains of language (from Howell, 1993, p. 189)

More open to borrowing	→	Less open to borrowing
Less affected by imposition	←	More affected by imposition
Less stable domains		More stable domains
(lexical items, derivational morphology)		(phonology, inflectional morphology, syntax, semantics)

Although phonetic properties were not specifically considered in Table 2, Natvig (2019) shows gradient and asymmetric transfer types within the sound system, arguing that the more abstract level of representations (e.g., phonology) are more stable than the more concrete ones (e.g., phonetics) in a contact situation. Assuming that speakers acquire the relevant contrasts of their languages' phonemic inventories, these representations are less likely to change over the lifespan than the gestures that complete these categories, which are in turn more stable than the gestures' phonetic properties. This perspective situates phonological operations in line with the feature reassembly hypothesis of language attrition in morphosyntax, where "the feature configuration of the L1 is adjusted to conform to the mapping of syntactic features onto morphological forms found in the L2 grammar" (Putnam, Perez-Cortes & Sánchez, 2019, p. 19). In sound systems, similar processes target the gestural completion of phonological categories and the phonetic implementation of those gestures (Natvig, 2019). Likewise, the more concrete the representation, the more consistent use, processing, and activation is required to maintain stability over time. As AmNo speakers in Westby and Coon Valley became more English dominant, both as a community and over the lifespan of the younger heritage speakers, variation in both surface-level and more abstract /r/ representations is expected. As such, less dominant AmNo speakers may be more prone to r-approximation, although the specific properties of their Norwegian phonological system shape those outcomes (e.g., Fruehwald, 2017).

2.5 Hypotheses on the effects of contact on the AmNo sound system

The advantage of this modular framework is that it provides a paradigm for analyzing the potential effects of changes, contact-induced or otherwise, on the sound system. For example, changes involving surface-level properties, such as the timing and duration of a particular gesture, occur at the Phonetic level of representation, whereas a new gesture or change in a gesture for a given phoneme is a Phonetic-Phonological change. On the other hand, changes in the contrastive system – mergers, splits, different feature specifications – affect the Phonological module. This is particularly relevant for HLs because it offers a means to examine changes in their sound systems that accounts for both variable and stable patterns (e.g., Benmamoun et al., 2013; Kupisch, 2020; Polinsky, 2018; Polinsky & Scontras, 2020). It is not only important to understand that HL sound patterns change, but how those changes do and do not affect the system and its contrasts, processes, and phonetic realizations.

Contextualizing these changes within the present modular framework allows for specific hypotheses of where in the sound system a potential phonetic change affects. If, for example, [ɹ] is limited to, or only increases in proportion in coda clusters with coronals (retroflexion codas) it is a Phonetic-level change, involving the timing and duration of the drop in F3. If this acoustic pattern extends beyond retroflexion environments, in other codas and/or onset positions, this is a Phonetic-Phonological change because the articulatory gesture for retroflexion is generalized as a completion of the /r/ category. Finally, if this new completion occurs as the prototypical one for /r/ as well as /ɽ/ it has the potential to induce Phonological-level change to the system due to a lack of contrast between the two categories, i.e., phonological merger resulting in a single phoneme produced as [ɹ]. In the next section, I discuss the methods for investigating this variation over time for the AmNo of Coon Valley and Westby, Wisconsin.

3. Method

3.1 Participants

Data from twenty speakers, nine women and eleven men, come from wav files stored in the Corpus of American Nordic Speech (CANS; Johannessen, 2015).[7] These files are the products of three projects on Norwegian in the United States spanning seventy years, with recordings in 1942, 1990–1992, and 2010–2012. Informants all live or lived in and near Coon Valley and Westby, in the western part of the state of Wisconsin, and range in birth years from 1879 to 1957. Eighteen speakers were born in the United States, with ancestors from rural, eastern Norway in and around Gudbrandsdal; two from the 1942 material were born in western Norway. Although many western Norwegian varieties often have uvular /r/ and lack retroflexion, both Norwegian-born participants share the relevant liquid patterns and processes with the other speakers with eastern backgrounds. Finally, the lengths of the recordings and speaking contexts are variable, from approximately five minutes to an hour and a half. They contain both researcher-participant interviews and participant-participant conversations. All participants in the corpus receive a codename based on their place of residence and a code number. I use 'CV' and 'W' for Coon Valley and Westby, respectively, and retain the unique numerical indicator from CANS (see Table 3 for a summary).

These recordings were chosen to distribute participants as evenly as possible based on gender, recorded on a binary scale, and year of birth. There are four individuals in five age group categories, roughly divided by decade. The oldest group (ca. 1890s), however, has one speaker born in 1879 and the youngest (ca. 1940s) has one speaker born in 1957; the 1910s group also has one member born outside of the decade, in 1909. These groupings are not operationalized for analysis; they are purely for the purposes of participant selection.

3.2 Data collection, processing, and evaluation

Using the recordings discussed above, I manually coded allophones of /r/ in Praat (Boersma & Weenink, 2020) and categorized them as one of four types discussed in Section 2.2, i.e., the three eastern Norwegian /r/ allophones and the English approximant.[8] Each of the four r-types – [ɾ/r], [Ø], [ɹ], [Ø↓F3] – are organized based on the phonological environments in which they occur: onsets,

7. Available online at https://tekstlab.uio.no/glossa2/cans3

8. Future tests on this data will include an inter-rater reliability score to ensure that categorization is consistent for the author and other coders.

Table 3. Summary of participant metadata

Participant	Birth year	Gender	Birth country	Year recorded	Recording type
CV_43	1879	F	US	1942	Interview
CV_46	1892	M	Norway	1942	Interview
CV_45	1894	F	Norway	1942	Interview
W_41	1895	M	US	1942	Interview
CV_32	1909	M	US	1992	Conversation
CV_49	1912	F	US	1942	Interview
CV_17	1913	M	US	1992	Interview
CV_31	1915	F	US	1990	Conversation
W_03	1922	F	US	2010	Conversation
CV_02	1923	M	US	2010	Conversation
CV_04	1925	M	US	2010	Interview
CV_01	1928	F	US	2010	Conversation
W_07	1931	F	US	2010	Interview
CV_06	1932	M	US	2010	Conversation
CV_07	1934	F	US	2010	Conversation
W_05	1936	M	US	2010	Conversation
W_12	1942	M	US	2011	Interview
W_06	1943	M	US	2010	Interview
CV_12	1944	M	US	2012	Interview
W_10	1957	F	US	2011	Interview

codas not followed by coronals (*non-retroflexion coda*), and codas preceding coronals (*retroflexion coda*). I categorize intervocalic /r/s as occurring in onsets following long vowels and codas following short vowels according to Norwegian syllabification rules (see Kristoffersen, 2000, pp. 131–139). Tokens with indecipherable formant patterns, due to, e.g., noise, simultaneous speech, poor sound quality (especially prevalent in the older recordings), etc., were discarded. Finally, because of the variance in token numbers across participants, r-types are normalized for each individual based on their proportion within a given environment, that is, the proportions of [ɾ/r], [Ø], [ɹ], and [Ø↓F3] in onsets, their proportions in non-retroflexion codas, and their proportions in retroflexion codas. To examine changes in r-types over time, I calculated linear regressions of their proportions in R using the *lm( )* function (R Core Team, 2013) with birth year as the main factor and gender and speaking context (interview or conversation) as covariates.

In the next section, I present descriptive and inferential statistics that I used to test these hypotheses laid out in Section 2.5.

4. Results: AmNo rhotic patterns over time

From the 20 participants in the sample set, a total of 4645 r-type tokens were collected; Figure 2 shows the distribution across all environments combined ('Total') and individually. Generally, r-approximation is rare, occurring for 7.3% of total tokens, the majority of which is in retroflexion codas – 238 of 339 (70.2%) of [ɹ] productions. The tap/trill allophone, [ɾ/r], on the other hand comprises over half of all tokens (57.6%) and nearly categorical in syllable onsets (97.0%), but with more variability in coda positions of both kinds (retroflex [9.4%] and non-retroflex [57.6%]). The null allophone ([Ø]) patterns expectedly, occurring almost exclusively in codas, with only 14 of 1330 onset tokens lacking acoustic evidence of a rhotic. Finally, the short drop in F3 ([Ø↓F3]) is primarily restricted to retroflexion codas; approximately 91.8% (312/340) of [Ø↓F3] tokens occur in these environments.

To compare speakers' /r/ variations, proportions of three acoustic categories, [ɾ/r], [Ø], and retroflex phones (combining the [ɹ] and [Ø↓F3] r-types) in each phonological context are presented in Figure 3, plotted by participant birth year. The three columns of plots show the different categories and each row contains the three environments independently from each other. The top row shows from left to right the proportions of taps/trills, null allophones, and retroflex phones in onsets. For each individual, the sum of each proportion in a single row equals 1. Accordingly, Figure 3 shows context-sensitive changes in the relative occurrences of these three categories over time, based on participant birth year. Linear regression models of the effects of birth year on /r/ proportion are plotted for each environment; year of birth is only a significant factor for [Ø] and retroflex phones, and both only in retroflexion codas (see below).

From linear regression models, neither gender nor speaking context have a significant effect on any category proportion in any phonological environments. The regression models further indicate that /r/ proportions do not change significantly over time in onsets and non-retroflexion codas; [ɾ/r] shows no significant change in retroflexion codas either. However, in retroflexion codas, significant results were found for the retroflex phones ($F(3,16)=7.338$, $p=.003$**, see Table 4 for individual factor effects), and for [Ø] ($F(3,16)=7.51$, $p=.002$**, see Table 5 for individual factor effects). In the environments in which r-deletion and retroflexion are two variably licit outcomes, deletion becomes less common.

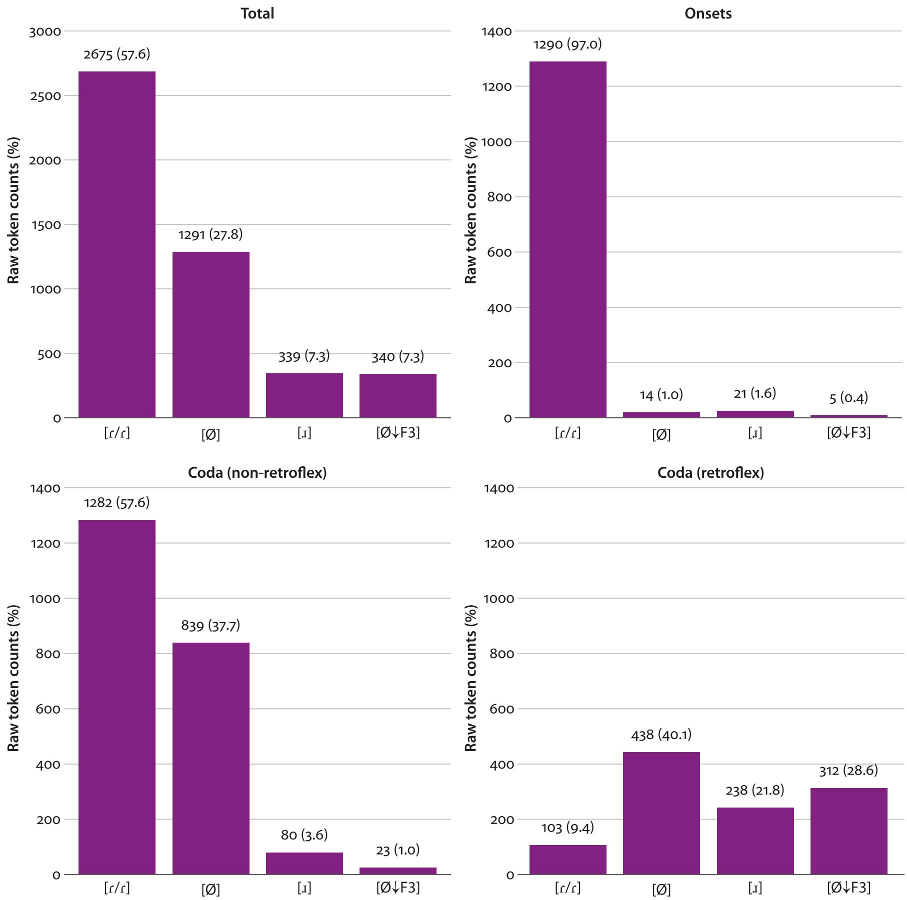

Figure 2. Counts of r-type tokens, with percentages, in total and by phonological environment[9]

The decrease of the null allophone [Ø] with an increase of [ɹ] and [Ø↓F3] by birth year shows an increase in retroflexion over time. Furthermore, linear regression models shown in Figure 4, with [ɹ] and [Ø↓F3] in retroflexion environments plotted by birth year, indicate that they are completing this process with an English-like [ɹ] allophone. Significant results were found for [ɹ] ($F(3,16)=3.438$, $p=.042$*, see Table 6 for individual factor effects), but not [Ø↓F3] ($F(3,16)=1.128$, $p=.367$), in this phonological environment. Neither [ɹ] nor [Ø↓F3] were found to have significant results in the other two environments. The low proportions of

9. Percentage totals for Coda (non-retroflex) and Coda (retroflex) are 99.9% due to rounding.

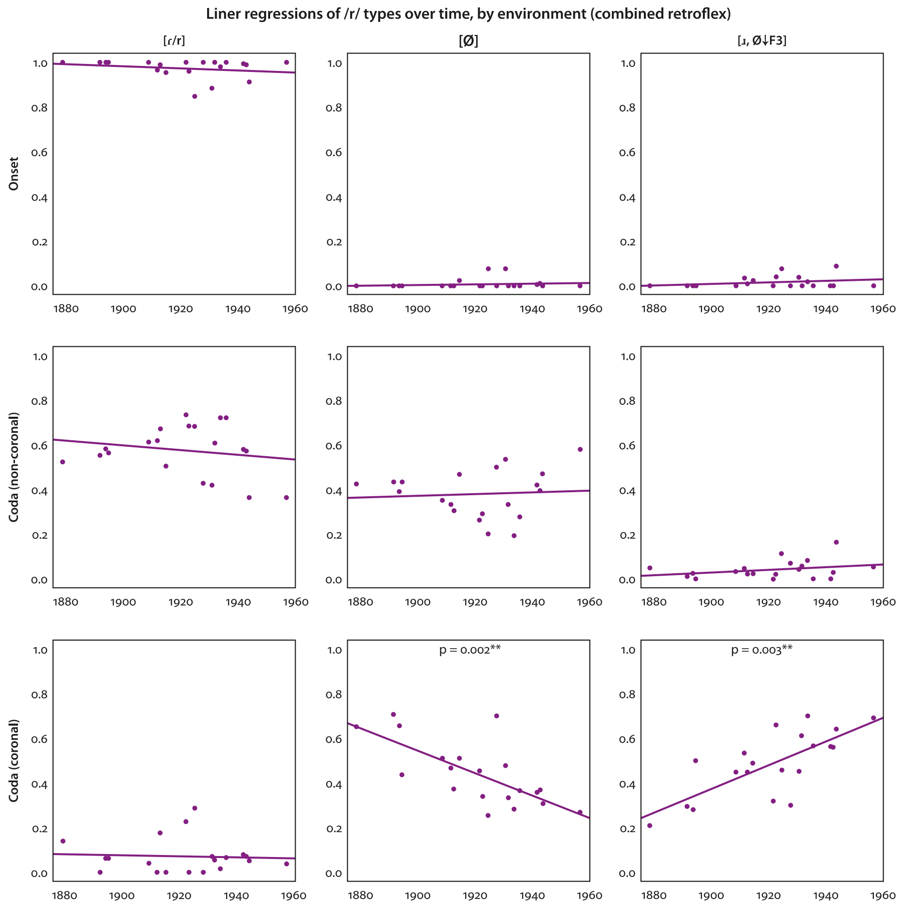

Figure 3. Linear regression models of the proportions (y-axes) of acoustic categories (columns) by participant birth year (x-axes), in the three phonological environments (rows)

these r-types in onsets and non-retroflexion codas indicate that their expression is limited to retroflexion codas.

There is, therefore, a limited change to the Norwegian sound system – likely supported by Norwegian-English contact over time – that is restricted to the surface expression of the outcome of a Norwegian process. Accordingly, this is a phonologically conditioned phonetic change because the [retroflex] gesture in this phonological environment results from the inherited retroflex process. The occurrence of [ɹ], then, is an outcome of the timing of the gesture: producing it earlier, longer, or both. I now turn to a discussion of these results and their implications on the AmNo sound system under intense contact with English, especially recently, and on HL sound patterns more broadly.

Table 4. Regression analysis summaries for predicting retroflex phones ([ɹ] and [Ø↓F3]) in retroflexion codas based on birth year, gender, and speaking context

	B	Std. Error	β	*t*	*p*	CI Lower	CI Upper
(Intercept)	−9.162	2.281	–	−4.016	.0009***	−13.998	−4.326
Birth Year	0.005	0.001	0.697	4.222	.0006***	0.002	0.008
Gender	0.062	0.047	0.220	1.342	.198	−0.036	0.161
Context	−0.018	0.048	−0.061	−0.371	.715	−0.119	0.083

Note.
R^2 adjusted = 0.500.

Table 5. Regression analysis summaries for predicting [Ø] in retroflexion codas based on birth year, gender, and speaking context

	B	Std. Error	β	*t*	*p*	CI Lower	CI Upper
(Intercept)	9.833	2.235	–	4.399	<.001***	5.095	14.572
Birth Year	−0.005	0.001	−0.690	−4.182	<.001***	−0.007	−0.002
Gender	−0.080	0.046	−0.285	−1.749	.099	−0.177	0.017
Context	−0.016	0.047	−0.056	−0.342	.737	−0.115	0.083

Note.
R^2 adjusted = 0.507.

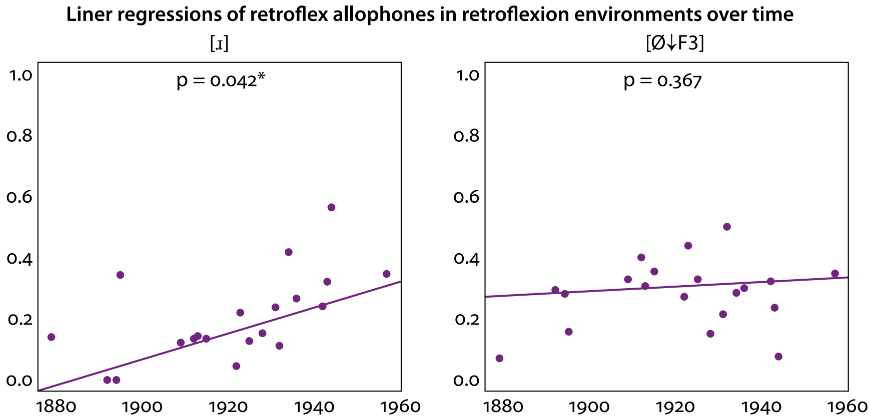

Figure 4. Linear regression models of the proportions of retroflex r-types, [ɹ] and [Ø↓F3], by participant birth year, in retroflexion environments

Table 6. Regression analysis summaries for predicting [ɹ] in retroflexion codas based on birth year, gender, and speaking context

	B	Std. Error	β	*t*	*p*	CI Lower	CI Upper
(Intercept)	−8.046	2.688	–	−2.993	.009**	−13.743	−2.348
Birth Year	0.004	0.001	0.606	3.054	.008**	0.001	0.007
Gender	0.024	0.055	0.086	0.437	.668	−0.092	0.141
Context	0.057	0.056	0.200	1.009	.328	−0.062	0.176

Note.
R^2 adjusted = 0.278.

5. Discussion

The present findings indicate a phonologically restricted increase in a rhotic variant introduced or supported by contact with English. The net effect to the AmNo phonological system is limited to gradient surface representations in the phonetics, not abstract categorical distinctions. These results, analyzed within a modular framework, illustrate how in spite of intense bilingual contact and a high potential for phonetic variation over generations, HL phonologies, both in their representations and processes, may remain stable.

5.1 Contact effects on the AmNo sound system

It is reasonable that the introduction and adoption of approximant [ɹ] in AmNo is the result of, or at least supported by, Norwegian-English bilingualism due to the presence of this form in English. Although limited, the data support this: of the Norwegian-born participants, CV_46 (b. 1892) has no [ɹ] tokens and CV_45 (b. 1894) has one, but shows evidence of retroflexion, i.e., [Ø↓F3] tokens, in the relevant environments (see Appendix, Tables A1 and A2 for individual patterns). Although the degree of r-approximation varies, it occurs for all American-born participants. Accordingly, there is a change to the AmNo sound system relative to that of the immigrant and homeland varieties. The limited distribution of [ɹ], in terms of both proportions and phonological environments, however, shows that this change is not a direct substitution of the English surface form for the Norwegian one. Rather, it is a structured phonetic change to the output of an inherited Norwegian phonological process.

The significant increase of [ɹ] in retroflexion codas reflects a change at the Phonetic level of representation. Specifically, the retroflexion process that existed in Norwegian prior to contact with English conditions an articulatory gesture with the acoustic effect of lowering the preceding vowel's F3. In order to examine what changes over time, the distributions of AmNo r-types in retroflexion environments in relation to modular representations and processes are presented in Table 7.

Table 7. Modular representations of AmNo /r/ in retroflexion environments

Level of representation		**/r/{#} Coronal**			
Phonological	[consonant] [sonorant] [retroflex]	✓ ✓			
Phonetic-Phonological	[consonant] [sonorant] [retroflex]~Ø	[aperture] [sonorant] [coronal]	~~[aperture]~~ ~~[sonorant]~~ ~~[coronal]~~	~~[aperture]~~ [sonorant] [retroflex]	~~[aperture]~~ [sonorant] [retroflex]
Phonetic		*alveolar tap/trill*	*deletion*	*short F3 decrease*	*long F3 decrease*
IPA		[ɾ/r]	[Ø]	[Ø↓F3]	[ɹ]
Notes on distributions		rare	decreases over time	stable	increases over time

Although all four r-types occur in retroflex codas, [ɾ/r] is uncommon, suggesting the maintenance of coda deletion and variable retroflexion. Of the two expected /r/ processes in retroflexion codas, deletion and retroflexion, deletion decreases and retroflexion increases over time, presenting increasingly as [ɹ]. The inherited acoustic retroflex variant [Ø↓F3] – or short F3 decrease – holds for speakers today; presence of [ɹ], or a long F3 decrease, involves a change in the surface properties of that same retroflex gesture. It is produced over a longer vowel duration, and it occurs earlier and quite possibly for a longer period of time than [Ø↓F3]. It is clear that, at least for retroflexion codas where the increase of retroflexion as a process and r-approximation are statistically significant, there is no new articulatory gesture or phonological representation in the HL. The increase of [ɹ] in AmNo over time is not a gradient change from one phone to another, but a variable increase in the time and duration of an already present gesture. Both the Phonological and Phonetic-Phonological levels of representation with respect to /r/ are stable within this sample, consistent with the modular contact framework where the more concrete representations are more prone to transfer and change than the more abstract ones (Natvig, 2019). What is more, these AmNo /r/ patterns are consistent with the recurrent finding that HL phonologies tend to be stable, but with changes in their phonetic realizations, a result that follows from this direct relationship between abstract structure and general stability over time.

This early, yet restricted, adoption and spread of r-approximation in AmNo here contrasts with Salmons' (2016) findings for Wisconsin German, where [ɹ] is more or less the prototypical form for /r/. This difference is surprising considering the greater intensity of Norwegian-English bilingualism relative to the German communities in the state, which tended to have more monolingual HL speakers than Norwegian ones. For one example, in the German-speaking town of Hustisford, Wisconsin, 310 (24%) individuals reported German monolingualism in 1910 and of those 108 (35%) were born in the United States (Wilkerson & Salmons, 2008, pp. 268–270). Recall that in 1910, Norwegian monolinguals comprised approximately 13% and 16% of the respective populations of Westby and Coon Valley. Of those reported Norwegian monolinguals, there were only two American-born in Westby and three in Coon Valley. Although research is still underway, this comparison appears to hold true for differences in language use between German- and Norwegian-speaking communities in Wisconsin.

Assuming this pattern holds, the share of bilingualism in the local population is a poor predictor for the distribution of r-types in this sample. If HL monolingualism in these communities served as a buffer for these contact-induced changes, one would expect the German ones to conserve the phonetic properties of /r/ to a greater extent than the Norwegian ones; in fact, the opposite appears to be the case. This outcome however follows from the phonological structures of the HLs in relation to the sound system of the contacting language, English. A comparison of AmNo and Heritage German modular sound systems with potential r-variants is present in Table 8. For German, [retroflex] is a completion for /r/ and not contrastive feature in the system.

For AmNo, [retroflex] is a contrastive feature for /ɽ/, with [ɹ] as an allophone (Hjelde, 1996). Accordingly, an unconditioned adoption of [ɹ] as an allophone of /r/ would potentially obscure and change the language's abstract contrasts, i.e., the Phonological level of representation (marked by the bolded [retroflex] features and shaded boxes in Table 8). This has however not occurred for the speakers investigated here. Because /r/ remains distinct from /ɽ/ in non-retroflexion environments, their contrastive distributions remain unchanged. Were this not the case, and [ɹ] consistently occurred for both phonemes in other phonological environments, further examination into the distributions of [ɹ] and [ɽ] would be warranted to investigate whether /r, ɽ/ show evidence of merging or changes in their phonological content. On the other hand, Wisconsin German lacks [retroflex] as a phonological feature; [ɹ] transfer for /r/ in this case is not a change to the Phonological representations, but Phonetic-Phonological ones in the form of a new or different gesture for /r/, likely from the English completion processes. In

Table 8. Modular representations of Wisconsin German and American Norwegian /r/ variation*

Wisconsin German					
Level of representation		/l/	/r/		
Phonological	[consonant] [sonorant] [lateral]	✓ ✓ ✓	✓ ✓		
Phonetic-Phonological	[consonant] [sonorant] [lateral]~Ø	[aperture] [sonorant] [lateral]	[aperture] [sonorant] [coronal]	[aperture] [sonorant] [dorsal]	~~[aperture]~~ [sonorant] [retroflex]
Phonetic		*alveolar lateral*	*alveolar tap/trill*	*uvular trill*	*long F3 decrease*
IPA		[l]	[ɾ/r]	[ʀ]	[ɹ]
American Norwegian					
Level of representation		/ɽ/		/r/	
Phonological	[consonant] [sonorant] **[retroflex]**	✓ ✓ ✓		✓ ✓	
Phonetic-Phonological	[consonant] [sonorant] [retroflex]~Ø	[aperture] [sonorant] [retroflex]	~~[aperture]~~ [sonorant] **[retroflex]**	[aperture] [sonorant] [coronal]	~~[aperture]~~ [sonorant] **[retroflex]**
Phonetic		*retroflex flap*	*long F3 decrease*	*alveolar tap/trill*	*long F3 decrease*
IPA		[ɽ]	[ɹ]	[ɾ/r]	[ɹ]

* This table shows the possibility of both coronal and dorsal articulations for /r/, with [dorsal] as a possible Phonetic-Phonological gesture implementation for the contrast against [lateral] /l/. See Natvig (2020) for [r] and [ʁ] as allophones of a cohesive /r/ category for German.

both instances, it is argued that /r/ is only specified contrastively as [consonant] and [sonorant] (Natvig, 2020; Natvig & Salmons, 2020). That is, /r/ has the same abstract representation in each language, but German does not have [retroflex] as a contrastive feature in the system, whereas AmNo does. In spite of the distinct patterns of variation in the surface forms of /r/ in the HL varieties of German and Norwegian, in neither case do they conflict with, nor change, these underspecified representations because there is no phonological feature governing their specific place and manner of articulation. For both, the more abstract representations are stable, whereas the more concrete ones are subject to change, especially when unspecified phonologically (Natvig, 2019).

Although the Phonological-level representations appear to be more stable, it does not mean that they are never susceptible to CLI or change. This model predicts that they would, however, require more time to become rooted throughout the community than would changes to sub-phonemic properties. For example, in a situation where the majority language dominates throughout the entire span of the acquisition process, it is possible for the contrastive representations of the HL to change. In this case, a child learning AmNo under restricted input conditions might not acquire the contrast between /ɽ/ and /r/, and merge them as /ɹ/. As far as we know, this has not occurred for any AmNo variety as a whole, although there may be individual speakers who display this pattern. For an AmNo variety that appears to be more advanced in the spread of [ɹ] in non-retroflexion environments, there is still evidence of a stable set of contrasts, representations in the most abstract domain in a modular sound system. Of course, speakers who acquired these contrasts based on more heterogeneous input may also be more prone to merge the categories following a dominance shift to the majority language. Further research will be required to directly address this question.

5.2 Implications for HL sound patterns

AmNo rhotic distributions are further evidence in support of broad observations of HL sound systems: stable phonology, but often with surface-level differences between monolingual and L2-learner comparison groups (Polinsky, 2018, p. 115). Here, this amounts to the limited adoption of [ɹ] as an allophone in retroflexion, which occurs as a phonetic change in contact with English. Viewing these patterns in a modular framework sheds light on the mechanisms that contribute to the asymmetries between the abstract components of contrastive features on the one hand and the concrete properties of the speech signal on the other.

It appears that HL speakers acquire the phonological contrasts from their exposure to and use of the language. This domain of the sound system is furthermore argued to be the least susceptible to contact-induced change (Natvig, 2019), which contributes to the stability of the HL phonological system over an individual's lifespan and, as this study suggests, within a community over time. On the other hand, the more fine-grained manipulation of phonetic targets and their distributions in relation to competing forms appears to require more consistent use and/or indirect feedback from the speech community. How speakers implement abstract phonemic categories into real speech sounds is more likely to change over time, particularly when individuals shift almost exclusively to a majority language.

Phonetic targets and implementations may converge toward those of the dominant or more commonly spoken language or languages, a Phonetic-level change. What is more, the acquisition of a HL in a multilingual setting may modify the input quality and quantity such that learners make different generalizations about the distributions of sociophonetic variables and other completion rules than previous generations. For example, a sequentially bilingual AmNo-English speaker may learn that [ɹ] is an allophone for /r/, but is not sensitive to its presence as a retroflexion allophone, extending it to codas more generally. This would still be a sub-Phonological change to the sound system so long as /r/ and /ɽ/ remain in contrast prevocalically.

Recently, Kupisch (2020, p. 30) has called for researchers to "integrate the notion of variation and investigate whether there is a hierarchy amongst various [acquisition] mechanisms" for differential acquisition outcomes of HLs. Incorporating HL acquisition, knowledge, and performance within a modular framework is a move toward that end because it formally models the relationship between structure and variation, irrespective of its source. It identifies specific types of relationships between inherently gradient and variable properties of speech sounds and discrete and formal cognitive representations. The model further provides metrics for making clear predictions about likely HL changes, how they may spread through the system and, accordingly, the community.

6. Conclusion

In this article, I examined diachronic patterns of AmNo /r/ surface forms in the neighboring communities of Westby and Coon Valley, Wisconsin, over nearly 80 years. Results show general stability in the proportions of four /r/ allophones in three distinct phonological environments. As a group, these speakers increasingly implement a variable retroflexion process, and consequently more of the American-innovated [ɹ] allophones, over time. Based on the present framework, this represents a phonetic, not a phonological, change. Furthermore, the phonetic change is highly constrained within the inherited Norwegian phonological system and its processes. Over the 78 years of available AmNo data for this community, the phonological representations, at least with respect to rhotics, appear to be stable.

These findings demonstrate the value of a modular phonological architecture for analyzing variation, contact-induced and otherwise. Here, the introduction of an English-like variant [ɹ] in AmNo may appear to be a change in the Norwegian phonology or the lack of maintenance of the prototypical tap or trill, increasing over time as the community shifts to English. However, we find r-approximation as the outcome of an inherited phonological process. Examining the sound system holistically, as interconnected sets of computations of distinct representation types, reveals how variation and CLI effects this broader system. In this case, it manifests as a change in the phonetic properties of the timing and duration of a retroflex gesture. Other types of CLI may, however, target gestural completions (e.g., Wisconsin German), or abstract, contrastive features. Further investigations of CLI under this framework will shed light on the factors that contribute to increases in susceptibility to change in these domains of the sound system.

Although the sound changes investigated here are not Phonological in this model, it does not mean that phonological representations in HLs cannot change. However, these systems undergo the same processes that underlie phonological change generally: variation within an abstract, formal structure that spreads socially and is received as input for subsequent generations of language acquirers (Salmons, in press). That is, language contact and multilingualism are factors that may introduce variation and variability into the system, but the core components of language and their properties are the same.

Funding

Research funded by H2020 Marie Skłodowska-Curie Actions (838164) to David Natvig and by Norges Forskningsråd (223265).

Acknowledgements

I would like to thank Synneva Boxrud Bratland, Liquan Liu, Mike Putnam, Joe Salmons, and the audience at the 10th Workshop on Immigrant Languages in the Americas for discussions and feedback over the course this project. I am also grateful for the editors' and three anonymous reviewers' suggestions for improving and sharpening this article. All errors and oversights are my own.

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Appendix

Table A1. Total token counts for each r-type in each phonological environment for every participant (by year of birth). Retroflex phones equal the sum of [ɹ] and [Ø↓F3]

	Onset					Coda (non-retroflex)					Coda (retroflex)				
	ɾ/r	Ø	ɹ	Ø↓F3	Total	ɾ/r	Ø	ɹ	Ø↓F3	Total	ɾ/r	Ø	ɹ	Ø↓F3	Total
CV_43	50	0	0	0	50	32	26	2	1	61	6	28	6	3	43
CV_46	59	0	0	0	59	47	37	0	1	85	0	24	0	10	34
CV_45	56	0	0	0	56	46	31	1	1	79	2	21	0	9	32
W_41	36	0	0	0	36	39	30	0	0	69	2	14	11	5	32
CV_32	61	0	0	0	61	73	42	2	2	119	2	25	6	16	49
CV_49	28	0	1	0	29	26	14	2	0	42	0	7	2	6	15
CV_17	199	0	2	0	201	246	112	6	2	366	30	63	24	52	169
CV_31	41	1	1	0	43	41	38	1	1	81	0	23	6	16	45
W_03	33	0	0	0	33	36	13	0	0	49	5	10	1	6	22
CV_02	72	0	2	1	75	63	27	1	1	92	0	17	11	22	50
CV_04	100	9	5	4	118	108	32	9	9	158	27	24	12	31	94
CV_01	17	0	0	0	17	18	21	3	0	42	0	14	3	3	20
W_07	23	2	1	0	26	29	37	3	0	69	3	20	10	9	42
CV_06	60	0	0	0	60	31	17	3	0	51	3	18	6	27	54
CV_07	52	0	1	0	53	52	14	6	0	72	1	17	25	17	60
W_05	33	0	0	0	33	26	10	0	0	36	2	11	8	9	30
W_12	166	1	0	0	167	162	117	0	0	279	9	40	27	36	112
W_06	87	1	0	0	88	94	65	3	2	164	6	31	27	20	84
CV_12	83	0	8	0	91	79	102	34	2	217	4	24	44	6	78
W_10	34	0	0	0	34	34	54	4	1	93	1	7	9	9	26
Total	**1290**	**14**	**21**	**5**	**1330**	**1282**	**839**	**80**	**23**	**2224**	**103**	**438**	**238**	**312**	**1091**

Table A2. Total proportion of each r-type in each phonological environment for every participant (by year of birth). Retroflex proportions equal the sum of [ɹ] and [Ø↓F3] proportions

	Onset				Coda (non-retroflex)				Coda (retroflex)			
	ɾ/r	Ø	ɹ	Ø↓F3	ɾ/r	Ø	ɹ	Ø↓F3	ɾ/r	Ø	ɹ	Ø↓F3
CV_43	1.00	0.00	0.00	0.00	0.52	0.43	0.03	0.02	0.14	0.65	0.14	0.07
CV_46	1.00	0.00	0.00	0.00	0.55	0.44	0.00	0.01	0.00	0.71	0.00	0.29
CV_45	1.00	0.00	0.00	0.00	0.58	0.39	0.01	0.01	0.06	0.66	0.00	0.28
W_41	1.00	0.00	0.00	0.00	0.57	0.43	0.00	0.00	0.06	0.44	0.34	0.16
CV_32	1.00	0.00	0.00	0.00	0.61	0.35	0.02	0.02	0.04	0.51	0.12	0.33
CV_49	0.97	0.00	0.03	0.00	0.62	0.33	0.05	0.00	0.00	0.47	0.13	0.40
CV_17	0.99	0.00	0.01	0.00	0.67	0.31	0.02	0.01	0.18	0.37	0.14	0.31
CV_31	0.95	0.02	0.02	0.00	0.51	0.47	0.01	0.01	0.00	0.51	0.13	0.36
W_03	1.00	0.00	0.00	0.00	0.73	0.27	0.00	0.00	0.23	0.45	0.05	0.27
CV_02	0.96	0.00	0.03	0.01	0.68	0.29	0.01	0.01	0.00	0.34	0.22	0.44
CV_04	0.85	0.08	0.04	0.03	0.68	0.20	0.06	0.06	0.29	0.26	0.13	0.33
CV_01	1.00	0.00	0.00	0.00	0.43	0.50	0.07	0.00	0.00	0.70	0.15	0.15
W_07	0.88	0.08	0.04	0.00	0.42	0.54	0.04	0.00	0.07	0.48	0.24	0.21
CV_06	1.00	0.00	0.00	0.00	0.61	0.33	0.06	0.00	0.06	0.33	0.11	0.50
CV_07	0.98	0.00	0.02	0.00	0.72	0.19	0.08	0.00	0.02	0.28	0.42	0.28
W_05	1.00	0.00	0.00	0.00	0.72	0.28	0.00	0.00	0.07	0.37	0.27	0.30
W_12	0.99	0.01	0.00	0.00	0.58	0.42	0.00	0.00	0.08	0.36	0.24	0.32
W_06	0.99	0.01	0.00	0.00	0.57	0.40	0.02	0.01	0.07	0.37	0.32	0.24
CV_12	0.91	0.00	0.09	0.00	0.36	0.47	0.16	0.01	0.05	0.31	0.56	0.08
W_10	1.00	0.00	0.00	0.00	0.37	0.58	0.04	0.01	0.04	0.27	0.35	0.35
Total	**0.97**	**0.01**	**0.02**	**0.00**	**0.58**	**0.38**	**0.04**	**0.01**	**0.09**	**0.40**	**0.22**	**0.29**

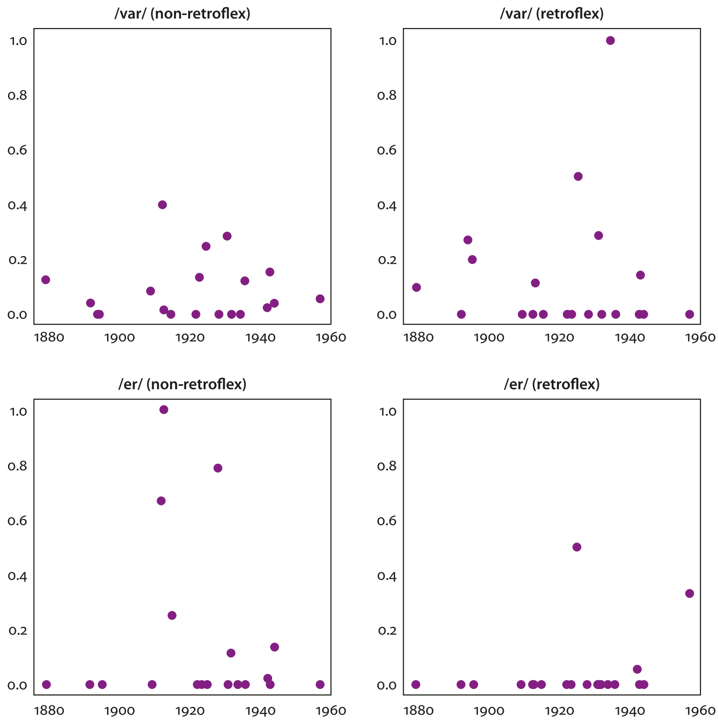

Figure A1. Proportions by birth year of *var* 'was, were' and *er* 'am, is, are' without r-deletion in non-retroflex and retroflex environments

Address for correspondence

David Natvig
University of Oslo: Universitetet i Oslo
Center for Multilingualism is Society across the Lifespan
Niels Henrik Abels vei 36
Oslo 0313
Norway
d.a.natvig@iln.uio.no
https://orcid.org/0000-0001-7993-3847

Publication history

Date received: 11 September 2020
Date accepted: 15 March 2021
Published online: 15 April 2021