A phonologically weak contrast can induce phonetic overlap

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The Romanian vowel system is unique among the Romance languages, in particular due to its phonemic central vowels and diphthongs (Chitoran 2002). The central vowels /ɨ, ʌ/ are argued to be *marginally contrastive* (Renwick 2014); they are historical allophones, and despite the synchronic presence of minimal pairs, they are in nearly complementary distribution. A study of phoneme type frequency showed that in over 90% of cases the high central vowel appears in pre-nasal position or before /r/, and is either stressed or pre-tonic; by contrast, the mid central vowel is word-final nearly half the time as a morphological marker, and is typically post-tonic. Because context is thus a very strong cue to vowel identity, and because the contrast has low functional load, it was hypothesized that the phonetic contrast between /ɨ/ and /ʌ/ was subject to merger; however, laboratory studies of both production and perception found little evidence for this. In the present study we show that in continuous speech, unlike in laboratory speech, the /ɨ, ʌ/ contrast is phonetically weak, with strong overlap between /ɨ, ʌ/ in the F1 dimension.

Methods: In this study, a laboratory speech corpus is compared to data from a corpus of broadcast speech originally gathered to build a system for automatic transcription of Romanian (Vasilescu, Vieru & Lamel 2014). Lab data include all seven Romanian monophthongs, extracted from stressed and unstressed syllables in target words produced by 18 native speakers. Three repetitions of each word were recorded within a carrier phrase; formant values (F1, F2) were automatically extracted at the vowel midpoint and hand-checked, providing 5,261 tokens (2,396 central vowels). The broadcast data (7 hours, 86 speakers) came from prepared speech recorded from Romanian radio shows, or from semi-spontaneous debates recorded on the television channel Antena; the recordings portray careful speech in the standard, southern dialect of Romanian. The broadcast data were automatically aligned with the system described by Vasilescu et al. (2014); acoustic parameters were extracted following the methods described in Gendrot & Adda-Decker (2005). From this corpus, statistics on the contextual frequencies of vowels were calculated. The broadcast dataset was filtered: first, only tokens with voicing in more than 40% of the vowel were included. Second, tokens were excluded as outliers based on their Mahalanobis distance (a multidimensional Euclidean distance; Mahalanobis 1936) from each speaker-specific, vowel-specific centroid. This produced 104,456 vowel tokens (11,006 central vowels), whose formant values were normalized by speaker (Lobanov 1971). We calculated acoustic overlap among adjacent vowel pairs using the algorithm presented by Fougeron & Audibert (2011).

Results: Despite their presence in many frequent function words, in the broadcast data, the central vowels are relatively rare; together, [ɨ, ʌ] are only 10.5% of all tokens in the filtered data set. Across the corpus their distribution is highly complementary, as shown in Table 1: while [ɨ] is common in word-initial position, [ʌ] rarely appears there; conversely, [ʌ] is common word-finally, in its role as a marker of nominal declension (e.g. [fatʌ] 'girl' vs. [fata] 'the girl') or verb form ([sʌ ˈfakʌ], 'may he do it'), but [ɨ] *never* appears finally. Within the CVC context where both appear, [ɨ] overwhelmingly occurs before nasals or [r] (74.48% of CVC [ɨ] tokens), due to its emergence as a product of pre-nasal raising, while [ʌ] can precede a wider range of segments ([ʌ] precedes [m, n, r] in 43.46% of CVC cases). Turning to the acoustic results, Fig. 1 illustrates that in lab speech, the central vowels are distinct; [ɨ] has a high mean F1 value comparable to [i, u], while [ʌ] has an F1 similar to [e, o]. In broadcast data, [ʌ] maintains its position, but [ɨ] centralizes, so that the vowels' distributions are highly overlapping (results are similar for male speakers). This result is clear in Fig. 2, where a positive value indicates F1 overlap. We find that the centralization of [ɨ] is widespread, occurring in individual speakers' data and across segmental contexts.

Discussion: Our results show strong overlap between [ɨ] and [ʌ] in prepared speech; specifically, [ɨ] is reduced in height with respect to its position in lab speech, and thus this pattern differs from previous results in both production and perception observed with laboratory data. Taken together, the datasets show that while phonologically the central vowels have different representations, this contrast is severely

diminished in continuous speech, leading to a phonetic near-merger. The phonological competence exhibited in lab speech is not realized in continuous speech, where performance permits considerable overlap among central vowels. Speakers do not maintain a strong distinction in production, and it is possible that their cognitive representations of /ɨ, ʌ/ are not separable from the contexts in which each appears. Indeed, in the vowels' nearly complementary distributions, underlying vowel quality is highly conditioned by morphology, segmental context, or stress. Future perceptual study will indicate whether listeners are sensitive to these vowels' acoustic characteristics independent of context.

Table 1. Distribution of /ɨ, ʌ/ across contexts, with examples of most frequent words per context.

Context	/ɨ/		/ʌ/	
CVC	30.5%	*România* 'Romania'	26.6%	*astăzi* 'today'
#VC	67.2%	*în* 'in'	0.4%	*ăsta* 'this one'
CV#	0.0%	Ø	65.8%	*să* 'that' (conj.)
Other	2.3%	*mâine* 'tomorrow'	7.2%	*său* 'his'
Total	100%		100%	

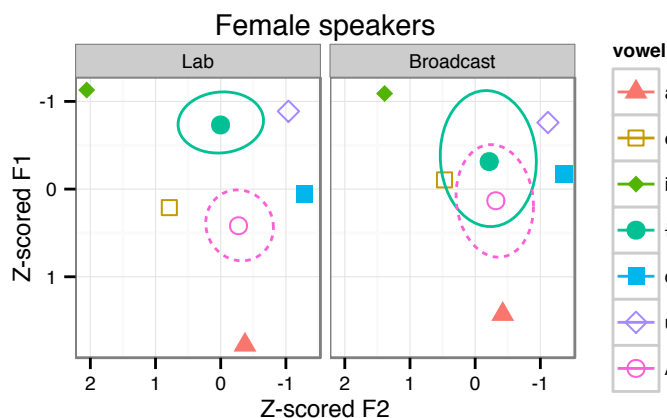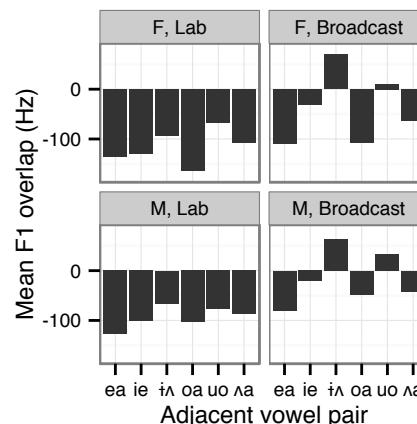Figure 1: The Romanian vowel space (ellipse = 1σ)   Figure 2: Overlap in Romanian vowels

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