Vowel systems in convergence

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Introduction: At what level of the representation does convergence generalize? Previous work has demonstrated that convergence is generalized across words with the same sound (e.g. Pardo et al. 2012). Nielsen (2011) further demonstrated that convergence can generalize across sounds with the same feature: exposure to lengthened VOT at one place of articulation results in lengthening at other places of articulation. However, it is unclear whether or not feature-level effects would behave similarly for other features. VOT is realized in the same way across places of articulation, which may facilitate extension across these categories, while other characteristics often have less clearly parallel realizations across different sounds, because they are cued differently or interact with other cues.

No convergence work has tested this effect in other characteristics, but similar work in perceptual training illustrates how extension can behave differently across different contrasts. Although participants' production is not tested, the task elicits a shift in the representation: their categories are shifted by exposing them to words in which an ambiguous sound is disambiguated by the lexical item it appears in, and then they identify the same sound in test items which the lexicon does not disambiguate. For this task, as in convergence, a shifted VOT contrast trained in one place of articulation was extended to other places (Kraljic and Samuel 2006), and a place contrast in fricatives was extended across voicing categories (Schuhmann 2014), but a place contrast trained in voiced stops was not extended to nasals (Reinisch et al. 2014).

Vowels provide a particularly informative test case, because the vowel space includes many contrasts, along several dimensions. Based on shared features, a shift in the formants of one vowel should similarly change the formants of other vowels. One hypothesis is that a change will only influence other vowels when they have a shared target phonologically and acoustically in the domain of manipulation: raising a mid vowel will only result in raising of other mid vowels.

The other main hypothesis is that whole vowel space will shift. Historical chain shifts in the vowel space suggest that shifting one vowel will shift other vowel categories that it encroaches on, though historical mergers of course also occur (Labov 1994: Ch. 20). However, some convergence work finds that exposure to stimuli that reduce the distance between categories simply fails to generate convergence, at least in VOT (Nielsen 2011) and vowel duration (Podlipský and Šimáčková 2015).

To examine how convergent shifts in the vowel space generalize, this study uses a shadowing task to test how exposure to shifted F1 in a single vowel quality (/ɛ/) influences F1 of other vowels that match either in frontness or in height. The results suggest that convergence in the vowel space generalizes to vowels that share an acoustic target within the domain of manipulation.

Methods: 24 female native English speakers participated in the study. First they read a set of monosyllabic English words twice in randomized order. The second set of productions were used for each speaker's baseline. The list included 60 target words and 60 filler items.

In the shadowing task, participants repeated after 15 acoustically manipulated target words produced by a female native English speaker, given in randomized order; each was presented three times. The exposure items in this task only had the vowel /ɛ/: *best, bet, dead, debt, fed, guess, less, mess, met, net, pet, red, set, test, wet*. There were two conditions: half of participants heard these words with a raised F1 in the /ɛ/ and half heard a lowered F1. The base recordings used for manipulations were the same in both conditions, so the F1 manipulation was the only difference. In the lowered F1 condition, stimulus vowels on average had an F1 lowered by 48 Hz, and in the raised F1 condition, the vowels on average had an F1 raised by 98 Hz. The difference in the size of the manipulation in each condition was based on pilot testing of perceived vowel quality; F1 was shifted as far as possible while maintaining the perceived quality /ɛ/.

After the shadowing task, participants read all the target words again. The 60 target words included the 15 training items with /ɛ/, 15 test items with /ɛ/, and 10 test items each of /æ/, /ɪ/, and /ʌ/. Participants' F1 was measured for each word before and after the shadowing task. Reported statistics come from a regression model with change in F1 as the dependent variable (Table 1).

Results: Convergence was predicted by the manipulation condition: participants' F1 increased in the raised F1 exposure condition and decreased in the lowered F1 exposure condition. This effect was present both for the /ɛ/ words presented in the shadowing phase and those that were not, with no difference between them (see Figure 1).

The effect of the manipulation was present not only in words with /ɛ/, but also exhibited a parallel effect in words with /ʌ/: F1 increased in the raised F1 exposure condition and decreased in the lowered F1 condition. There was no significant effect for /ɪ/ or /æ/.

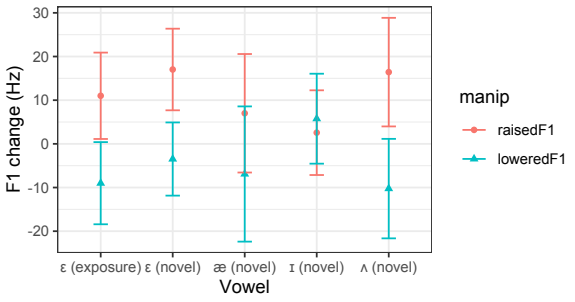
Conclusions: Consistent with previous work in consonants, this study suggests that convergence to one vowel is generalized to vowels with the same phonological representation or acoustic target in the domain of manipulation – in this case, convergence to the manipulated F1 in /ɛ/ was extended to the other mid vowel, /ʌ/. Because the target realization of their height is shared (participants' mean baseline F1 was 790 Hz for /ɛ/ and 779 Hz for /ʌ/), training speakers on a new target for one mid vowel is extended to the other, but does not produce corresponding shifts in other vowel heights, which have distinct F1 targets.

In contrast to chain shifts observed in sound change, the convergent shifts in this data cannot be explained as the result of category maintenance exerting a pressure on the system. F1 convergence was not extended to the high and low front vowels that shifted /ɛ/ would be encroaching on; rather, the shift was extended to /ʌ/, keeping it closely matched to the height of /ɛ/.

Table 1: Model for F1 change. *Intercept: Manipulation = lowered F1, Vowel = /ɛ/*

	β	SE	t-value	p-value
(Intercept)	-6.2	5.38	-1.16	0.254
Manip RaisedF1	20.3	7.47	2.71	0.0104*
Vowel /æ/	-0.66	7.05	-0.09	0.925
Vowel /ɪ/	12.0	7.05	1.7	0.0905
Vowel /ʌ/	-4.0	7.05	-0.57	0.571
Manip RaisedF1*Vowel /æ/	-6.35	9.53	2.71	0.505
Manip RaisedF1*Vowel /ɪ/	-23.5	9.53	-2.46	0.014*
Manip RaisedF1*Vowel /ʌ/	6.41	9.53	0.67	0.501

Figure 1: F1 change (posttest-pretest)



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