Comparing neighborhood density and clear speech effects in the French vowel system
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This study investigates fine-grained phonetic variation conditioned by communicative context and phonological neighborhood density (ND). Both of these factors have been associated with hyperarticulation and/or reduction in phonetic realization. For example, talkers speak louder and slower in a noisy room (Lombard 1911), louder and with less phonological reduction when speaking to someone hard-of-hearing (Picheney, et al. 1986), and with an expanded vowel space simply when asked to speak more clearly (Bradlow et al. 1996). Similarly, words with many phonologically-similar neighbors (i.e., high-ND words, which are subject to greater lexical competition) show greater vowel dispersion (Wright 2004), more extreme voiceless stop VOT (Baese-Berk & Goldrick 2009), and increased nasal and vowel-vowel coarticulation (Scarborough 2013), relative to words with fewer neighbors (i.e., low-ND words) in English. Both clear speech effects and neighborhood-conditioned effects have been interpreted as listener-directed accommodations to potential difficulties, communicative or lexical, encountered by listeners. Comparisons of contextual clarity and neighborhood density effects in English indicate that the two types of effects indeed involve similar, but essentially independent, phonetic adjustments, and that ND effects are comparable or greater in magnitude, relative to clarity effects (Scarborough & Zellou 2013).

Here, we investigate both contextual clarity and ND-conditioned effects in the production of vowels in French. In addition to providing a basic description of these effects in a language for which they have previously been very sparsely described, the focus on French also allows us to investigate the role that contrast (in height, backness, rounding, and nasality) plays in each of these types of effects. Moreover, the multi-dimensional approach undertaken here (examining size of acoustic spaces, dispersion within those spaces, classification based on vowel-specific acoustic properties) allows for a more comprehensive picture of the notion of hyperarticulation.

Two communicative tasks were used in which a participant had to instruct the experimenter on how to place high or low ND target words on a grid comprised of 4 different shapes in 5 different colors. The target word could be on, above, below, or next to any of the shapes, so the instructions were of the form “C’est le mot XXX sur l’étoile jaune” (“It’s the word XXX on the yellow star.”). In a second version of the task, both the speaker and the listener completed the same task while simultaneously listening to conversational noise (8-talker French babble) over headphones, increasing demands of clarity. Thus, we were able to compare features of target word production in two communicative conditions, a normal communicative task and a communicative task requiring enhanced clarity, and in two lexical ND conditions. The targets were 144 mostly disyllabic words of French, representing 12 different final vowels: /i, y, e, ø, e, a, o, u, ê, ࠟ, ࠠ, ࠢ/ (all the vowels of standard French except ࠠ and schwa). Test words had frequency-weighted neighborhood densities either in the bottom (low ND) or the top (high ND) trentile of mono- and disyllabic words in French, and were selected in high-low ND pairs that match phonetically as closely as possible to avoid potential biases due to phonetic context. All words had comparable mid-range lexical frequencies. There were six test words per ND category per vowel. We looked at vowel duration and means of F1, F2, F3 measured at ¼, ½, and ¾ of the vowel duration, as well as at several calculated metrics of the vowel space. The study will include 12 native French speakers (northern dialect of France); analyses presented here are based on four speakers.

Our findings show both for high ND words and in the clear task: (i) larger F1/F2 vowel space, as measured both by the vowel space triangle formed by i, a, u and by the vowel space formed by the full set of peripheral vowels, (ii) greater dispersion of target vowels from the system centroid (in F1/F2 space), (iii) less variability (in F1, F2) within vowel categories, indicating greater target stability in these conditions (though speaker-specific patterns are seen especially for ND), (iv) increased vowel duration for only some speakers. A linear discriminant analysis, which tested differentiation between vowels based on F1 and F2, yielded lower misclassification rates for vowels
from high ND words and words produced in the clear task. In the crowded front vowel system, where both rounding and height contribute to vowel contrasts, we also found lower misclassification rates based on F2 and F3 for front vowels in both the clear task and high ND words.

Closer examination of the data, however, shows important differences between the two factors, resulting in different consequences for the way the vowel space is organized. For task effects, there is an increase in F1 across vowels in the clear task, and especially for the lower vowels, leading to the observed increase in vowel space. With respect to ND, on the other hand, vowel space expansion is seen in both F1 and F2 for vowels from high ND words, and variations are made in vowel-specific directions resulting in more peripheral vowels (e.g., increased F1 in low vowels and decreased F1 in high vowels, as illustrated in Fig. 1). Relatedly, the increased distance to F1/F2 centroid is shown in most vowels for ND, whereas it is shown only in a few for task clarity. In the front F2/F3 vowel space, greater distance to F2/F3 centroid is also found for high ND words, whereas no effect is seen for task clarity. Due in part to these different patterns of effects, ND-conditioned differences tend to be larger in magnitude in most of the dimension tested than differences due to contextual clarity. Also, ND effects appear to be more systematic across speakers, whereas the clarity effects are more speaker-specific.

![Figure 1 Vowel space (F1/F2) for a representative female speaker, comparing tasks (left) and ND conditions in the “normal” task (right). ‘2’ = /æ/, ‘3’ = /e/, ‘9’ = /œ/](image)

In sum, then, our study shows there are (1) contextual clarity effects and (2) neighborhood density effects in the French vowel system such that both communicative contexts requiring clarity and potential lexical competition yield productions that can be interpreted as clearer. However, this clarity is not produced identically in the two cases. In the case of ND-conditioned effects, it appears that harder, high ND words are produced in such a way that vowel-specific dimensions are specifically enhanced, while in the clear task, adjustments are less sensitive to the specific system of contrasts. Complete results of this study will be discussed at the conference in regard to the question of defining hyperarticulation phenomena in these communicative and lexical contexts. We will also illustrate how a multi-dimensional approach of the type taken here can lead to a better understanding of the notion of hyperarticulation.

References