Notes on "A Coarticulatory Path to Sound Change" - Patrice Speeter Beddor (2009)

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This paper explores the production and perception of coarticulatory effects in American English through the attested historical sound change VN>Ṽ. Beddor argues that the nasal gesture, that is velum-lowering in both Ṽ and N, may be reinterpreted as the distinctive property rather than a coarticulatory one. She tests her hypothesis in conditions with covarying durations of Ṽ and N in production and perception trials to explore the perceived equivalence of these phonemes.

Previous studies of this seminar course that were also cited by Beddor include deCourtenay, Ohala, Lindblom, and Blevins. **These preceding papers largely focused on sound variation as a result of imperfect transmissions** such as acoustic interference, inexperienced listeners, hyper- and hypo- articulation (H&H theory). **Beddor's paper differs in that it observes correct perception** and subsequent variation in output to determine that sensitivity, rather than misinterpretation, of coarticulation allows speakers/listeners to extract acoustic signals that are varyingly reproduced, leading to sound change. She also cites evidence of coarticulatory cues as informative to listeners—perhaps even a way to facilitate communication.

Note that:

- Despite correct perception of an input signal, output can highly vary
- Variation can be temporal, spatial, and language-specific
- Therefore, perception and production of coarticulation may occur differently across individuals and even inconsistently within individual speakers

The Experiments

3 experiments are conducted using American English native speakers to explore the articulatory and perceptual interactions of Ṽ > VN:

1. Covariation in production between coarticulatory source (N) and effect (Ṽ) via the production of C(C)V(N)C words
2. Perceived equivalence between Ṽ and N in ṼNCV stimuli
3. Perceived equivalence between Ṽ and N within context

Beddor illustrates the co-variation of vowel nasalization and a following nasal consonant, which is a key consideration in the design of this paper's experiments:

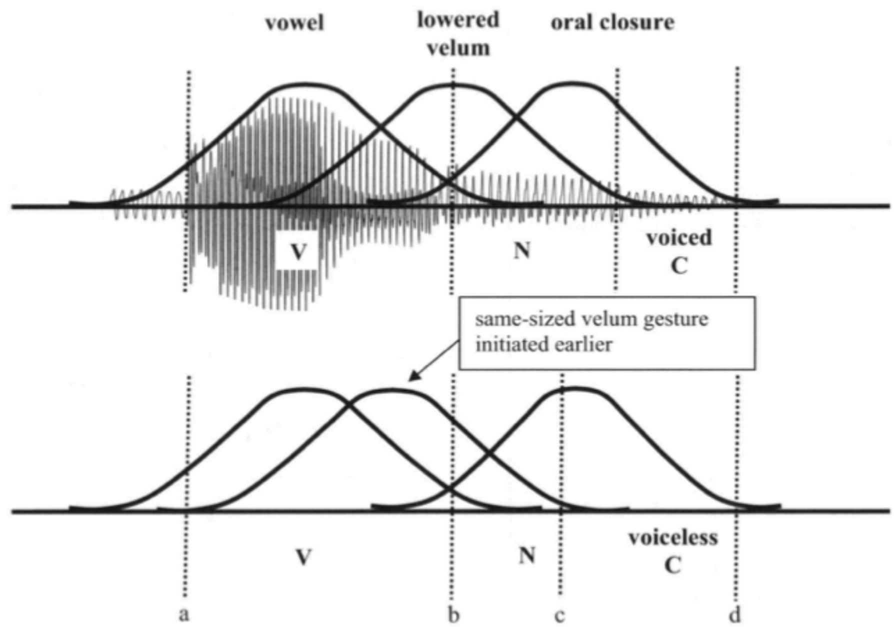

FIGURE 1. Schematic representation of the consequences for vowel nasalization, the nasal consonant, and the postnasal oral constriction if the velum gesture is initiated earlier in voiceless (bottom) than in voiced (top) contexts. Dashed lines indicate acoustic segmentation.

Above are schematic representations demonstrating equivalent nasal gestures across two VNC contexts, the top showing a voiced coda over the acoustic waveform of [bɛnd] and the bottom a voiceless coda. She hypothesizes that an earlier onset lowered velum gesture (such that would result in Ṽ), if temporally equivalent to its later onset counterpart in the upper figure, should result in a "shorter acoustic signal nasal consonant (b–c) and a longer postnasal oral constriction (c–d)".

In short, **extensive vowel nasalization may co-vary with shorter nasal consonants**. Several studies are also cited that attest to this phenomenon:

- Cohn (1990): shorter or absent N and increased likelihood of nasalized vowels in /Vnt/ compared to /Vnd/
- Raphael et al (1975): short N in /Vnt/; extense vowel nasalization in /Vnd/ when combined with short N
- Busà (1975): N shortening likelier before voiceless fricatives, vowel nasalization extensive
- Hattori et al (1958): N triggers partial vowel nasalization when followed by oral stop; vowel is more nasalized and N disappears when followed by voiceless fricative

<u>Experiment 1: Covariation in Production Between Coarticulatory Source (N) and Effect (Ṽ)</u>

METHODOLOGY

- 9 American English native speakers read a randomized word list with multiple repetitions of C(C)V(N)C
- /ɛ/ chosen for V due to high frequency in English
- Individual words are prompted with the context 'Say __ quickly'
- Assessment of FFT spectra in 10 ms increments beginning at vowel onset, using SoundScope and Praat
- Nasalization onset was identified by the marked decrease in overall vowel amplitude

HYPOTHESIS

- **Temporal alignment will vary over a stable duration of the velum gesture, resulting in the co-varying effects Ṽ and N over different coda contexts** as represented in Figure 1.

RESULTS

- 3 participants excluded for producing fully nasalized vowels (may indicate category shift)
- Inverse relation is found overall between duration of Ṽ and N with variants among speakers
- Inverse relation found between duration of N and voiceless postnasal closure
- Unlike Figure 1, duration of velum gesture varies greatly across and within contexts
- Vowel, velum, and alveolar constriction gestures all lengthened when with voiced coda (20–30%)
- Significant N duration increase from $VNC_{VOICELESS}$ to VNC_{VOICED} (125%)
    - *Why the big difference?*

INTERPRETATION

- Perhaps a combination of auditory and aerodynamic factors contribute to the significant N duration increase from voiceless to voiced codas, as voiceless obstruents require high pressure buildup incompatible with a lowered velum, resulting in a speaker's resistance of "velic leakage", whereas voicing is facilitated by it
- Speakers' stable velum gesture may facilitate listeners' interpretation as N shortens
- Evidence needed for stable velum gesture where N is relatively short or long, maybe influenced by coda manner and vowel length
- **Variables in velum gesture now have implications for listener perceptions of Ṽ and N and their resulting phonological grammar**
    - Perceived equivalence of co-articulary source (N) and effect (Ṽ) must be tested...

Experiment 2: Perceived Equivalence Between Ṽ and N in ṼNCV Stimuli

METHODOLOGY

- Trading-relations paradigm and same-different discrimination trials
- 28 American English native speakers asked to select 'same' or 'different'
- Original stimuli [gaba] and [gãma] produced by the natural pronunciation of a female native speaker of Botswanan Ikalanga
- Waveform editing used to create a [b]–[mb] continuum and vowel nasalization continuum
- Stimuli pairs consisted of 'same' pair and 'different' pairs:
    - 'Same' pair: stimuli paired with itself
    - Nasal-only pairs: differ in N duration only
    - Different-nasality pairs: short overall nasality to long overall nasality
    - Similar-nasality pairs: same overall nasality with differing Ṽ and N

HYPOTHESIS

- **Listeners are more sensitive to the total nasalization (Ṽ+N) across the syllable rhyme than to the individual durational differences of Ṽ and N**
- Therefore, listeners will make the most incorrect 'same' results for similar-nasality pairs
    - predicted order of discriminability: different-nasality > nasal-only > similar-nasality
    - 'Same' trials will be more correct than 'different'

RESULTS

- 'Same' trials were 78% correct compared to 'different' trials at 58% correct
- 'Different' correct results: different-nasality (78%) > nasal-only (60%) > similar-nasality (41%)
- 1 participant excluded for responding 'same' at equal frequency for all stimuli
- Discriminability decreases overall as [m] increases

INTERPRETATION

- Discriminability probably decreased as [m] increased due to degrading temporal resolution
- Difficulty to accurately discriminate similar-nasality pairs can be explained by a **perceptual equivalence for Ṽ and N; listeners may treat vocalic and consonantal vocality as the same**
    - Now we test for perceived equivalence within different contexts, returning to voiced and voiceless codas…

Experiment 3: Perceived Equivalence Between Ṽ and N Is Context-Dependent for Some Listeners

METHODOLOGY

- Trading relations paradigm for (1) same-different discrimination trial and (2) identification test
- 32 American English native speakers
- Stimuli provided by a female native speaker of American English for *bet*, *bed*, and *mend*
- Waveform editing continua for [bɛt]–[bɛ̃nt] and [bɛd]–[bɛ̃nd] with [n] from *mend* spliced in

HYPOTHESIS

- Listeners will focus on total nasalization [Ṽ+N] rather than Ṽ and N separately due to evidence of temporal covariation
- As with Experiment 2, the predicted order of discriminability will be:
    - different-nasality > nasal-only > similar-nasality
- $\text{VNC}_{\text{VOICELESS}}$ words tend to have short [n], making Ṽ a more reliable cue for voiceless codas for some listeners since nasal-only has no Ṽ variation, so another possibility is:
    - different-nasality = similar-nasality > nasal-only

RESULT

Discrimination test

- Correct predicted order of discriminability for [bɛ̃(n)t] stimuli
    - different-nasality = similar-nasality > nasal-only
- [bɛ̃(n)d] stimuli, however: Different-nasality > similar-nasality = nasal-only
    - Different-nasality > similar-nasality was expected; similar-nasality = nasal-only was not
- Listeners recategorized as 'different = similar nasality' and 'perceived equivalence' listeners to correct for those who are more sensitive to total nasalization or vowel nasalization, respectively
- 9 listeners were 'perceived equivalence'; 12 'different = similar'; 8 'mixed result'
- Overall: [t]-final more likely to trigger more attention to Ṽ; [d]-final more likely to bring attention to total nasalization

Identification test (Figure 11)

- Longer [n] needed to identify stimuli as CVNC for [d]-final
    - Shift from CVC to CNVC ~30ms earlier in [t]-final
    - Parallels [n] duration differences from 3 participants of the production experiment
- Oral and nasalized vowels have significant effect on CVC to CNVC perception shift
    - As Ṽ increased, [n] did not need to be as long for shift to occur
- Highly accurate /t/ and /d/ judgements

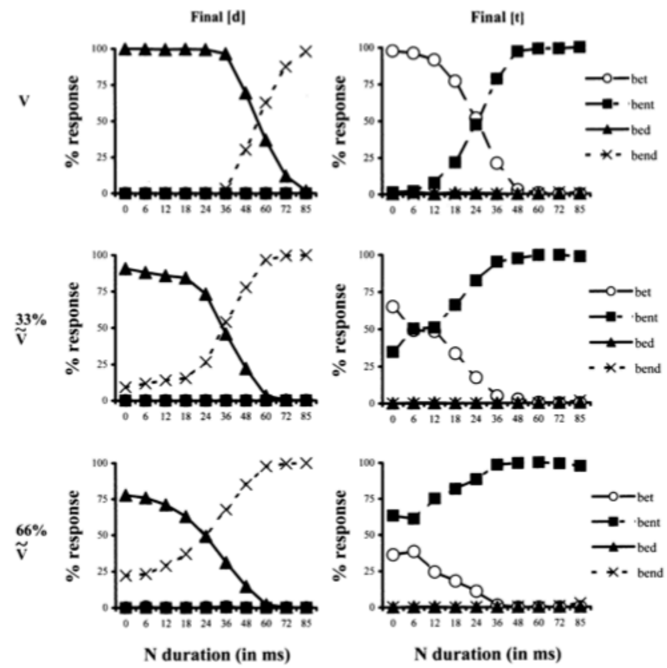

FIGURE 11. Identification responses of thirty American English-speaking listeners to the *bed–bend* (left) and *bet–bent* (right) series for three degrees of vowel nasalization (increasing from top to bottom).

INTERPRETATION

- Confirmation of co-varying effects of [Ṽ+N]
- Marked difference of interpretation between 'perceived equivalence' and 'vowel nasalization' listeners
    - The latter heard *bent* at high rates when Ṽ was present even if N was not
- Evidence of perceptual differences and variations in individual grammars
- Differences in phonological grammars could involve different phonological representations of the sounds themselves
- Creates a basis for possible sound change to occur (i.e.: VN>Ṽ)

Summary

Beddor's hypothesis that the target gesture within a coarticulation (in our case, total nasalization) remains relatively stable within the coarticulatory variation falls through with this experiment, albeit with temporal variations. She provides a few historical examples of VN>Ṽ sound change as evidence for nasal consonant deletion in the presence of preceding nasalized vowels:

- Sampson (1999): Northern Italian and Alps to Switzerland

- Hajek (1997): Northern Italian
- Ruhlen (1978): Indo-Aryan

She also briefly cites examples of children's perceptions of phonemes in these contexts:

- Hernández-Chávez et al (1975): Toddler Chicano Spanish speakers producing ṼC when modeling adult $\text{VNC}_{\text{VOICELESS}}$
- Treiman et al (1995): American English children with phoneme counting tasks interpret VNC as ṼC when C is voiceless

And more examples of nasal deletion in Romance languages which I will not list

Listeners have knowledge of these coarticulatory effects and can correctly perceive them while reproducing them in varied ways. The acoustic signals identified, such as that of **total nasalization, can be reinterpreted by a speaker as a deliberate way to facilitate communication**. Consider that [n] shortening preceding an obstruent makes it so that a longer nasalized vowel can help a listener sooner perceive a target word. Though a listener might not easily discriminate a distinct Ṽ or N, they should be able to discriminate nasality overall. And in production, the resulting temporal proportionalities of Ṽ and N may vary, but nasality may remain consistent. Therefore, "**the psychoacoustic salience of the source (N) diminishes as the extent of its anticipatory influences increases**" (p. 816), and Ṽ becomes the identifying property for an utterance as the presence of N decreases.

(In Beddor's conclusion, she continues to link her findings to other historical examples of covariation and even tonogenesis)

Class Discussion

1. Do you think you're a 'perceived equivalence' or 'vowel nasalization' listener? It would probably be difficult to tell on our own. Many of us are multilingual in this class. Do you think proficiency in other languages can influence your perception, and to what extent?
2. Are there already examples of VN>Ṽ sound change in any English varieties you can think of? If not English, then other languages you're familiar with?
3. The participants of this experiment originate from the midwest in regions that share many similar phonological variants with Canada. There is some evidence of VN>Ṽ use to the point where 3 speakers were included in Experiment 1 for their exclusive use of nasalized vowels over oral vowels. Does this mean that VN>Ṽ is on the horizon for us as well? How long, if ever, do you think VN>Ṽ will take to arrive into standard Canadian or American English?