TEMPORAL VS. AREA-SUM FORMULAE OF VOWEL NASALITY IN SIMULATED & NASOMETRIC CORPORA

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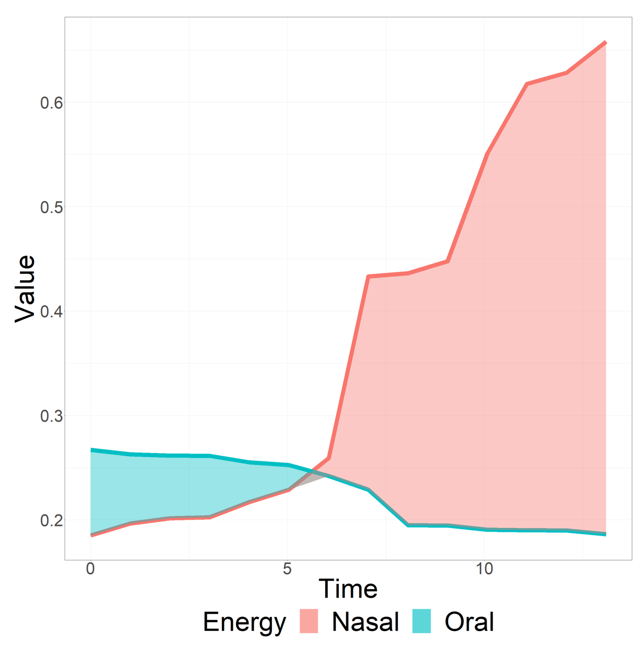
Not all formulae for vowel nasality are created equal, for instance...



Counting points where nasal energy > oral **= 57% nasal**

Calculating the degree of difference between the two energies **= 88% nasal**

Fig. 1: Oral and nasal energy of a vowel

This paper compares the two approaches mathematically in two nasometric corpora: **simulated** and **real-world** (French).

BACKGROUND

“Split-level” methods like nasometry give us information about both **time** and **degree** of some correlate of nasality. Their relation can be turned into an expression of **global** nasality (e.g., a percentage).

Of the various types of formulae present in the literature (see paper), this study compares two types, one prioritizing **temporal information** (Nasalance Based Ratio (NBR), à la Rochet & Rochet 1991) and the other prioritizing **differential information** (Differential Energy Ratio (DER), e.g., Dow 2020).

See (1) and (2) for formulae. x = oral energy, y = nasal energy, i = measured point until N.

METHODS

14 pre-determined types for all logical permutations of parameters for oral and nasal energy (Fig. 2):

- Does oral energy rise or fall? Nasal?
- Is the starting point of oral energy greater than that of nasal? The final point?

Intersection of each vowel’s energy readings estimated with `line.line.intersection()` (Sterratt et al. 2013).

Simulated corpus (14000 vowels)
Oral and nasal energy readings for 1,000 vowels of different lengths per type randomly generated in R with `runif()`.

Process for type 2 (= nasal energy overtakes oral, nasal energy rises and oral energy falls), illustrated in Fig. 3.

1. Number of readings randomly chosen between 7 and 20: *n*
2. 4 points randomly generated between 0 and 1 and sorted
3. Points 1 and 4 (lowest and highest) are assigned *nasal*
4. Points 2 and 3 are assigned *oral*
5. n points between points 1 and 4 are generated for the nasal readings and sorted increasing
6. n points between points 2 and 3 are generated for the oral readings and sorted decreasing

Real-world corpus (4319 vowels)
Nasometric corpus of 20 native speakers from Northern France, from words containing one of all phonemic vowels preceding or followed by an oral or nasal consonant (see Dow 2020).

Linear regression performed on each set of energy readings for each vowels, then procedure above repeated. This helps with marginal cases of likely error and homogenizes corpora.

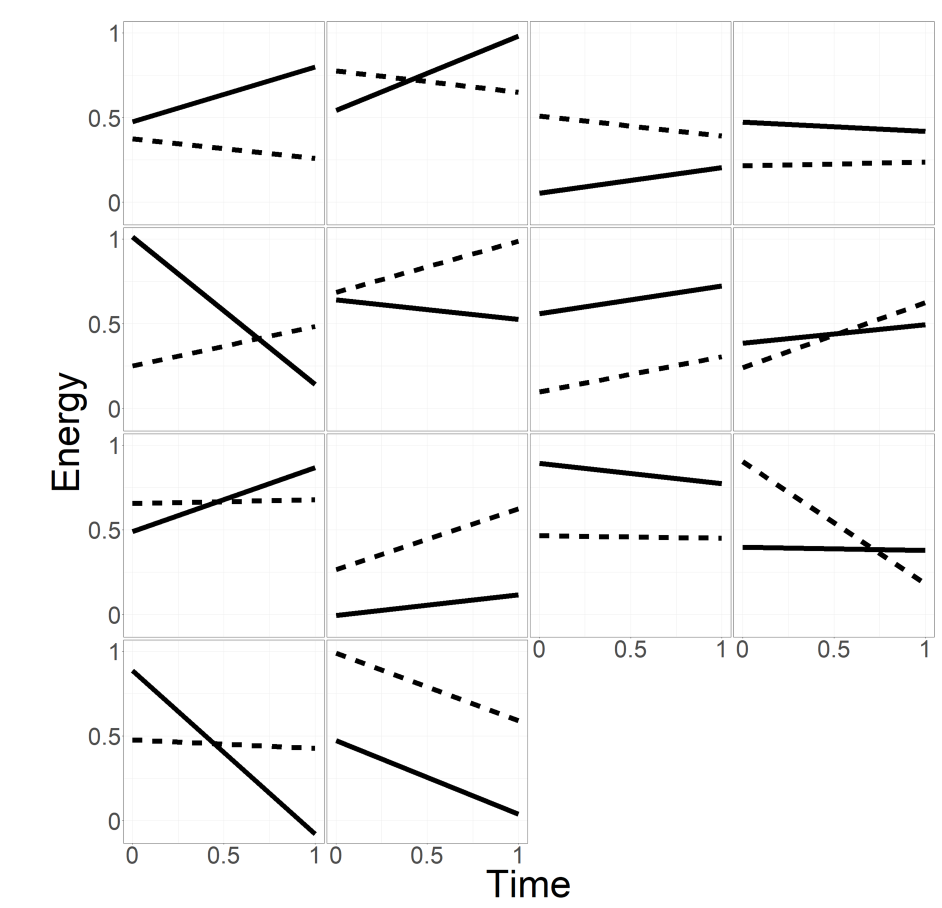


Fig. 2: Illustration of vowel types, oral (dashed line) and nasal (solid) energy over time

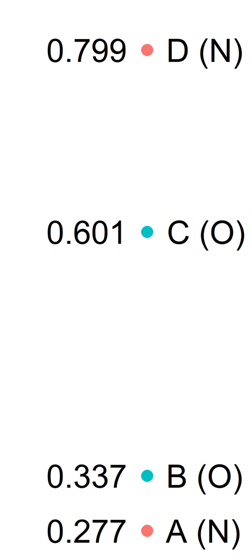


Fig. 3a: Initial points

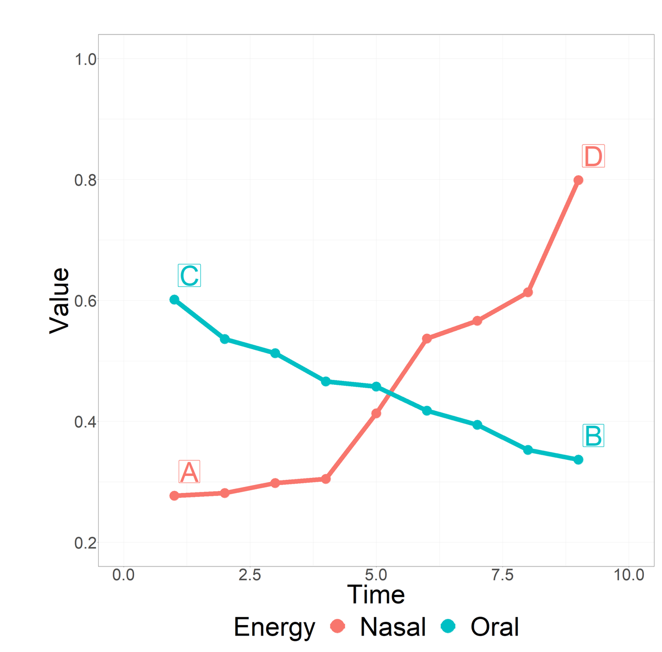


Fig. 3b: Vowel generation

(1)
$$DER = 100 \times \frac{|\sum_i min(x_i - y_i, 0)|}{|\sum_i min(x_i - y_i, 0)| + \sum_i max(x_i - y_i, 0)}$$

(2)
$$NBR = 100 \times \frac{1}{N}\sum_{i=1}^{N} \frac{y_i}{x_i + y_i} \geq 0.5$$

RESULTS

- Perfect agreement at extremes in both corpora, i.e., vowels with 0 DER have 0 NBR, and vice-versa. The same for 100. Mean agreement within 2 points on average for oral vowels in oral contexts and phonemic nasal vowels in the French corpus.
- In contextually nasalized vowels (progressive and regressive), NBR shows a linear relationship with crossover point, whereas DER shows a more distinct curve towards the edges. (Fig. 4).
- The difference between the two formulae is sinusoidal with respect to crossover point, such that vowels nasalized early (VN) or denasalized late (NV) are judged as more nasal by DER. On the opposite side, late nasalization (VN) or early denasalization (NV) lead to less nasal scores from DER (Fig. 5).
- No discernable difference between the corpora – with the possible exception of post-nasal French /i/, which has already proven exceptional (Dow 2020), with steep and rapid changes in nasality compared to other vowels.
- Here, it was found by the DER to be much more nasal than all other vowel qualities in the same position.

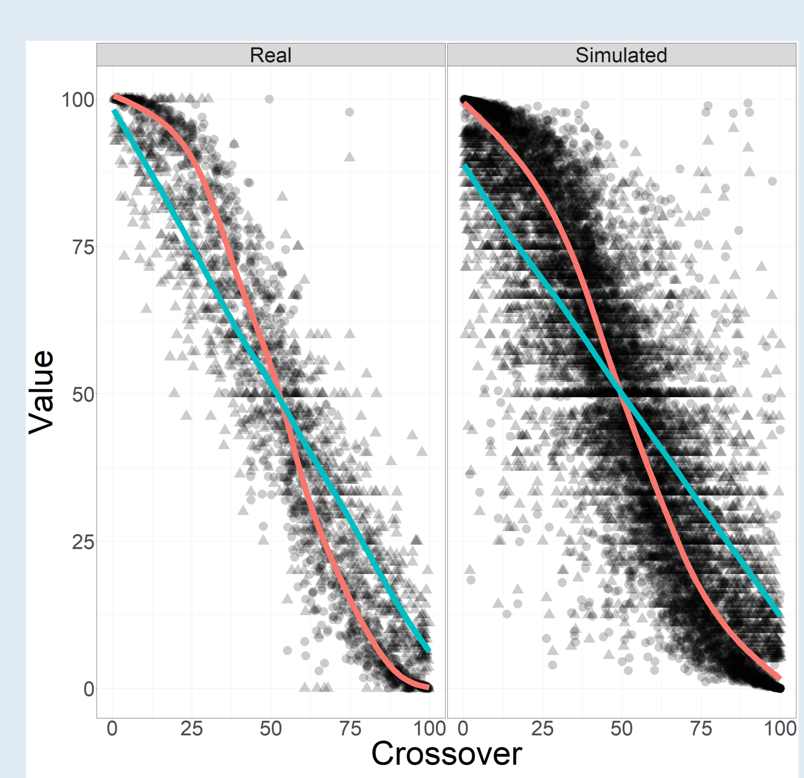


Fig. 4: Relationship between crossover point and nasality, DER and NBR, contextually nasalized vowels

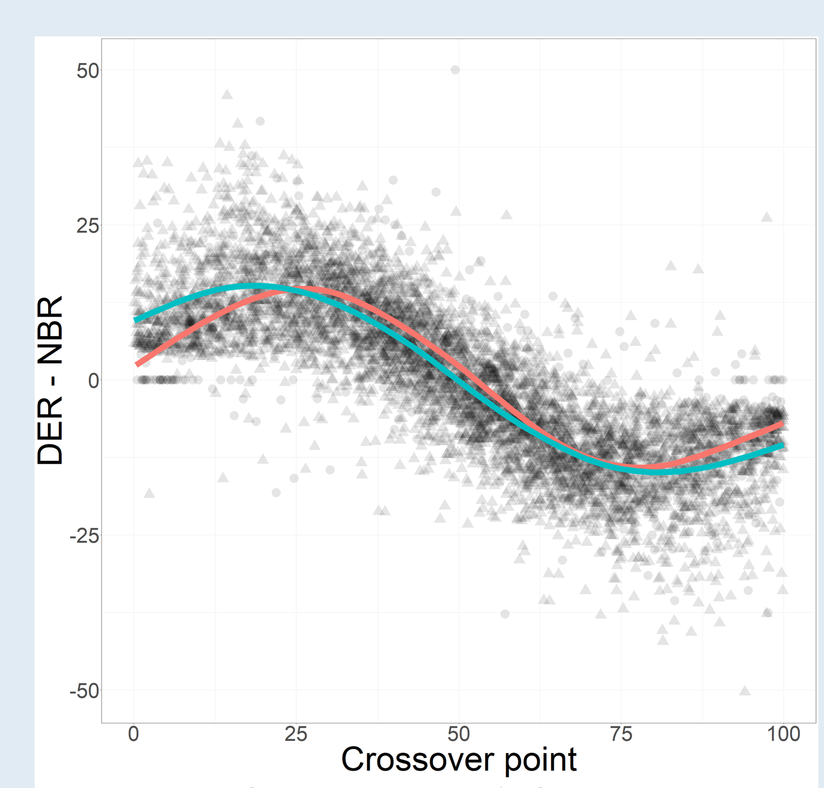


Fig. 5: DER - NBR by crossover point, contextually nasalized vowels

DISCUSSION

Regardless of corpus, the DER and the NBR differed on contextually-nasalized vowels as a function of crossover point, such that higher nasality leads to higher differences in favour of the DER, and lower nasality in favour of the NBR.

The behaviour of post-nasal French /i/ suggests that languages may still exploit degree of nasality and/or velocity of change beyond temporal properties. In the future, degree of change needs to be incorporated into these comparisons. In addition, perceptual studies may elucidate if one formula is more representative of global nasality than the other.

REFERENCES

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