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Problems in the interpretation of the data related to nasality

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Abstract

This presentation deals with the difficulty of assembling the wealth of available data on nasality into a coherent whole, taking into account all of the seemingly divergent findings yielded by electromyographic, articulatory, aerodynamic, acoustic and perceptual investigation.

Some of the difficulties will be illustrated by confronting data published in the literature about nasality (Beddor, Bell-Berti, Benguerel, Clumeck, Ohala, Vaissière, among others), with emphasis on Ph. D. dissertations about nasality (in particular: work by Amelot, Cohn, Delvaux, Krakow, and Rossato). A set of new data, from ongoing research by students at our laboratory, will also be adduced. Some of the remarks on perception, based on spectrograms reading courses, call for systematic verification.

1. On discrepancies that can in part be explained

1.1. Differences in the temporal extent of coarticulatory nasalization as measured by different instruments

Part of the divergences across authors concerning the observed extent of anticipatory lowering of the velum before a nasal phoneme come from differences in instrumentation. The suppression of the activity of the levator palatini precedes the descent of the velum. EMG-based studies [6, 9] therefore tend to conclude to a large anticipation, as do fiberoptic studies [1]. Aerodynamic data generally report more extensive carry-over than anticipation [4, 8] – note, however, that there is no need of an outgoing nasal airflow to create nasal coupling. Velum descent creates a negative nasal

airflow [the pumping effect: 8]) and most (if not all) studies based on aerodynamic data neglect the fact that the negative airflow delays the estimation of the beginning of anticipatory nasalization. Velum descent precedes the opening of the velopharyngeal port. The velum may be high, but there may be lateral opening of the velopharyngeal port [3D MRI, 36]. Velum height, opening of the velopharyngeal port and aerodynamic data, when taken simultaneously [3], seldom display a perfect correlation and symmetry. Furthermore, the lowering of the velum for a nasal consonant is slower than its raising [29, 8: fiberoptic data; 14: 160 msec for closing and 130 msec for opening; 31: 50 msec for sufficient opening], and both movements are rather slow as compared to the average acoustic duration of the phonemes. The point of maximal airflow often appears at the beginning of the obstruent consonant following the nasal vowels, because of airflow resistance in the oral cavity (while the velum has almost achieved closing). Moreover, the upward movement of the velum along the pharyngeal wall may create a positive nasal airflow, while the velopharyngeal port may be already closed. Beddor's acoustic data suggest that the global velar gesture is of equivalent duration in "tent" as compared to "tend" in American English [5]; Ohala's nasographic data point to a slightly larger velum gesture in "tend" [31]; but X-ray Microbeam data point to a much larger difference for the same sequences (see Powerpoint presentation).

1.2. Choice of vowels for experiments

Velum height is lower for lower vowels than for high vowels [15: nasograph, 6 languages; 25: velograph; 6: English; exception in nasal context: 21; see also 30]; but the relationship between vowel aperture and intrinsic velar height is not clear-cut [2: EMA, French]. Velum height during vowels

influences its height during the flanking nasal consonant(s) [35]. X-ray and EMA data show that the low vowels appear as more easily nasalized, with more extensive coarticulatory phenomena. The reverse finding is reported in studies based on aerodynamic data: high vowels appear to be more easily nasalized, with more extended coarticulatory phenomena [19: French]. This is because egressive nasal airflow greatly depends on resistance to airflow in the oral cavity; it is therefore greater for high vowels. Furthermore, the evidence of acoustic nasality is more easily detected on high vowels [38]. *Ceteris paribus*, high vowels require less nasal coupling to be perceived as nasalized [12, 27]. In French, high oral vowels do not have a nasal counterpart; they can therefore undergo a degree of nasalization without causing confusion between phonemes, whereas nasalization of low vowels may cause confusion with the phonemic nasal vowels (which are low). Vowel height and the system of phonemic contrasts thus offer partial explanations for the fact that there is more nasal airflow and more extended coarticulation for high vowels [see discussions by 18], but the use of nasality as a contrastive feature for vowels is not a good predictor of the degree of coarticulated nasality [15, 37].

1.3. Coarticulated speech ready gesture and presence of a pause

Some discrepancies may be explained by the presence of the speech ready gesture before or during the phoneme under study [40] and by the presence/absence of pause after this phoneme. For example, in isolated CVC or nVn (often used in the literature), the initial consonant is “strong” and the tense LP may resist coarticulation. Moreover, the exact timing of the speech ready gesture (which concerns all articulators) relatively to the acoustic beginning of speech is random for a given speaker, and may greatly vary from one repetition to the next [41: X-ray data, English]. Conversely, in nV + pause sequence, the pause is intrinsically “nasal”, and acts as a nasal consonant (nV+pause = nVn). Thus, studies based on VCV, where V and C are either nasal or oral, may underestimate the extent of anticipatory nasalization and overestimate the extent of carry-over [8, 33]. Coarticulated speech ready gesture and presence of a pause are generally ignored

as factors influencing velum behaviour. Even when the logatoms under study are placed in a frame sentence, the researcher should mention the absence/presence of an adjacent pause.

1.4. The influence of syllable structure on velic height

EMG data [22: Japanese], fiberoptic data [39: Japanese], velotracheal data [23: English], nasographic data [31: English], X-ray Microbeam data [41: English] all show the decisive importance of the position of the nasal consonant in the syllable, as onset or coda. *Ceteris paribus*, a nasal coda is phonetically “more” nasalized, as compared to a nasal onset: longer suppression of the levator palatini activity, larger lowering, lower velum height, longer low plateau. Few studies take the position of the nasal consonant within the syllable as a parameter.

2. Examples of conflicting data

Some of the diverging conclusions cannot be explained by a difference in instrumentation, context or corpus.

2.1. Anticipatory nasalization in CVN- in English

There are three types of models for describing anticipatory lowering of the velum in CVN sequences; their results are contradictory. First, according to Bell-Berti’s interpretation [7] of her velographic data, the anticipation is minimal (mechanistic), as if the vowel in English were [-nasal]. The interpretation of an earlier onset of velar lowering as coarticulation of the nasal consonant is considered as unfounded by Bell-Berti: the reason why velic lowering occurs at vowel onset could simply be because the velum is lower during vowels than during consonants (this is verified in other articulatory studies, though not always visible [2]). Flege concludes from a large-scale study that more vowels were fully nasalized in the /nVd/ context than in the /dVn/ [20: acoustic study, with two microphones]. Second, most if not all articulatory data [41], aerodynamic data [17: comparing English with French] and nasographic data [37: comparing English with Spanish] show a strong anticipatory nasalization of the vowel

preceding a nasal in coda in English, much stronger than in French and Spanish. Solé and Ohala [37] conclude that in English nasalization is a phonological effect—as if a vowel followed by a nasal coda became [+nasal], implemented as such by the speaker [see also 28]: the extent of anticipatory nasalization increases as the rate of speech decreases. In the same vein, Vaissière's X-ray data illustrate the fact that in stressed CVN syllables in English, the velum lowers at the vowel onset, as soon as it can after the release, and as rapidly as possible – as if the vowel were a French nasal vowel (see also Benguerel's data). Third, Cohn's aerodynamic data [17: 150] bring out a continuous transition (interpolary function), with large intra-speaker variability, as if the vowel were underspecified for nasalization in English.

Note that none of the previous studies considers the intrinsic length of the vowel (Clumeck found that the lowering of the velum is delayed in CVN- when V is a long vowel [16]), or the effect of stress, style and rate of speech; more investigation is needed. Concerning, for example, the influence of the rate of speech on the extent of nasalization in English, Flege's data [20: acoustic] point to almost no effect, Bjork [14] to less variability in extent of coarticulatory nasalization than variations in rate of speech, and Solé and Ohala [37] to the adjustment of nasalization to the duration of the vowel.

2.2. The limit of nasalization of the oral vowels in French

The velum is lower for the nasal vowels than for the oral vowels, but the oral vowels can be fully nasalized in nasal context. Cohn's aerodynamic data suggest that there is a limit to contextual nasalization in French as compared to English in nVN- context, but Delvaux's similar aerodynamic data show that there is no limit [18].

3. Models

The nasal feature has to be realized acoustically on different parts of a segment for it to be perceived as nasal.

3.1. Oral and nasal vowels

Nasal vowels have to be increasingly nasalized acoustically (only) on their final part. Acoustic nasality is only necessary on the second portion of the vowel (the target of maximum nasalization at, say, 2/3rds of vowel duration in French); and it has to last for a sufficient time to be perceived. The very final part of the nasal vowel may be phonetically oral (and perceived as such [12]).

Oral vowels may or may not be fully nasalized, but if nasalized, they should not be increasingly nasalized during the second portion of the vowel.

The extent of the phonetic nasalization of the first portion of a vowel, oral or nasal, depends on the oral/nasal feature of the preceding consonant (for nasalization of the first part of oral vowels preceded by a nasal consonant: fiberoptic data [10]; X-ray data [13]; nasometry [34]; aerodynamics [17, 18]). There are differences between dialects (Canadian vs. European French) and languages (for Portuguese, nasalization only occurs at the very end of the nasal vowel).

3.2. Oral and nasal consonants

Onset and coda nasal consonants:

For what concerns a nasal at the beginning of the syllable, nasalization of the very first part of the vowel is necessary (but not sufficient) for the perception of the nasal feature of the preceding consonant [26, 33, among others]. Some portion of nasal murmur should be present just before the release. Acoustic nasalization may last for a very short time (sufficient condition: Stevens [38]). Nasal consonants may be realized with positive, but also negative airflow (examples given), except for their very final part, which has to be phonetically nasalized.

For a nasal in coda (in VN- or VNC-), if unreleased, the last part of the preceding vowel has to be nasalized, together with the onset of the consonant. Acoustic nasalization should last for a longer time than for nasal consonants at the beginning of the syllable (necessary condition: [16]) and there is less nasal airflow (see [17]: English and French).

Maximal airflow, minimal velum height, and maximal velopharyngeal port generally appear well aligned at the nasal consonant release in nV (in

synchrony with the lip gesture for /m/ [23]), but more loosely, just before, at or after the nasal onset in vN-. A larger movement and a lower velum are generally observed in nasal vowels as compared to nasal consonants (some exceptions, [35]: EMA, French).

Oral stops and the interaction between voicing and nasality

Voiceless stops are sometimes considered as doubly oral: at their onset [for details on aerodynamic constraints, see 32], and at their release (for perceptual reasons, Vaissière; see also the description of the difference in aerodynamic data between voiced and unvoiced stops in Cohn's thesis). There are cases however where the onset and even the release of the voiced stops are nasalized, and the consonant is still perceived as an unvoiced stop (demonstration). The aspirated part of the voiceless stops may or may not be nasalized in English [17: 151].

Voiced stops only have to be oral at their release and just after their release (otherwise, /b/ is confused with /m/, and /d/ with /n/). The very first part of the vowel has to be oral.

The velum is generally observed as higher for stops than for fricatives, lower for liquids, and lowest for nasal consonants. In French, however, the "nasality scale" is not a good predictor of the resistance to coarticulation [15] (for examples of leakage of air through the velar port during oral obstruent in continuous speech: [4]).

4. Conclusion

A large number of assumptions concerning nasality need further investigation. There is a clear lack of perceptual data (see however Beddor this meeting). Multisensor investigation, combining different instrumentation, should be carried out.

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