Compensatory Lengthening In Hungarian VnC Sequences: Phonetic or Phonological?

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Data

• Hungarian evidences a number of optional compensatory lengthening (CL) processes

• In casual speech styles a medial sonorant consonant ([l r j n]) may be deleted in the coda position of a syllable and, as a result, the preceding vowel is lengthened (Vago 1998, Siptár & Törkenczy 2000, among others)
• Here, we will be concerned only with those cases where CL is induced by the loss of /n/ in VnC sequences

• Descriptions of VnC sequences undergoing CL in the phonological literature:
  – C must be continuant (= fricative obstruent, lateral approximant, or central approximant)
  – /n/ drops
  – V becomes long and noticeably nasalized
    • The nasal quality of vowels next to nasal consonants is insignificant (will not be indicated in phonetic transcriptions)
• Furthermore, the C following /n/ may be:
  – tautomorphemic with /n/
  – the initial segment of a following suffix
  – the initial segment of a following word
• I.e., CL applies “across the board”
• Examples:
• nagyon furcsa ‘very odd’ [nɒʃɔːfurʧɑː] (/ɒnʃ/ → [ɒʃ])
• szenved ‘suffers’ [sɛnved] (/ɛnʃ/ → [ɛːv])
• köszön-sz ‘you say hello’ [køʂøːs] (/øns/ → [ʊːs])
• vonz-ó ‘attractive’ [vøːzoː] (/onz/ → [ʊːz])
• impotens ‘impotent’ [impotɛːʃ] (/ɛŋʃ/ → [ɛːʃ])
• ötv enzsák ‘fifty sacks’ [øtvɛːʒaːk] (/ɛŋʒ/ → [ɛːʒ])
• un-lak ‘you bore me’ [ʊːlɔk] (/unl/ → [ʊːl])
• latin-ra ‘to Latin’ [lɔtɪnɾa] (/inr/ → [ɪɾ])
• szépen játszik ‘plays well’ [seːpɛːjɑːtʃtsik] (/ɛnj/ → [ɛːj])
• Each of the preceding phonetic representations has a variant without the effects of CL, i.e. containing a short vowel followed by a nasal consonant, whose place of articulation agrees with that of the following consonant

• E.g.: szenved ‘suffers’ = [sɛ̃vɛd] or [sɛmve̯d]
• If /n/ is followed by a non-continuant C (stop or affricate), CL does not obtain:

negyven perc ‘forty minutes’  [ɛɲɛmpɛr̝ts] (*[ɛɲɛmpɛr̝ts])
nagyon buta ‘very stupid’  [nɒɛmbutə] (*[nɒɛmbutə])
tinta ‘ink’  [tɪntə] (*[tɪntə])
sündisznó ‘porcupine’  [ʃyndisnɔː] (*[ʃyːdisnɔː])
ötven tyúk ‘fifty hens’  [ɒtvɛntuːk] (*[ɒtvɛntuːk])
igen gyakran ‘rather often’  [igɛŋɒkron] (*[igɛŋɒkron])
bank ‘bank’  [bɒŋk] (*[bɒŋk])
barlang ‘cave’  [bɔrlɔŋ] (*[bɔrlɔŋ])
kuncog ‘chuckle’  [kʊntsɔɡ] (*[kʊntsɔɡ])
narancs ‘orange’  [nɔɾoŋʧ] (*[nɔɾoŋʧ])
findzsa ‘tea-cup’  [fiŋʧə] (*[fiŋʧə])
Moraic analysis

• In classic moraic theory, CL is based on the principle of “mora preservation” (Hayes 1989)

• Two-step process:
  – the consonant in coda position is deleted, leaving behind its mora unit
  – the unaffiliated mora is then reassigned to the preceding vowel, which becomes bimoraic, i.e. long
Syllable: \( \sigma \) \( \sigma \)

Mora: \( \mu \) \( \mu \) \( \mu \) \( \mu \)

Root: c v c c v c

Segment: s \( \varepsilon \) n \( \varepsilon \) d
Syllable \( \sigma \) \( \sigma \)

Mora \( \mu \mu \) \( \mu \mu \)

Root \( c \, v \, c \)

Segment \( s \, \varepsilon \, v \, \varepsilon \, d \) (nasalization suppressed)
• But what about the fact that CL is triggered only by a following continuant consonant?
• In this regard, the moraic phonology treatment lacks explanatory force: it must stipulate that /n/ is deleted precisely before the class of continuant consonants
OT analysis

• In the constraint-based approach of classic optimality theory and its successor versions (for discussion, see McCarthy 2002, 2007), choosing the output candidate [sɛːvɛd] as optimal from the input /sɛnvɛd/ entails minimally the following:
• (1) the highly ranked markedness constraint *n CONT can be respected in a number ways, including, but not limited to:
  – (a) deleting /n/
  – (b) inserting a vowel between /n/ and the continuant consonant
  – (c) deleting the continuant consonant

• (2) Of the competing output candidates, option (a) is flagged as optimal by proper constraint ranking
• (3) /n/ is moraic
  – Both the mora unit and the [nasal] feature of /n/ must be preserved in the most harmonic output (mora and [nasal] faithfulness)
• (4) the features of the preceding vowel are aligned right to the unassociated mora
  – the vowel becomes long by virtue of its bimoraic status
• The optimality theoretic analysis, which crucially relies on the markedness constraint \( * \) in CONT, is just as stipulative as the rule based analysis, unless this constraint can be shown to have phonetic motivation
Goal

- The purpose of this presentation is to report on an acoustic phonetic study we have conducted, providing the basis for claiming that both the *n CONT constraint and vowel lengthening, the two integral components of CL under consideration, are in fact grounded.
- We will advance the argument that the entire process is phonetic, rather than phonological.
Material, method, subjects

- Eight native Hungarian speakers (4 women, 4 men) with no known speech or hearing defects read isolated words in a sound-proofed chamber
- Their ages ranged from 24 to 32
- The word lists consisted of Hungarian words and phrases that contain the dento-alveolar nasal /n/ followed by either a fricative / approximant or a stop / affricate consonant
- These represent the possible and impossible CL contexts, respectively
- There were four vowels used in the material, two front (/i [i], /ɛ [ɛ]) and two back (/o [o], /ɑ [ɒ])
• The words were recorded and digitalized up to 44,000 Hz
• Acoustic phonetic analysis was carried out by Praat software, 5.4 version
• The consonant /n/, if present, the previous vowel, and the following consonant were defined in each word for each speaker
• The duration of the nasal consonant and the preceding vowel was measured
• The statistical evaluation of the data was carried out using ANOVA (multivariate analysis, paired sample $t$-tests and correlation test by SPSS 12.0.1 for Windows software package) and regression analysis

• In all cases, the confidence level was set at the conventional 95%
Results: Grounded /n/ Deletion

• The principal question to raise is: why does /n/ drop out – or change its acoustic structure – before continuants but not before non-continuants?

• The explanation lies in the basic difference between the articulation of /n/ plus continuant clusters vs. /n/ plus non-continuant clusters
• If /n/ is followed by a non-continuant, the entire cluster shares the same place of articulation under anticipatory assimilation:
  – In the labial cluster [m] plus [p], [b], or [m] a single closure is made with the lips
  – In the dento-alveolar cluster [n] plus [t], [d], [n], [ʦ], or [ʣ], a single closure is made between the tongue and the teeth or the alveolus
– in the alveo-palatal cluster [ⁿ] plus [ʧ] or [ʤ] a single closure is made with the tongue in the alveo-palatal area
– in the palatal cluster [ŋ] plus [c] or [ɟ] a single closure is made in the palatal area
– in the velar cluster [ŋ] plus [k] or [ɡ] a single closure is made in the velar area
• In all of these cases, the closure gesture is shared by the nasal consonant and the following stop or affricate
• The two closures – the one that belongs to the nasal and the one that belongs to the following consonant – follow each other in time, but meld into one gestural movement, since normally the closure of the nasal is not released before the homorganic closure of the following stop or affricate
• In contrast, the motor command of the nasal closure is modified in the case of a following continuant consonant

• Except in very careful pronunciation, the articulation of the nasal in this context is characterized by an early onset of the velar gesture and by the lack of articulatory closure, another instantiation of anticipatory assimilation

• As a consequence, /n/ is not pronounced
• The two cases of VnC sequences have different acoustic consequences
• Before non-continuants, there is a well-defined nasal consonant, including the closure gesture, and the preceding vowel is short and non-nasal (recall that we are ignoring the weak nasal coloring of vowels next to nasals):
latin csoda [lɔtintʃɔdə] ‘Latin miracle’
• It turns out that before continuants the facts are much more complex than the phonological descriptions would indicate: the realization of /n/ falls into four distinct patterns
• In the first one the nasal consonant is missing and the preceding vowel is long and slightly nasalized:

Transitioning CL

nagyon szalad [ɲɒ̞ːŋ sdɒ] ‘runs fast’
• In the second case, the vowel is long and heavily nasalized, and there is no trace of the nasal consonant at all:

Non-transitioning CL
istenség [iʃɛnʃeːg] ‘deity’
• In the third case, typically found in careful / deliberate speech, CL does not obtain: the nasal consonant is present (the closure is actualized) and the vowel is short and non-nasal:

латинськ [латинськ] ‘the Latin people’
• In the fourth case, there is no trace of the nasal consonant: /n/ drops and the preceding vowel remains short and non-nasal:

/\n/ drop

olyan zöld [oʃɒzɒld] ‘so green’
• The greatest difference between nasalized and non-nasalized vowels is found in the second formant history, as seen in the first two formants of [õː] (occurring before continuants) and [o]: (occurring before /n/ followed by a non-continuant):

![Graph showing formant frequencies for different vowels.]

• The distance between the first two formants in the same vowel is different, depending on whether the vowel is nasalized or not. When the vowel is nasalized, the first two formants are closer to each other.
The acoustic consequence of nasalization can also be seen in the energy distribution differences between nasalized and non-nasalized vowels. Vowels are more intensive when nasalized:

The energy distribution curves of [õː] (upper curve) and [o] (lower curve)
• The difference between the realization of /n/ before continuants as opposed to non-
continuants is statistically significant (one-way ANOVA: F(1,255) = 250.379; p < 0.000)
• The distribution of the /n/ realizations before continuants is as follows
  – 49.23% with transitioning CL
  – 19.53% with non-transitioning CL
  – 14.84% without CL
  – 16.40% with /n/ drop
• In contrast, if /n/ is followed by a non-continuant, the nasal consonant is retained in 98.44% of all
data (1.56% are transitions)
• Analysis was carried out to answer the question of whether the duration of the nasal consonant was also dependent on the following consonant
• One-way ANOVA proved this to be significant as well (F(1,255) = 212.535, p < 0.000)
• This means that the continuant or non-continuant nature of the following consonant has an impact on the realization of /n/
• In cases where CL is possible (before continuants), the mean duration of the /n/ realization (independent of the actual type or acoustic structure) is 25.39 ms (std. dev.: 22.08 ms), including all variations
• (The mean duration of the transition type of /n/ realization is 28.11 ms (std. dev.: 7.54 ms))
• In cases where CL is not possible (before non-continuants) the mean duration of the /n/ realization is 66.05 ms (std. dev.: 22.54 ms)
The medians and the ranges of the durations of the /n/ realizations before continuants and non-continuants.
• Correlation analysis also supports the strong interrelation between the duration of the /n/ realization and the type of the following consonant (Pearson’s rho = 0.675, p < 0.000 at 99% confidence level)

• It also confirms a strong interrelation between the acoustic structure of the /n/ realization and the following consonant (Pearson’s rho = 0.705, p < 0.000 at 99% confidence level)
• In more careful speech styles /n/ is retained in VnC sequences regardless of the manner of articulation of the following C
• A parallel investigation of these cases by Gósy, Beke, and Vago (2010) found that C has a significant effect on the duration of both the vowel and the nasal consonant:
• (1) The data reveal that the nasal is shorter before both continuant obstruents and approximants than before non-continuant obstruents:
<table>
<thead>
<tr>
<th>C types</th>
<th>Duration of $n$ (ms)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>std. dev.</td>
</tr>
<tr>
<td>non-continuant obstruent</td>
<td>107.8</td>
<td>30.06</td>
</tr>
<tr>
<td>continuant obstruent</td>
<td>59.6</td>
<td>23.9</td>
</tr>
<tr>
<td>approximant</td>
<td>53.25</td>
<td>20.56</td>
</tr>
</tbody>
</table>

VnC sequences: The duration of $n$

- The difference in nasal duration before continuant vs. non-continuant obstruents is significant ($F(3,629) = 193.2; p=0.001$)
- Post hoc Tukey tests confirm that there is no significant difference in nasal duration before continuant obstruents vs. approximants
• (2) Conversely, the vowel is longer before continuant obstruents and approximants than before non-continuant obstruents:

<table>
<thead>
<tr>
<th>C types</th>
<th>Duration of V (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
</tr>
<tr>
<td>non-continuant obstruent</td>
<td>155.5</td>
</tr>
<tr>
<td>continuant obstruent</td>
<td>185</td>
</tr>
<tr>
<td>approximant</td>
<td>174.65</td>
</tr>
</tbody>
</table>

VnC sequences: The duration of V

• This difference is statistically significant (one-way ANOVA: $F(3,629)=49.1; p=0.001$)
• (3) In addition, the duration of both V and /n/ is affected by the voicing of the following C: both are shorter before voiceless obstruents than before voiced obstruents (see also Beddor 2007)
• (4) Putting it together, in VnC sequences:
  – V is shorter and /n/ is longer before non-continuants (stops and affricates)
  – V is longer and /n/ is shorter before continuants (fricatives and approximants)
• (5) The entire V+n sequence is longer before continuants than before non-continuants
• In summary:
  – The actual realizations of the dento-alveolar nasal phoneme heavily depend on the following consonant, which also has an effect on the vowel preceding the nasal
  – The nasal consonant is stable before non-continuants, variable before continuants
Results: Grounded Vowel Lengthening

• All of our subjects evidence longer vowel durations before /n/ plus continuant sequences, where CL is possible, than before /n/ plus non-continuant sequences, where CL is not possible, paralleling the finding of Gósy, Beke, and Vago (2010)
• In approximately 85% of the cases /n/ is not pronounced before continuants, and in 69% of these cases the preceding vowel is lengthened.

• We may exclude the cases without CL from our data set, i.e. those where /n/ is retained and the preceding vowel does not become long and nasalized, on the view that this realization of /n/ is not characteristic of casual speech, the principal sociolinguistic context for CL.
• In 16.4% of the cases /n/ disappears without a trace, i.e. it is not pronounced and has no effect on the preceding vowel (/n/ drop)
• We may also prune these realizations from our case load, the justification being that they represent extreme and atypical ways to expunge the nasal consonant
• Then, essentially, /n/ survives under the cloak of a lengthened and nasalized vowel in 100% of the time
• (Even if we do not exclude the /n/-drop cases, CL manifests itself with 83.6% frequency.)
• Regression analysis is a forecasting model for the investigation of relationships among variables
• In this analysis the coefficient of determination ($R^2$) is the proportion of variability in a data set that is accounted for by a statistical model
• Regression analysis shows that the variables predict greater changes in vowel duration in contexts where CL occurs (before continuants) than in contexts where CL does not occur (before non-continuants):
• The figure below compares the duration of vowels in contexts preceding /ns/ and /nz/, revealing that the vowel durations are almost identical if /n/ is followed by continuants (casual speech contexts where /n/ generally is not pronounced):
• The figure below shows the differences between the duration of the vowels preceding /nz/ (/z/ representing the class of continuants) and /nd/ (/d/ representing the class of non-continuants), revealing that there is no correlation between the two:
• This means that the measured vowel durations do in fact differ from each other, leading to the generalized conclusion that continuants and non-continuants have different effects on the duration of preceding vowels
• The duration differences of the vowels proved to be significant with all subjects, depending on whether the vowels occurred in contexts where CL is possible vs. where CL is not possible (paired-sample t-test: \( t (127) = 5.338, p < 0.000 \))

• The data show that vowels are about 10 ms longer in CL contexts than in non-CL contexts:

<table>
<thead>
<tr>
<th>Context</th>
<th>Vowel duration (ms)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. dev.</td>
</tr>
<tr>
<td>CL possible</td>
<td>97.62</td>
<td>20.75</td>
</tr>
<tr>
<td>CL impossible</td>
<td>86.65</td>
<td>19.63</td>
</tr>
</tbody>
</table>
• We are now in position to explain the second component of CL: vowel lengthening

• A crucial fact to bear in mind is that the lengthening of the vowel before an unpronounced /n/ is 100% correlated with nasalization: under both transitioning and non-transitioning types of CL, the vowel that is the reflex of /n/ is both long and nasalized

• And therein lies the clue to understanding the CL phenomenon of Hungarian involving /n/
• As we have argued, there are good articulatory reasons for /n/ not to be realized in the shape of a nasal consonant before continuant consonants

• An extreme, one might say immediate, resolution of this pressure is to drop the nasal consonant lock stock and barrel, without any residue

• In our experimental study, this happened in roughly 16% of the time
• But more commonly, the dissolution of /n/ is not as sudden
• With the nasal cavity opened up by a lowered velum, the tongue fails to make a closure in the oral cavity, bringing about an articulatory time span which is characterized as having nasal airflow but lacking oral gesture
• This unarticulated nasal phase can not exist in a vacuum; it most naturally settles on and becomes part of the preceding vowel
• It is this extra nasal span that gives the host vowel its newfound nasality and expanded space
• The nasal tonality can be an addendum to the vowel (transitioning CL), or it can be absorbed by the vowel to various degrees (non-transitioning CL)

• Either way, the spatial dimension of the vowel expands
• Putting the entire CL process in perspective, in Vn[continuant] sequences the nasal consonant is inherently weak (recall that it is short relative to the vowel), whereas the vowel is inherently strong (recall that it is long relative to the nasal)

• So the articulatory modification or weakening of an already weak segment sets in motion the enhancement or strengthening of an already strong segment
Concluding remarks

• We have set out to consider the phonological treatment of CL in Hungarian VnC sequences
• We claimed that the classic moraic phonology treatment failed to capture the facts in an insightful manner
• We further maintained that Optimality Theory, classic or post-classic, would be rendered similarly ineffectual, unless it could be shown that the central component of its analysis, namely a *n CONT markedness constraint, is motivated phonetically
• We have provided acoustic phonetic evidence, buttressed by a host of statistical analytical data, that indeed, this constraint is grounded
• Optimality Theory can provide an explanation for vowel lengthening and nasalization in terms of mora and [nasal] faithfulness, respectively
• But treating vowel lengthening in terms of phonological weight renders accidental the grounded nature of this process, for which we have provided acoustic phonetic evidence, supported by various types of statistical analysis
• It is our overarching thesis that any phonological account of the phenomenon at hand is misguided, for the following principal reason: as we have shown, the moving components of CL are variable and, crucially, gradient, rather than categorical

• As such, it is the grounding of phonetics, and not the categorical units of phonology, that provides us with the tools to understand the process
• If we are on target, our results are in comport with recent research that has succeeded in providing phonetically based explanations for sound patterns that have long been relegated to the domain of phonology
• See Gordon (2002, 2006), Kavitskaya (2002), Hayes, et al. (2004), and the entire Articulatory Phonology paradigm (Browman and Goldstein 1986 et seq.), among others
References


