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Phonetically Driven Coda Maximization

Abstract
Building on the contemporary functional phonology, the present paper posits physical groundings in coda maximization. The four sorts of conditioning consonants that commonly undergo the syllabification stem from the articulations that preferentially affiliate to stressed syllable codas: contact of the tongue for the American English tap, no incompatibility for the British English glottal stop, less articulatory energy for voiceless stops and weak plosion for voiced stops, the latter two of which are categorized into a weakening choice different from consonant lenition. The commonly heterosyllabified examples of coda phonemes (e.g. /ln, lm/) lack a physical conditioning. The ongoing case in American English in which coda maximization has been avoided due to the nasalized tap (i.e. [nɾ] → [ɾ̃]) is meant to be the shift typical to the variant, and not to be a flaw in the phonetic grounding. Conversely, two sonority-based accounts have flaws.

1. Introduction

Some languages have instability and disagreement with respect to syllable boundaries of medial consonants. Relative to English Historical Phonology (Murray and Vennemann 1983, Lutz 1986, Fulk 1997, Terajima 1998, Pierce 2010), Germanic languages (Hall 1989, Murray 1991, Vennemann 1991, Kristo-ffersen 1999, van Oostendorp 2003), Romance languages (Noske 1982, Steriade 1982) and others (Hayes and Abad 1989, Rubach and Booij 1990), Present-Day English (PDE) variants are the most typical language in the sense of the long-standing, unresolved controversy. The arguments of the previous works are: ambisyllabicity made by Kahn (1980), followed by Picard (1984), Gussenhoven (1986), Rubach (1996) and variable ambisyllabicity in Trousdale (2002): resyllabification (Selkirk 1982, followed by Borowsky 1986): dimoraic stressed syllables, following the classical research, say, Borowsky (1989), Jensen (1993): prosodic approach made by Jensen (2000): coda maximization (Hammond 1999) and, in the shared sense, stress attraction (Wells 1990): experimental approach (Treiman and Denis 1988, Treiman, Straub and Laver 1994, Turk 1994). The wide variety of the suppositions are based on (a) the fluctuation in terms of each dialect, each speaker and each utterance, (b) the shift from an allophone to other and the subsequent syllabic shift, (c) the different syllabifications among the same kind of sequences (sC clusters), and (d) being unsatisfactory by the sole notion of the syllable. Jensen's (2000) prosodic approach to the allophones might be able to reconcile all of the controversies, but further refinement should be necessary.

Whereas the counting of morae is not always consistent with the general one (e.g. monomoraic, not dimoraic, diphthongs), stressed syllables are, for the most part, likely to consist of dimoraic elements. Observing the analyses listed above, a definite characteristic of the PDE syllabifications is, relative to the universal ones, meant to be stress-sensitive, but not stress-insensitive: commonly three or four morae, but not monomora. This holds strongly to those of the coda maximization (henceforth MaxCoda), where the stressed syllables satisfy the upper limits on the possible codas as far as phonotactic constraints are met.

The discussion of whether or not MaxCoda is applied to the stressed syllables is based either on the finals in more than one codas or on the epentheses that constitute the clusters. The common four sorts of MaxCoda consist of the AmE tap, and voiced and voiceless stops as the second elements, and the BrE glottal stop as the second or the epenthetic first ones, although minor cases are also dealt with in the main parts of the argument (cf. Kahn 1980, Hammond 1999, Wells 2008, and others).[1] Ambisyllabicity and resyllabification differ from MaxCoda in the sense of the explanatory theories, but the surface stress-sensitivity remains still consistent. Both of them share with MaxCoda the feature that the more than one codas are, unless phonotactically prohibited, syllabified:

(1) a. *gui[lɾ.]i* *ce[nɾ.]er* *i[nɾ.]ernational*
b. *fei[st.]y* *bu[lk.]i*
c. e*[ld.]er* *wo[nd.]er*
d. *ce[nʔ.]er* *tea[ʔtʃ.]ing*

On the contrary to the crosslinguistic attestation on NoCoda and dimoraic rhymes, these syllabifications illustrate the PDE-internal ones with crosslingustic rareness. Sequences of long vowel or diphthong plus a singleton violate the principle dimoric stressed syllable. They are more common than other nondimoraic ones both in the English language and crosslinguistically, but represent a case different from two or more codas. Since this study focuses on MaxCoda, the sequence is out of issue.

Phonetic bases play an intrinsic role in the functional literature of the contemporary phonology (see section 2 on the lists of the research). Building on this framework, the present paper argues in favor of the phonetic conditionings under which word-medial consonants are syllabified; the four common cases of MaxCoda are grounded in individual physical activities; some heterosyllabic consonants do not have any positive factor; an ongoing avoidance of MaxCoda in a variant does not mean to show the phonetic dispreference of the tautosyllabic clusters, but to have the effect of an accent-internal shift. Phonetic bases on syllabifications have been suggested and reexamined in Steriade (1999), Gordon (2002, 2005) and Blevins (2003), all of the phonologists herein taking a crosslinguistic view. Thus, many pieces of the literature on the PDE syllabifications listed in the first page and some works addressing phonetically driven syllabifications are involved in the previous

[1] The [nɾ] clusters have been undergoing the mutual assimilations that result in the singleton [ɾ̃]. See section 5 on this issue.

research, but there has been no article that argues that the English syllabifications are phonetically driven. This work presents the phonetic bases on MaxCoda.

It is organized in the following way. Section 2 addresses the phonetic bases. Section 3 posits the four sorts of the articulatory conditionings with regard to MaxCoda. Section 4 discusses the commonly heterosyllabified consonants, which are assumed to lack a phonetic basis, and section 5 the ongoing shift in the codas from the cluster to the singleton, which owes to an accent-specific shift, instead of the phonetic dispreference. Section 6 demonstrates the flaw of the two phonological bases syllable contact and prominence demotion. Section 7 concludes.

2. Phonetic bases

Phonetic bases have constituted a topic frequently addressed in the literature in the recent fifteen years in the several respects: markedness constraints (Hayes and Stivers 1995, Jun 1996, Pater 1999, Crosswhite 2001, Kirchner 2001, Hall 2003, Blevins and Garrett 2004, Flemming 2005, Kochetov and So 2007, Linebaugh 2008, Kaplan 2010, Oda 2011), Laryngeal Phonology (Steriade 1997), mechanism (Hayes 1999, Pierrehumbert 2000), diachronic shift (Hall 2004, Oda 2008a, 2010), phonological changes (Page 1997, Howell and Wicka 2007, Blevins 2008, 2009, Garrett and Johnson to appear), unified model for phonetics and phonology (Flemming 2001), Evolutionary Phonology (Blevins 2004, 2006a, b, Blevins and Wedel 2009), typology (Hall 2000, Hall and Hamann 2010, Blevins 2010), Dispersion Theory (Flemming 1995, 2004), syllabification (Steriade 1999, Blevins 2003, Gordon 2002, 2005), articulation and perception (Boersma 1998, 2007, Hamann 2009). See Hayes, Kirchner and Steriade (2004) for the relevant edited volume and Gordon (2006) for the overview.

The advent of Optimality Theory has rendered highly active the discussion that the phonetic bases that involve, say, sequential movement and air flow in the conditionings play a functional role in constraints and phenomena that phonological grammars specify. The reason for the contemporary analyses stems from one of the differences from the classical ones. The former integrates physical factors with abstract ones with sonority or features (cf. Kirchner 1997, Kingston 2006). This makes a contrast with the classical functional phonology that separates the phonological basis from the phonetic one. Both of the conditionings are internalized in a unified model of the contemporary framework. (see also Flemming 2001.) Following the shift on the theory, the phonologists have insisted on the functional motivation from which phonological entities stem. See Ohala (1975, 1993), Keating (1985), Westbury and Keating (1986), Lindblom (1986, 1990), Archangeli and Pulleyblanck (1993), Kingston and Diehl (1994) on the antecedents of the modern functional phonologies.

Phonological bases consist of sonority, features and generalizations, all of which represent the abstract ones. By contrast, the phonetic bases are, to put it simply, movements of articulators: movement and posture, duration, easiness or difficulty in pronunciation, duration to resolve difficulty, air flow, (in-)compatibility, etc. My view takes the phonetic bases for being true for MaxCoda. The (in-)applicability on it is schematized in the following:

(2) a. $V(V)C_1C_2.V$ *instead of* $V(V)C_1.C_2V$
b. $V(V)C_1C_2C_3.V$ *instead of* $V(V)C_1C_2.C_3V$
c. $V(V)C_1.V \rightarrow V(V)C_2C_1.V$

The case in (2a) represents the tautosyllabified second coda which renders MaxCoda applicable. The third coda in (2b) is equivalent to it. The last one shows the epenthetic consonant which varies the singleton into the cluster. The phonetic motivations in this context refer to the explanations which facilitate the coda clusters in the preceding syllables, instead of the heterosyllabic ones.

If the arguments made at this point hold true, there should be a certain physical preference regardng C_2 in (2a) and C_3 in (2b) in relation to the syllabic affiliations and it must lead the coda-finals to take precedence on the onset-initials. In the syllabification in (2c), the epenthetic C_2 requires that the subsequent coda cluster be phonetically preferred. In particular, the assumable conditionings are, to put it simply, the preferred articulations in coda-finals relative to onset-initials, as will be shown in the remainder of this article.

Let us move on to examine the cases in which the uncommon sequences in English stem from a phonetic basis. The sense of ‘uncommon’ entities is shared by MaxCoda and some of the syllable-based sequences. Hall (2000) and the subsequent works (Hall 2003, 2004, Hall and Hamann 2010) argue that rhotic is articulated with the tip of the tongue and as the shape of concave, while palatal glide with the blade and as that of convex and that the markedness in the sequence rhotic plus palatal glide is grounded in the incompatible articulation. The markedness constraint bans on the adjacency of the sequence. Taking into account the syllable structures relevant to MaxCoda, adjacency functions as one of the decisive factors: tautosyllabicity in codas, instead of heterosyllabic consonants. Whereas, in the Hall’s sense, the two consonants rhotic and palatal glide are prohibited from occurring adjacently to each other due to the two-way incompatibility, compatible movements might induce the tautosyllabicity to take place. First, the onset-initials are resyllabified to the preceding coda-finals: the AmE tap (guil[ɾ.]y), the BrE glottal stop (cen[ʔ.]er); whereas the BrE tap derived from the central approximant of /r/ occurs in the coda, it is preceded by stressed vowel and constitutes the singleton. It might be the case in point that the cluster with the resyllabified coda stems from compatible articulation and that some of the unstressed syllable onsets are prohibited from shifting to the coda-finals owing to incompatibility. Second, the articulation of stops fluctuates between onsets and codas. It is possibly assumed in the similar vein that stops as the second coda and as the first onset differ phonetically from each other and that the blocking of MaxCoda is attributed to incompatibility.

When considering the divergence of the consonants between the preceding coda-finals and the following onset-initials, as well as the shifts across syllable boundary with the different manner of articulation (e.g. the AmE tapping), phonetic details differ according to the syllabic affiliations; in terms of the movements of articulators, voiced and voiceless stops are commonly illustrated in the well-known English phonetic books (Roach 2000, Gimson and Cruttenden 2004, Ladefoged 2006).[2] The plosions for voiced stops are phonetically represented as strong or weak one and voiceless stops as aspirated, plain and unreleased.

We must also examine what determines to select one of the two functional bases. MaxCoda is a language-specific phenomenon in PDE variants. On the one hand, crosslinguistic phenomena manifested in the English language are grounded in the phonetic or the phonological factors: taking each one case, vowel reduction as the former (Crosswhite 2001) and the distribution of stressed and unstressed vowels in terms of the sonority, as the latter (de Lacy 2004). On the other hand, English-specific phenomena commonly have phonetic bases. The reason for it is caused by the fact that the majority of the language-internal phenomena are incapable of being accounted for by phonological principles, which are shown in the works such as Clements and Keyser (1983), Selkirk (1984), Vennemann (1988), Clements (1990), Hall (2002) and others. Howell and Wicka's (2007) smoothing, preceded by breaking, and Hall's (2004) diachronic shift on syllable contact take the view of a phonetic basis:[3]

(3) a. <u>*Breaking*</u>
a front vowel (i, e, æ) + back vowel (neoh 'nigh', weork'work')
b. <u>*Smoothing*</u>
Diphthong → monophthong(neh, werk)

(4) a. <u>*Early West Germanic Gemination*</u>
p.j > p.pj d.j > d.dj m.j > m.mj l.j > l.lj (skappian 'to create, biddian 'to ask for', etc)
b. *r.j > *r.rj*
c. <u>*Contemporary variant*</u>
[Vr.jV] and [Vr.V] (erudite, virulent, garrulous)

The smoothing contradicts with the historical direction of stressed syllables that, in highly general terms, proceeds to the stronger ones in terms of the number of morae, the ranking of sonority, etc. The shift from the diphthongs to the monophthongs is shown to be the one common to unstressed syllables. This implies that it is not grounded in the phonological basis. The avoidances of the derived onset /rj/ and the /r.j/ syllable contact do not conform to the direction of the syllabic organizations, either. The two examples demonstrate the

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[2] Generally speaking, the articulatory differences are dependent on syllabic affiliations, though the phonological units higher than syllable are in essence regarded as more or less efficient (Kiparsky 1979, Jensen 2000, Oda 2009a). They range from foot to utterance.

[3] Stockwell (1996) posits the conditioning of phonetic drift regarding Old English breaking.

exceptions to Preference Laws (Murray 1987, Vennemann 1988 and the subsequent works). MaxCoda makes a crucially inconsistent syllabic organization in comparison with the crosslinguistically applicable ones, where NoCoda, dimoraic rhymes in stressed syllables and the Syllable Contact Law have by and large the opposite effect on the two or more codas. Not to mention NoCoda, the dimoraic rhymes do not contain the two or more codas in any case. With MaxCoda applied, the final segments of the preceding syllables are likely to have smaller sonority value on the basis of the contour on coda clusters in general. The two or more codas yield the converse outcomes on the Syllable Contact Law. (It will be dealt with in section 6.1.)

As is repeatedly shown in this study, the conditioning consonants that commonly undergo MaxCoda consist of the AmE tap, voiced and voiceless stops in the finals, and the BrE glottal stop as the final or the epenthesis. All of them play a decisive factor in increasing the number of codas (i.e. one to two, two to three). The final or epenthetic consonants of MaxCoda either entail phonetic details beyond the phonemic representation or have allophonic status in relation to the syllabic affiliations. The assertion this paper makes differs from such surface pronunciations. The explanation that the phonetic factors hold to the functional motivations represents the conditionings behind the phenomena: certain preferences in terms of easiness, pronounceability and compatibility for (the stressed vowel plus) the coda clusters.

3. Segmental conditionings

3.1. The American English tap

The tap (*ci<u>t</u>y*, *da<u>dd</u>y*, *be<u>tt</u>er*) has a few cases in which it occupies the second codas when preceded by a stressed vowel plus the lateral or the alveolar nasal:

(5) a. *Gui[lɾ.]y*
b. *Ce[nɾ.]er* *i[nɾ.]ernational*

In the sequence in (5a), the variants of the lateral render the physical conditioning different. The lateral like the one in (5a) is articulated with the dark allophone (cf. Wells 1982, Sproat and Fujimura 1993, Jensen 2000, Ladefoged 2006 for the descriptions and the phonetic details).

Turn next to consider the physical conditionings in the sequence dark ‘l’ plus tap. The unclear variant is required to retract the body of the tongue while the light one is not. The posture of the former is relatively similar to that of the tap; observe the fronting of the tongue for clear ‘l’, the retracting of it for dark ‘l’; observe also the movement of the front of the tongue from the neutral position, the tongue shape making a contact with alveolar ridge for the lateral and the shape and the subsequent return to the neutral position for the tap (i.e. closer to that of dark ‘l’, cf. O’Connor 1980 for the shapes of the articulations). The articulation of the lateral, in either variant, necessitates the firm contact of the tip with alveolar ridge. In comparison with the corresponding quick contact, it is capable of readily shifting to the following consonant due to the stability of the tongue. Hall employs the term incompatible articulation with respect to the marked sequence rhotic plus palatal glide, as cited in the last section. Oppositely, the sequence of dark ‘l’ plus the tap is meant to be a compatible articulation, which leads speakers to pronounce it easily.[4]

The coda cluster [nɾ] stems from the conditionings which are equivalent to that of [lɾ]. The tongue tip for the alveolar nasal is required to produce in a manner with a firm contact with alveolar ridge, which allows the articulator to readily shift to that of the tap. This means that the [nɾ] sequence has the phonetic preference in the two senses.

Beside the phonetic groundings made up to this point, another phonetic preference holds true for the preferred articulation of the resyllabified tap relative to the underived stop. Given the syllable-based generalizations, the tap and the underived [t] affiliate to the preceding coda and the following onset, respectively:

(6) a. *gui[lɾ.]i* b. *gui[l.t]i*

The evidence is necessary that the former is superior to the latter in terms of a certain phonetic conditioning. The shift from an alveolar stop to the tap is included in consonant lenition, which stems from the phonetic conditioning under which effortful consonants shift to effortless ones (Kirchner 2001, 2004) or under which to interrupt the air flow on stronger consonants is weakened (Kingston 2006). Relative to the plain [t] in the onset, the coda tap has a shorter time to make a contact with alveolar ridge and turbulence of air flow becomes weaker. The allophonic shift, thus, represents a case of the phonetically driven consonant lenition. According to Wells (1982, Vol. 3), consonant lenition inside AmE also contains glottaling and voicing of obstruents:

(7) a. *bo[ʔ]le* b. *le[ʔ]er*
(8) *grea[z]y*

The occurrences of the two lenition processes have restrictions. The glottaling before the syllabic consonants in (7a, b), though pronounced in New York City, present the less common case than the highly common tapping (i.e. bo[ɾl̩], le[ɾr̩]). The glottal stop in (7) represents the pronunciation which distinguishes New York City English from other American accents (ibid.). The case in which the obstruents voice also occurs only in minor examples. The phonetic

[4] Whereas the AmE tap occurs, for the most part, in the codas, it is neither preceded nor followed by an alveolar stop (i.e. *[tɾ, dɾ, ɾt, ɾd]). The ban on those sequences has the different conditioning from (in-)compatibility. In each of the articulations, once the tip of the tongue moves away from alveolar ridge, it returns to the postion. The ban on this movement is reflected in [tn̩, ʔn̩] vs. *[ɾn̩]. The disallowed form in the latter is grounded in the returns made twice.

implementation has also the restriction within the AmE accents (ibid.).

In contrast to the two lenition processes, the tap is pronounced by the majority of the AmE speakers (hyperrhoticity, e.g. Britton 2007). In the environment followed by syllabic [n], the glottal stop or the plain [t], instead of the tap, is phonetically implemented. However, the blocking of the tapping is rather limited. Some basic wirds such as *little*, *better* and *city* are articulated with it as illustrated everywhere in the literature. The allophonic occurrence of the tap is meant to shifting from the onset of the unstressed syllables to the coda of the stressed syllables and MaxCoda is applied to the stressed syllables.

Regarding the environment where consonant lenition is likely to occur, examine one of the typologies argued in Kirchner (2001, 2004). While, another typology says, fast or casual speech has weakened consonants more commonly with other conditions identical, it is beyond the scope of the discussion:

(9) "All else being equal, lenition occurs more readily the greater the openness of the flanking segments (the widely attested pattern of intervocalic lenition being a special case)." (Kirchner 2004:316)

Given two forms with other conditions consistent, therefore, consonant lenition processes only in intervocalic environments are likely to be more common and those in both intervocalically and nonintervocalically less common. The glottal stops in (7a, b) may or may not be followed by the syllabic consonants. In the underlying form that consists of schwa plus nonsyllabic consonants in the coda (Gimson 1980, Wells 1995, Oda 2007), the environments of the lenitions as well as that of the voicing turn out to be intervocalic.

However, both of the allophones are prohibited from occurring in nonintervocalic positions, as Wells illustrates. The glottalling in New York City English is applied to syllable-final of word-medial but blocked in word-final position. The word-final examples like *tha[ʔ] man* and *qui[ʔ] well* are involved in common ones in BrE. This means the blocking of the glottalling in the nonintervocalic positions. The voicing of obstruents is also blocked in the word *grease*, in contrast to the affection on *greasy*. The intervocalic status conditions the sole difference. Thus, the partial blockings of the consonant lenitions are based on the environments inconsistent with the typology.

Apparently, it seems that the tapping does not always occur intervocalically since some of the taps precede syllabic consonants. The examples with the syllabic consonants are shown with relevance to MaxCoda:

(10) a. *ce[nɾ.r̩]* b. *i[nɾ.r̩]national*

It must be asked at this point whether or not the taps occur intervocalically. The divergence is based on the abstract form of the syllabic [r]; the underlying /ər/ leads to the intervocalic occurrence of the taps, while the underlying /r/ does not. I assume the former makes sense due to two reasons. First, given the pronounced syllabic [r], the underlying schwa implies to be the deletion of schwa. Conversely, the underlying form without schwa means the epenthetic schwa, if [ər] is pronounced. In AmE as well as in the other variants, the former is more common since the latter has the restricted occurrences on the minor case like *ath[ə]letic*. Second, AmE has undergone hyperroticity, which refers to highly increasing /r/-like sounds. The occurrence of a rhotic and the deletion of schwa are reflected in the second elements of diphthongs (e.g. you[r], tou[r]). The shift from the underlying /ər/ to the surface [r̩] is therefore more appropriate than the other. Because of the preceding stressed vowels and the following schwa in the underlying form, the derived rhotics in (10a, b) are meant to be the intervocalic occurrence.

The AmE tapping represents one of the cases in which consonant lenition occurs definitely intervocalically. It makes a contrast with the other two weakened consonants which do not conform to the typology cited in (9). Those for the tapping confirm to the Kirchner's account for frequently occurring consonant lenitions.

The coda tap is derived from /t/ or /d/ in the following onsets. MaxCoda holds to the diconsonantal clusters [lɾ, nɾ]. The resyllabified tap renders the coda clusters workable owing to no triconsonantal cluster with it. The AmE tapping represents a common case on MaxCoda and much more common pronunciation relative to the underived alveolar stops. The common occurrence of the tapping is relevant to one of the typologies on consonant lenition, which states the crosslinguistically common occurrences in intervocalic positions. The resyllabified tap, therefore, takes precedence on the underived alveolar stops in terms of the phonetic conditioning on the lenition.

3.2. Voiceless stops

The cases in which the second codas in the stressed syllables are occupied by the voiceless stops are presented below: sC clusters (11), the lateral plus a voiceless stop (12) and the hormorganic cluster of nasal plus voiceless stop (13):

(11) fei[st.]y
(12) bu[lk.]i
(13) i[nt.]imate

The (in-)application of MaxCoda at this point implies the issue of whether the voiceless stops affiliate to the stressed syllable codas or the unstressed syllable onsets in terms of phonetic preference. The former affiliations give rise to the second codas, rather than the heterosyllabicity, as in (11) – (13). The prosodic affiliation including both of the syllabic ones is meant to be the non-foot-initial. Irrespective of the different accounts for foot boundaries (Prince 1983, Halle and Vergnaud 1987, Hayes 1995), the consonants following the stressed vowel and preceding the unstressed vowel have no exception on the definition. The variants of the voiceless stops in the non-foot-initial, excluding the tap, the glottal stop and other weakened obstruents, at present, consist of plain stops, unreleased stops and (weakly) aspirated stops, among which unreleased stops represent the weakest consonant due to the stage, solely, of closure. Weakened consonants stem from the phonetic basis of reduction in constriction degree or duration (Kirchner 2001, 2004). Unreleased stops lack the air flow after making a contact with alveolar ridge relative to weakly aspirated and plain stops. Weakly aspirated stops have the stronger articulation than the other two. After the release, the air flow sounds like bursting slightly. Plain stops occupy the mid status because the air flow after the release is weaker than that of weakly aspirated stops and because they have both closure and release, the latter of which leads to the stronger counterpart than unreleased ones. Syllabic phonology (Kahn 1980), specifies that the coda-finals in stressed syllables are occupied by plain or unreleased stops and the onset-initials in unstressed syllables by plain or weakly aspirated stops.

In the examples of MaxCoda like those in (11-13), all of the clusters are not followed by the third coda. The affixes attached to the coda clusters (plural noun-/s/ and past tense-/t/) may lead to triconsonantal clusters, but the word-medial environments, to which MaxCoda may apply, do not contain the sequence with the one; only diconsonantal clusters are to be discussed.

On the condition of the CC plus the WeakV as in those in (11) – (13), the coda-final voiceless stops surface as plain ones. Apparently, no example of unreleased stops appears with respect to the maximized second codas. Other possible case is the laterally or nasally released voiceless stops (e.g. pi[st.l̩], wi[lt.n̩]), though the examples on MaxCoda of this sort are themselves less common in the literature.[5] My account in this section points to the weak articulation of the voiceless stops in the coda-finals of stressed syllables. The laterally or nasally released stops do not make a difference between the degreed articulations. Thus, they do not play an important role in the present argument.

Following Kiparsky (1979), Jensen (2000) argues that aspiration has several degrees on the basis of several conditionings and that aspirated stops are generalized to foot-initial environments, which contain onset-initials in both stressed and unstressed syllables. Whereas the former commonly undergo aspiration, the example in the following illustrates that in the latter:

(14) [t^h]*oday we are going to …..*

The MaxCoda-relevant generalization on the phonetic implementations turn out to be the plain stops in stressed syllable codas and plain or weakly aspirated stops in unstressed syllable onsets. The articulatory difference between the latter two depends on some factors. In plain stops in unstressed syllable onsets, the plosion of the initial stop is slightly stronger than those in the preceding coda. Including everything, the articulatory strength/weakness and

5 The [tl̩] sequence is highly common or near obligatory in BrE. The syllabic alveolar nasal preceded by the stop occurs sporadically in some accents.

the syllabic affiliations correlate with each other. Assuming the application of MaxCoda, the segmental conditionings will become the preference of plain stops in stressed syllable codas, relative to the slightly stronger counterpart in unstressed syllable onsets.

The preference of the weaker articulation in the stressed syllable codas differs from Kirchner's phonetic basis on consonant lenition, where the effortful segment A becomes the effortless B. My own suggestion owes to preferring the weaker pronunciations to the stronger counterparts. The clear-cut stages, as in the consonantal lenition from effortful to effortless ones, do not exist, but a certain phonetic preference leads to the preceding coda, not the following onset. Lenition is meant to be shifts (i.e. A → B). The preference of MaxCoda for the voiceless stops depends on each word and each speaker. The former implies that the shifts lead to the other sounds, but in each opportunity of the latter speakers choose between the two. I will refer to the preference in the latter as weakening choice. Native speakers can choose the syllabic affiliation of a voiceless stop. If the preceding coda serves as the slot of the stop, the weakening choice is meant to be made.

In the examples at issue, some consonants affiliate to the preceding coda-final and others to the following onset-initial. Whereas the latter conforms to the tenet of basic syllable theory, in my assertion, a certain phonetic preference is stronger in the former. The phonetic preference on the voiceless stops stems from the weaker air flow in the coda of the stressed syllables. This means the effort-reducing syllabification. The reason why the weaker segments for the voiceless stops appear in stressed syllable coda-finals stems from other allophones. As mentioned above, the environment dealt with at this point is non-foot-initial where the allophones derived from underlying voiceless stops commonly occur, but not vice versa: the AmE tapping, glottaling in many variants, obstrent voicing, weak plosion and unreleased stops. Conversely, the fortitive process aspiration occurs foot-initially.

In the sequence sonorant consonant plus voiceless stop, the stop undergoes weak aspiration if there is the steady state of an articulator after the sonorant consonant is articulated and if a certain similar condition may apply to it. The relevant clusters with a voiceless stop in the coda-final have the easy movements between the two consonants and are likely to be tautosyllabified to the codas. Therefore, the easy movements facilitate MaxCoda.

3.3. Voiced stops

The examples illustrated below show the voiced stops as the second codas , which follow the lateral or the alveolar nasal:

(15) a. e[ld.]er
b. wo[nd.]er

As English phonetic literature (e.g. Roach 2000) shows, voiced stops differ between onsets and codas; those in codas are less audible and articulatorily weaker relative to those in onsets. The syllabic affiliation is equivalent to voiceless stops in the same environments. As well as voiceless stops, voiced stops affiliate to the preceding coda on the basis of weakening choice by way of which MaxCoda is applied to word-medial stops. Consonant lenition is referred to as a phonological process whereby sound A is weakened to sound B. It means the shifts in either diachronic or synchronic stages. Weakening choice is possibly made by speakers on the basis of each utterance containing speakers' opportunities and accentual differences.

In the sequences illustrated in (15), the articulatory preferences to the coda are highly similar to those in the coda of voiceless stops. The ones with the voiced alveolar stop in the second coda have compatible movements since the postures of dark 'l' and the alveolar nasal are similar to that of the stop. Those with the lateral plus other voiced stops (*lb*, *lg*) are involved in easy pronunciations. The reason for it is based on speakers' preparation for the posture of either the lip-closing for the /b/ or velum-lowering for the /g/ when the pronunciation of the lateral is made.

Due to the sequences without difficulty, native speakers are able to easily shift from the first to the second consonants. This means that the phonetic non-difficulty leads to the choice of the second codas that are derived from the following syllable-initials. The effect of pause or something similar to it renders the stops slightly stronger and, if it works, they affiliate to the following onset. The non-difficulty otherwise leads to MaxCoda.

3.4. The British English glottal stop

Whereas many variants of PDE have glottal stops, MaxCoda in relevance to glottal stop formations is, solely, or, if not accent-internal, typically, applied to British English (BrE). First, it has more glottal stops than others. The phonetic implementation of glottal stops derived from underlying /t/ is likely to occur before consonants, but they also occur before vowels in the late twentieth century Received Pronunciation (Wells 1997):

(16) Ga[ʔ]wick
(17) a. wa[ʔ]er b. ce[nʔ.]er

MaxCoda holds to the case in (17b). Thus, in the coda, the singleton shifts to the diconsonantal cluster. Other accents may or may not have taps or plain [t] for the underlying /t/ in the same words:

(18) a. tapping ci[ɾ]*i wa*[ɾ]*er ce*[nɾ.]*er*
b. plain stop ci[t]i wa[t]er ce[nt]er

BrE also contains the coda clusters where the epenthetic glottal stop occupies the first of the two consonants. The epenthesis forms MaxCoda in the way different from the preference of the coda-finals to the onset-initials:

(19) a. tea[ʔtʃ.]ing b. a[ʔp.]ril

The effect the glottalings have on the two sorts of MaxCoda stems from one case of (in-)compatibility. First, both of them do not have incompatibility or any other similar activity with difficult pronunciation. The epenthesis and the resyllabification of the glottal stop do not lead to difficult movement between the two consonants in each case; the difficulty of certain dicoronal sequences is posited by Hall and Pater: those with the different tongue shape and the different point of articulation (Hall 2003, 2004) and the difficult air flow for voiceless sounds following a nasal (Pater 1999). For the clusters in both (17b) and (19a, b), air flow is freely vented outside. The adjacent sounds therein have alveolar, palate-alveolar and labial as the points of articulation. No incompatible movement like Hall's account for the marked /rj/ on the basis of tongue shape and tongue posture occurs. No difficult movement of one articulator like Pater's account for the marked /nt/ relative to the less marked /nd/ on the basis of keeping voicing occurs.

The sequences of the glottal stop and an obstruent are required to articulate separately without any difficult movement. The coda clusters [nʔ], [ʔtʃ] and [ʔp], though less common both in the English language and crosslinguistically, are involved in pronounceable clusters which speakers do not have to overcome any trouble. In the first cluster, when pronouncing the alveolar nasal, speakers are ready for the closure of the glottal. This means, as it were, no incompatibility, which means that an articulation does not include a certain difficulty owing to activity lacking smoothness or countermovement.

The latter two are equivalent to the first one on the condition that speakers can prepare for the second one, when making the first consonant. In each of them, to make a constriction for the affricate or the stop is accessible and to shift from the first to the second does not contain any difficulty.

I observe that a difficulty arises on the sequences *[hʔ] and *[ʔh], both of them being shown to be lacking in the BrE allophones. Such sequences are, if any, an affricate; after the closure, stop-like release and fricative-like articulation are made. If both of them are separate from each other (i.e. a stop + a fricative), once the closure and the release were made, speakers have to prepare, again, for the articulation of another obstruent, then, it is made. For the sequence, the two activities of the articulators are made by the three activities. The latter is considered to be marked by way of the more effort on the same articulation.

4. Heterosyllabicity

MaxCoda may or may not be applied to the word-medial sequences which correspond to the coda clusters in monosyllables. The first case to which MaxCoda does not apply are shown to be the ones of the disonorants.

They are unlikely to be involved in the examples of MaxCoda in the literature:

(20) a. vu[l.n]erable b. a[l.m]ost

Supposing that there are certain phonetic differences between the two syllabic affiliations, if the coda clusters are easier to articulate or perceive than the heterosyllabic sequence, the phonetic basis might make sense. The heterosyllabified nasals in (20a, b), however, have the identical phonetic details irrespective of the syllabic affiliations. For each of the nasals, the contact, the release, the airflow and nasal cavity remain consistent between the second codas and the first onsets. This means that the nasals as the second codas do not have a certain phonetic preference. Wells (1990) does not specify an allophonic condition with respect to the nasals as the second codas. The lack of a phonetic grounding renders the clusters heterosyllabic. The number of morae, or the basic syllable theory, in other words, holds to these examples.

The second examples are the clusters with a coronal obstruent. Phonotactic constraints allow the coda clusters /ŋkθ/ and /ks/ to occur tautosyllabically, but MaxCoda is commonly inapplicable due to the coronal obstruents /θ/ and /s/ in the onsets:

(21) a. stre[ŋk.θn̩] b. a[k.s]ent

The phonetic details in the following onsets are consistent with, if syllabified, those in the preceding codas. The postures, the movements, and the air flow do not vary in the articulations with different syllabic affiliations. Similarly to the last ones, the lack of the phonetic difference leads to the heterosyllabicity on the basis of the crosslinguistically common syllabifications.

Phonologists tend to argue that the examples like those in (21a, b) are ascribed to the structure that both the /θ/ and /s/ in the coda-finals cause the violations of the basic sonority contour and that the syllable-initial affiliations resolve the conflict. In my assertion, the sonority contour does not make sense. The reasons are two-fold. First, consider each of the heterosyllabic /ln, lm/ and the tautosyllabic [lɾ, nɾ]. The two consonants in the former sequences have the distance of one in terms of sonority. The latter ones have the very similar distribution. AmE has the specific ranking that the tap has the lesser sonority value than the lateral and nasals (Oda 2009).[6] The distance of the sonority between the tap and the lateral, nasals is shown to be two or one. Despite the very similar sonority contour of the two sonorant consonants, the opposite outcome is shown. The AmE sequences represent one of the highly common examples on MaxCoda and the [ln, lm] sequences are involved in the heterosyllabic cases, respectively. Relative to the AmE [lɾ, nɾ] sequences, the large distance of the sonority between two consonants is exemplified by the

[6] This author is a nonnative speaker of (American) English. A phonologist from America agreed to the ranking of the sonority I suggested on the tap. The scholar replied so on the basis of the intuition.

distance of five in the clusters /lt, lp, lk/ and that of four in /ld, lb, lg/ and /nt, mp, ŋk/. That is why the sonority distance between the two consonants does not play a decisive role in the syllabifications.

5. The avoidance

The postvocalic /nt/ in AmE surfaces as either [nɾ] or [ɾ̃] (see 23 for the examples). The difference between them implies to be the one of whether the codas represent the cluster or the singleton with the syllabic affiliation consistent. The allophones are not preceded by unstressed vowel. Syllabic [r] (center, international) as well as high front vowels (hunting) commonly follow the tapped pronunciations.

(22) Strong V(V) + [nɾ] or [ɾ̃] + Weak V or syllabic consonant

The allophonic pronunciations shift from [nɾ] to [ɾ̃]. In Ladefoged's 'A Course in Phonetics' (3rd ed., in 1993, 4th ed., in 2001 and 5th ed., in 2006), we can find out the partial rewritings in the editions. It is implicitly demonstrated that the nasalized tap has been increasingly common. The third edition does not specify the nasalized tap as an allophonic rule. The fourth and fifth editions regard it as the current common pronunciation:

(23) a.wi[nɾ]er → wi[ɾ̃]er b. pai[nɾ]er → pai[ɾ̃]er

The clusters shifted to the singletons. The case of MaxCoda therefore has been avoided in the examples illustrated above. The resyllabified tapping (/n.t/ → [nɾ.]) stems from the phonetic conditionings, as shown in section 3.1.: the tongue contact on alveolar ridge and the commonly occurring lenition. The question to be asked at this point is whether or not the coda cluster [nɾ] has phonetic dispreference. If dispreferred in a certain respect, the evidence appears that the phonetic bases in this article are incapable of being applied to MaxCoda. It is the case in point, however, that the allophonic shift does not imply that the phonetic bases have a flaw. The avoidance of MaxCoda seems to satisfy an explanatory adequacy, instead of making the insufficiency to my own account. It is analyzed that the shift to the nasalized tap is grounded in the common shft peculiar to AmE, which, I posit at this point, has the coarticulatory basis:

(24) Sequences of two segments with one of them a rhotic become one segment if and only if the two segments are articulatorily similar to each other.

The descriptions in Kahn (1980), Jensen (2000) and Ladefoged (2006) are employed in the data. The generalization in (24) ranges over several sorts:

(25) a. *long central vowel plus rhotic … syllabic [r] (first, heard)*
b. *High back vowel, but not high front vowel, plus rhotic … syllabic [r] (your)*
c. *Schwa as the second or the third elements of diphthongs or triphthongs plus r-coloring … [r] as the second (cure, power)*
d. *No example on the one between rhotic and obstruent*

Gick (2002) points out the articulatory similarity between schwa and the central approximant of /r/ in AmE. The difference between them is solely the one with or without constriction. The stressed [r̩ː] is common in the case of the underlying central long vowel, as in (25a). It does not occur with, say, the underlying /iː/ or /oː/. The shape of the tongue for the central approximant of /r/ is closer not to that of high front vowels, but to that of high back vowels. The tip of the tongue is not fronted, differently from the articulation of the former vowel, but rather, the back of the tongue is raised, similarly to that of the latter. (See Flemming 2003 on the research alongside this line.) The variant of the rhotic, which differs articulatorily from obstruents (e.g. quick or firm contac, weak or strong interruption of air flow), does not become a sound with obstruent.

Now turn to the issue addressed in this section. From the point of view of phonetics, the AmE tap is like other rhotics, but like voiced stops (Wells 1982, de Jong 1998). The language-internal feature shows that the shift from [nɾ] to [ɾ̃] is involved in this sort of allophonic shift. The fact of the phonetically stronger (i.e. rather obstruent-like) tap in AmE is assumably ascribed to the contact of the front of the tongue with alveolar ridge, although this article does not present the experimental evidence. Voiced stops are required to make a firm contact and, in other languages in general, taps to make a quick contact. It represents the high-degreed difference on the consonants where the front of the tongue makes a contact with alveolar ridge. The contact for the AmE tap has the one between the other rhotics and the voiced stops. Assuming the articulatory length, the articulation for the alveolar nasal is close to the one of the tap. The merge containing the tap does not occur when other segment is, say, schwa or a stop. The ongoing AmE shift from [nɾ] to [ɾ̃] thus does not imply the flaw on the phonetic bases, but rather represents the accent-specific coarticulation that the two similar sounds where one of them is a rhotic merge

6. Sonority-based accounts

6.1. Syllable Contacts

The issue of whether or not MaxCoda is applied to two or more consonants following a stressed vowel implies to be that of syllable boundaries. The second or the third codas of the stressed syllables remain to be the following onset-initials unless they affiliate to the coda-finals. In the sequence VSOV (V = vowel, S = sonorant consonant, O = obstruent), the two cases on the syllable break VS.OV and VSO.V give rise to the different contacts across the boundaries. The Syllable Contact Law represents the phonological principle on the preference of the sonority between the syllable edges. The definition is, in the relatively recent version, shown in the following:

(26) <u>the Syllable Contact Law</u>
The Preference for a string … syl_x syl_y increases as the right edge sonority of syl_x increases and the left edge sonority of syl_y decreases. (Murray 2000:222)

The degree to which the distance of the sonority across the boundary varies ranges over the several sorts in the following: the high satisfaction (a), the slight satisfaction (b), the slight violation (c) and the large violation (d):

	a. ti<u>ght</u>en	b. fi<u>nd</u>ing	c. se<u>cti</u>on	d. a<u>qu</u>a
(27)	[aɪ.t]	[n.d]	[k.ʃ]	[k.w]

The reason for the flaw on the syllable contacts as the conditioning stems from the fact that the coda-finals are occupied commonly by the AmE tap, the BrE glottal stop and the voiced and the voiceless stops. Other examples have a rare status. At this point, we are concerned with the coda-final sonority values with MaxCoda conditioned. Given the description in (26), the Syllable Contact Law has the basis of sonority. In AmE the tap has the lesser sonority value than the lateral and nasals, as stated above. The other consonants conform to the general ranking irrespective of the accents. Thus, all of the commonly occurring coda-finals are less sonorous than sonorant consonants. Taking the phonotactic constraints into account, the following syllable-initials tend to be occupied by a vowel or a syllabic consonant (cf. bu[lk.]i, AmE ce[nɾ.ɹ̩]). There are some examples followed by a sonorant consonant: [ˈɪŋk.ɹ]ease, [ˈɪmp.l]icite, etc. The shared features among them consist of the coda-final obstruents and the syllable-initial sonorant consonants. For the sequences SVCC.CWV (SV = stressed vowel, WV = unstressed vowel), as in those illustrated above, PDE allophonic constraints specify the less sonorous coda-finals, which definitely do not conform to the law. All of the other examples are followed by a vowel or a sonorant consonant. The AmE tap, the BrE glottal stop, voiced and voiceless stops as the coda-finals might be followed by a syllabic consonant, but all of them have the less sonorous value than the sonorant consonants. Even if the maximized codas are the sonorant consonants (i.e. /ln, lm/), they do not come before a syllabic consonant. To sum up, the coda-finals in all of the examples have the smaller sonority scale relative to the following syllable-initials. This contradicts extremely with the more sonorous syllable-finals in the principle. If the Syllable Contact Law meets the conditioning, the sonority must be oppositely more sonorous on the preceding coda-finals. The conditioning based on the law therefore does not make sense.

6.2. Distance of sonority between nucleus and syllable-final

Based on the facts that all of the common coda-finals are less sonorous than the sonorant consonants and that the sonorant consonants in the coda-final have a highly restricted distribution, the distance of the sonority between the stressed vowels and the coda-finals, all other values being consistent, becomes large. The ranking of the sonority for vowels is as follows:

(28) Low Vowel > Mid Peripheral Vowel > High Peripheral Vowel > Mid Central Vowel > High Central Vowel (Kenstowicz 2004)

By way of typology (e.g. de Lacy 2004), stressed vowels intrinsically have larger sonority value than unstressed vowels. All of the PDE variants have a strong tendency on it. The following hold to every accent with regard to the ranking. Low and mid peripheral vowels are stressed; vowels with and without stress are typically represented as high peripheral vocoids; mid and high central vowels are intrinsically unstressed; although TURNED V, a mid central vowel (en<u>ou</u>gh, s<u>u</u>nny), is stressed, it has larger sonority value than high peripheral vowels (Oda 2008b). To summarize, there is the clear-cut difference between the stressed and the unstressed vowels. All of the common coda-finals have the lower rankings than those of sonorant consonants. Sonority values are larger for stressed vowels and smaller for coda-finals relative to those in other languages to some degree.

Let us examine the two examples of MaxCoda with the sonority for both the stressed vowels and the coda-finals by the two extremes:

(29) a. fi[ɪɾ.]*er*
b. ba[lk.]ony,

The former example illustrates the minimal distance of seven: the high peripheral vowel and the tap, ranked between nasals and voiced fricatives; the latter one the maximum-degreed twelve: the low vowel and the voiceless stop. All of the other examples are placed inbetween on the basis of the least sonorous vowel and the most sonorous coda-final in (29a) and the most sonorous vowel and the least sonorous coda-final in (29b), respectively.

As mentioned up to this point, the sonority of the stressed vowels are grouped into the higher three, but not the lower two. All of the common coda-finals have the smaller sonority scale relative to the sonorant consonants. The contour of the sonority reaches the peak at nuclei and, then, falls down toward the coda-final. On the sonority-related assumption that the stressed vowels have a smaller value and that the coda-finals a larger one, MaxCoda is more inapplicable. At first glance, the application of MaxCoda to some of the less sonorous allophones seems to stem from the sonority owing to the larger distance between the stressed vowels and the coda-finals, but it is not the case in point.

Alongside this line of account, the case of the larger sonority distance must be more common than that of the smaller difference on the condition that the syllable-final allophone is consistent with each other. Other else being equal, the AmE tap induces the least distance of sonority due to the larger sonority value relative to voiced, voiceless and glottal stops. The derived rhotic frequently occurs when the stressed vowel is high peripheral:

(30) a. [ɪnɾ.]*ernational* *b. w*[ɪnɾ.]*er* *c. g*[ɪlɾ.]*i*

The case of the mid peripheral vowels appears slightly commonly:

(31) a. c[enɾ.]*er* *b. c*[enɾ.]*imental*

Low vowels give the least common case since no daily word includes the coda [nɾ] sequences in the rhyme (cf. Gimson and Cruttenden 1994, Wells 2008, for the examples). The account based on the distance of the sonority must predict that the AmE tapping relevant to MaxCoda is more common in the order of low, mid peripheral and high peripheral vowels. The actual distribution does not show the tendency. On the contrary, the actual case is just opposite and the ranking of the vowels on the frequency is, in the decending order, high peripheral, mid peripheral and low.

7. Conclusion

The current paper has argued in favor of the phonetic groundings in MaxCoda. The four conditioning consonants that increase the number of the codas in some way are grounded in the phonetic preferences, but the heterosyllabic ones are not. The ongoing avoidance in AmE stems not from the phonetic dispreference, but from the accent-internal preference on the rhotics. The two phonological bases were shown to be flawed.

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