

NP EXTENSION: B&B PHONOTACTICS

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ABSTRACT

This paper will report on an extension of the framework of Natural Phonology in the area of syllable phonology and phonotactics. In particular, it will present a universal model of phonotactics constructed within Beats-and-Binding Phonology (B&B Phonology, cf. Dziubalska-Kołaczyk 2002) – a syllable-less theory of phonology embedded in Natural Phonology. The thrust of the theory is the claim that intersegmental cohesion determines syllable structure, rather than being determined by it (if one insists on the notion of the “syllable” which is epiphenomenal here). The core of B&B phonotactics is the Net Auditory Distance Principle, according to which phonological naturalness of clusters can be evaluated.

KEYWORDS: Phonotactics; morphonotactics; Beats-and-Binding Phonology; universal preferences; Net Auditory Distance Principle.

1. Introduction^{*}

Beats-and-Binding Phonology and, consequently, Beats-and-Binding phonotactics, developed as extensions of standard Natural Phonology (Stampe and Donegan) under the guiding principles of Natural Linguistics (Dressler). Therefore, the B&B model goes beyond mere phonetic (physiological and acoustic) motivation and respects functional and semiotic principles in explaining phonological phenomena. In phonotactics, this shows in using the principles of figure-and-ground and perceptual contrast in formulating phonotactic preferences (constraints) which undergo strictly phonetic processing involving as much phonetic detail as necessary. The Net Auditory Distance Principle, proposed to govern phonotactics, involves three phonetic parameters: those of manner, place and glottal stricture. This set-up is, however, preliminary, and might be extended,

^{*} I want to thank both reviewers for their helpful and constructive comments which guided my revision of the paper. In what follows, I will refer to Reviewer A or B when addressing their respective remarks.

both in the number of the parameters themselves (e.g., by adding acoustic cues) as well as parameter-internally, to include more features. The computer tool called phonotactic calculator is supposed to help in verifying the appropriateness of the choice of the parameters against data from a variety of sources. Its sole purpose is to facilitate computations rather than simulate linguistic reality.¹

Phonotactic preferences in B&B phonotactics specify the universally required distances between segments within clusters which guarantee, if respected, preservation of clusters. Clusters, in order to survive, must be sustained by some force counteracting the overwhelming tendency to reduce towards CVs (the CV preference). This force is a perceptual contrast defined as the Net Auditory Distance Principle (NAD Principle; cf. Dziubalska-Kořaczyk 2002, 2005; Dressler and Dziubalska-Kořaczyk 2006; Dziubalska-Kořaczyk and Krynicki 2007a; Bertinetto et al. 2007). NAD is defined by the following formula: $NAD = |MOA| + |POA| + |Lx|$, where MOA, POA and Lx are the absolute values of differences in the Manner of Articulation, Place of Articulation and Voicing of the neighbouring sounds, respectively.

The NAD Principle makes finer predictions than the ones based exclusively on sonority, for instance it shows that among stop+liquid initial clusters, prV and $krV > trV$, brV , $grV > drV$, etc. (> read as ‘more preferred, better’). This universal principle leads to predictions about language-specific phonotactics, its acquisition and change.

For the purposes of B&B phonotactics, a phonotactic calculator has been developed (Dziubalska-Kořaczyk and Krynicki 2007b; Dziubalska-Kořaczyk and Pietrala, in preparation). It allows for statistical analysis of phonetic dictionaries and phonetically annotated corpora from various languages. The calculator works on various lengths of clusters in all word positions and estimates them with respect to the universal phonotactic hypotheses formulated to define each cluster type in each position (cf. Dziubalska-Kořaczyk 2002). It provides fast feedback on the predictability value of those hypotheses.

The present paper will discuss and illustrate the above model with a variety of data. A succinct presentation of the major features of Beats-and-Binding Phonology (Section 2) will provide a necessary background for introducing the Beats-and-Binding phonotactics and, in particular, the Net Auditory Distance Principle (NAD Principle; Section 3). The phonotactic calculator will be described next, and its potential illustrated (Section 4). B&B phonotactics will be then viewed from the epistemological perspective of the Natural Linguistic theory (Section 5). Finally, morphotactics (Dressler and Dziubalska-Kořaczyk 2006), the area of interaction between morphotactics and phonotactics, will be introduced to show that co-occurrence restrictions in consonantal clusters cannot be formulated independently of the morphological structure of words (Section 6).

¹ The first paragraph of the Introduction is meant as a response to Reviewer A’s skepticism about my referring to “the hallmark of more standard NP” by which s/he understands “physiological and acoustic knowledge” and, as a consequence, “the computer model [...] being [...] rather arbitrary”.

2. Beats-and-Binding Phonology²

Beats-and-Binding Phonology is syllable-less, i.e., the syllable is not a primitive in the model. The structure usually referred to as “the syllable” in standard syllable models here is epiphenomenal or indeed emergent due to principled phonotactic forces. The latter are responsible for different degrees of intersegmental cohesion which, in turn, determines the behaviour of segments and creates the impression of syllable structure. On the prosodic level, before melody is filled into the prosodic structure (consisting of feet), those forces are bindings between beats and non-beats (see below). When beats and non-beats receive actual phonetic realization, phonotactic preferences (corresponding to constraints or syntagmatic well-formedness conditions in other models) govern the shape of sequences. The phonotactic preferences rely on the auditory distance between segments as a measure (see NAD below).

In B&B Phonology, a unit called *beat* is proposed. A beat is a unit rather than a measurement or device, and it needs some referent in phonetic reality. It is expected to be more easily accessible than the mora, on the one hand, and the syllable, on the other. Its functioning in phonology in relationships with other units of structure, called non-beats (these relationships are called bindings), is expected to account better for the structure than the functioning of mora or syllable. A beat is a regularly recurring skeletal prosodic unit of phonological representation, of a size corresponding to that of a segment. The most basic organizational principle of a sequence is the alternation of beats (which are relatively more prominent) and non-beats (which are relatively less prominent). Beats and non-beats have direct phonetic correlates both in production and in perception. Most preferably, a beat is realized by a vowel (short, long, or a diphthong, the difference resulting in a difference in the weight count), but occasionally also by a consonant. The condition is perceptual prominence, brought about by such acoustic cues as intensity or duration. A non-beat is always a consonant; it cannot stand alone without support of a beat, either directly by a respective binding, or indirectly, when it appears in a cluster with other consonants, regulated by NAD.

In comparison to the syllable/mora structure, a beat acquires the same phonetic features as a nucleus; however, rather than being a centre of anything, it is a unit whose sole function is to alternate in a sequence with the less prominent units, non-beats. Such alternating sequence is cut into pieces called words and morphemes on its way from the prelexical to lexical level. Clusters of non-beats are “accidents” due to some distortions of the alternating sequence (e.g., dropping or breaking of some beats). A long or a diphthongal beat counts as double in quantity-sensitive languages, and a B←n binding might also contribute to weight there. This resembles mora counting, but does not require the introduction of a mora.

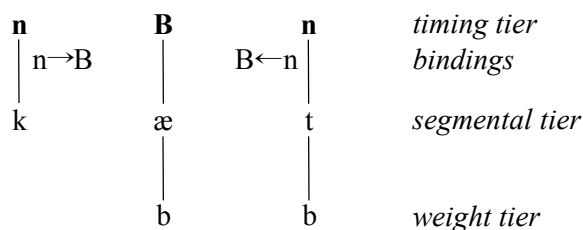
² I have expanded this section on request of Reviewer B, specifically to address the difference between B&B phonology and other frameworks in the treatment of such “unquestioned givens” as the syllable.

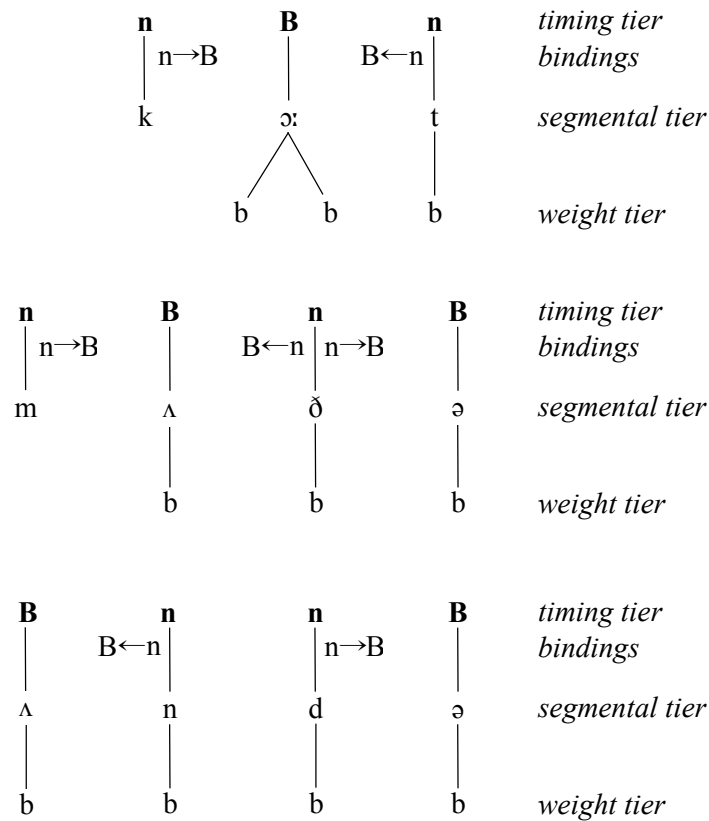
Universal *preferences* involving beats specify the patterning, strength and realization of beats in a sequence. These are: the preference for a trochee, the preference for the vocalic beat, and the preference for the alternation between beats and non-beats.

Beats (B) and non-beats (n) in a sequence are joined by means of *bindings*. Bindings in a sequence are binary; sound sequences are combinations of two basic binary bindings: $n \rightarrow B$ and $B \leftarrow n$ (and, possibly, single beats). Bindings work with reference to the principle of contrast, i.e. they are perceptually motivated. The $n \rightarrow B$ binding is stronger than the $B \leftarrow n$ one, which is a direct consequence of the CV preference. An acoustic phonetic basis for the preference consists in the observation that acoustic modulations in a consonant–vowel transition can be much better perceived than in a vowel–consonant one. To quote Ohala and Kawasaki (1984: 117, 118), “it is generally the case that the most salient acoustic modulations in a syllable occur near the CV interface”, and “auditory cues present in CV’s are more robust than those in VC’s”. Also articulatory factors contribute to a better perception of CVs. As Ohala (1990b: 265) put it, “since there is a richer, more reliable set of place cues in the CV transition than the VC transition, listeners weight the former more heavily than the latter in deciding what they’ve heard”. And, on the speaker’s side, according to Ohala and Kawasaki (1984: 119), “the speaker actively tries to create temporally more well defined, more precise, articulations near the CV as opposed to VC interface”.

A subjective perceptual measure of contrast between a beat and a non-beat is constituted by sonority; beats are uniformly more sonorous than non-beats. In objective terms, it is the degree of modulation in several acoustic parameters (amplitude, periodicity, spectral shape, F0; cf. Ohala 1990a) that decides whether an $n \rightarrow B$ binding is actually realized as stronger than a $B \leftarrow n$ one. As Ohala (1990a) notices, larger modulations have more survival value than lesser ones and therefore will persist in languages.

A few examples of representations in the B&B model are shown below. Notice that, in English, a $B \leftarrow n$ binding is always present, which is typical of the so-called stress-timed languages. In the prototypical syllable-timed languages, this binding is absent (cf. the discussion of the issue of rhythm in the B&B model in Dziubalska-Kořaczyk 2002).





Actual auditory distances between segments become relevant for phonotactics. These will be discussed in the following section.

3. B&B phonotactics

B&B phonotactics is a universal model of phonotactics within B&B Phonology. It describes the actual auditory distances between segments. In particular, it lists the universal phonotactic preferences which specify the universally required distances between segments within clusters in word initial, word medial and word final position. The preferences guarantee, if respected, preservation of clusters (or, in other words, they enhance intersegmental cohesion).

Clusters, in order to survive, must be sustained by some force counteracting the overwhelming tendency to reduce towards CVs (the CV preference). This force is a perceptual contrast defined as the Net Auditory Distance Principle (NAD Principle; cf.

Dziubalska-Kořaczyk 2002, 2003; Dressler and Dziubalska-Kořaczyk 2006; Dziubalska-Kořaczyk and Krynicki 2007a):

$$\mathbf{NAD} = |\mathbf{MOA}| + |\mathbf{POA}| + |\mathbf{Lx}|$$

where $|\mathbf{MOA}|$, $|\mathbf{POA}|$ and $|\mathbf{Lx}|$ are the absolute values of differences in the Manner of Articulation, Place of Articulation and Voicing of the neighbouring sounds, respectively.

Let us consider an example of the preference concerning word initial two-consonant clusters:

$$\mathbf{NAD} (\mathbf{C1,C2}) \geq \mathbf{NAD} (\mathbf{C2,V})$$

The preference reads: “In word-initial double clusters, the Net Auditory Distance (NAD) between the two consonants should be greater than or equal to the Net Auditory Distance between a vowel and a consonant neighbouring on it.”

The distances in terms of manner and place of articulation are calculated on the basis of Table 1. The manners and places assumed in the table are selected according to their potential relevance: 6 manners (stop, affricate, fricative, sonorant stop, approximant, semivowel), where affricates and semivowels are, tentatively, attributed half a distance due to their ambiguous nature; and 5 places (labial, coronal, dorsal, radical and laryngeal or glottal). Manners refer to the most generally acknowledged version of the so-called sonority scale, while places are taken from Ladefoged (2006: 258). Both lists are extendible and modifiable (e.g., Ladefoged’s list consists of 5 nodes which branch into 12 more detailed features), depending on the amount of detail we want to include in the definition of distance. In fact, one would need to investigate from the auditory perspective as many acoustic/articulatory cues as possible which potentially contribute to the overall perceptual impression brought about by phonotactic sequences. This, however, is a wider research perspective reserved for the future investigation. In the present research and for the purposes of the present data, the assumption has been made as described above and in Table 1.

Consider again the preference for initial double clusters:

$$\mathbf{NAD} (\mathbf{C1,C2}) \geq \mathbf{NAD} (\mathbf{C2,V})$$

Let us now define two Net Auditory Distances between the sounds (C1,C2) and (C2,V) where

- C1 (MOA1, POA1, Lx1)
- C2 (MOA2, POA2, Lx2)
- V (MOA3, Lx3)

in terms of the following metric for the (C1,C2) cluster

Table 1. Distances in manner and place of articulation.

4		3		2		1		0	
obstruent				sonorant					
stop		fricative		sonorant stop		approximant		V	
		affricate						semiV	
p	b	ɸ	β	m			w	labial	1
		f	v	ɱ					
t̪	d̪	θ	ð	n̪		r	l	coronal	2
t	d	ʃ	ʒ	n					
t̺	d̺	s	z						
		ʂ	ʐ						
		ʃ	ʒ						
k	g	ç	ʒ	ɲ			j	dorsal	3
c	ɟ	x	ɣ	ŋ					
								radical	4
ʔ		h						laryngeal (glottal)	5

$$|\text{MOA1} - \text{MOA2}| + |\text{POA1} - \text{POA2}| + |\text{Lx1} - \text{Lx2}|$$

and

$$|\text{MOA2} - \text{MOA3}| + |\text{Lx2} - \text{Lx3}|$$

for the (C2,V) cluster.

Let us now exemplify the above with an English initial double cluster in the word *try*.

$$t = (4, 2, 0), r = (1, 2, 1), V = (0, 0, 1)$$

$$\text{NAD}(C1, C2) = |4 - 1| + |2 - 2| + |0 - 1| = 3 + 0 + 1 = 4$$

$$\text{NAD}(C2, V) = |1 - 0| + |1 - 1| = 1 + 0 = 1$$

Thus, the preference $\text{NAD}(C1, C2) \geq \text{NAD}(C2, V)$ is observed, because $4 > 1$.

As mentioned already in the Introduction, the NAD Principle makes finer predictions than the ones based exclusively on sonority, for instance it shows that among stop+liquid initial clusters, prV and $\text{krV} > \text{trV}$, brV , $\text{grV} > \text{drV}$, etc. (since their NAD's are respectively: $5 > 4 > 3$). This universal principle leads to predictions about language-specific phonotactics, its acquisition and change. Specifically, it also allows to

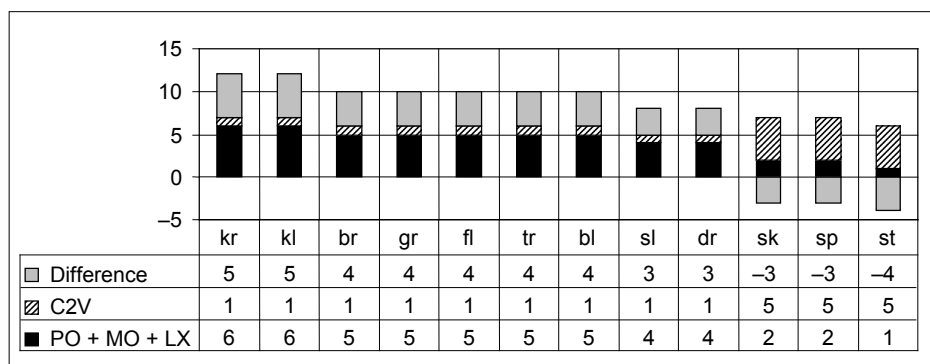


Figure 1. English frequent initial doubles according to the NAD Principle.

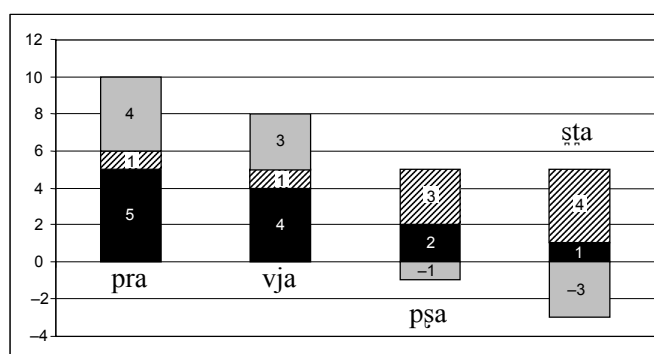


Figure 2. Selected frequent Polish clusters according to the NAD Principle.

predict and explain the order of difficulty in the acquisition of second language phonotactics, which appears to be universally valid, and as such calls for similar remedies across languages. For example, if one compares the frequent English (Figure 1) and Polish (Figure 2) clusters, one can observe that, among the English ones, many more clusters are universally preferred (i.e. they observe the respective preference for initial doubles discussed above). A Polish learner of English is therefore expected to have fewer difficulties in the acquisition of those clusters than an English learner of Polish.

Above, the preference for two-consonant clusters in word-initial position has been presented and discussed. Universal phonotactics specifies analogous preferences for all three word positions for 2- and 3-consonant clusters. Medial clusters are much better motivated than peripheral ones, especially double ones, since both consonants (non-beats) are well anchored between the vowels (beats) due to the leftward and rightward

binding. Indeed, among other things, one expects medial clusters to be easiest to acquire (both in L1 and L2), and to be present in languages which do not have any peripheral clusters.³

Some research results obtained so far (with the use of the calculator) concern the area of second language acquisition (cf. Dziubalska-Kořaczyk and Zielińska, in press). The aim of that research was to demonstrate that universal phonotactic preferences guide the acquisition of consonant clusters in a second language. The empirical evidence came from young learners of English (L2 English) with mother tongues (L1s) from the following families: independent (Japanese, Korean, Vietnamese), Sino-Tibetan (Chinese), Austronesian (Kosraean, Marshallese, Palauan, Ponapean, Samoan, Tagalog, Trukese, Visayan), Dravidian (Tamil) and Slavic (Polish).

On the most general level, it was predicted that clusters as such would be avoided or at least struggled with. Indeed, 68.9% of all 2-consonant input clusters were not produced correctly by the subjects. Three-consonant clusters, predictably, scored still worse, since 74.59% of the attempted productions failed, and the failure was much more profound than in the case of double clusters. On the word level, initial, medial and final clusters were predicted to behave according to their different status. Only 58% of the medial clusters were rendered incorrect, which is much more successful when compared to the 70% incorrect initial clusters and 76% incorrect final ones. The higher tolerance for medial clusters was confirmed by the changes of the other two types of clusters (initial and final) into medial ones – 85% of the cases involving any change. Certainly it was confirmed that less complex clusters are easier for the learners than the more complex ones. 36% of 2-consonant clusters vs. only a little over 10% of 3-consonant clusters were produced correctly by the subjects.

In terms of NAD, the difficulty of a cluster was expected to correlate with the “goodness” of a cluster, i.e. the degree of universal preferability of a cluster. The results obtained confirm the above claim in a number of interesting ways. Among others, and importantly, correlations have been found for both initial and final clusters between their degree of preferability (“goodness”) and the proportional degree of difficulty in their production (the number of errors).

Quite prominent negative feedback emerged from the analysis of medial clusters. In particular, geminates turned out not to be the most preferred medials; rather, combinations of consonants differing by one place or manner feature prevailed (significantly, <st> was the best!). This result calls for a modification of the universal preference for medials: rather than claiming the smallest C1C2 distance possible, one would need to introduce a necessary minimal distance there (i.e., the distance between two consonants in the medial position should be greater than zero but smaller than the distances of each

³ This paragraph addresses shortly Reviewer B’s remark concerning the different status of medial clusters. I have said more on the origin and acquisition of medial vs. peripheral clusters in other publications, among others in Dziubalska-Kořaczyk (2002).

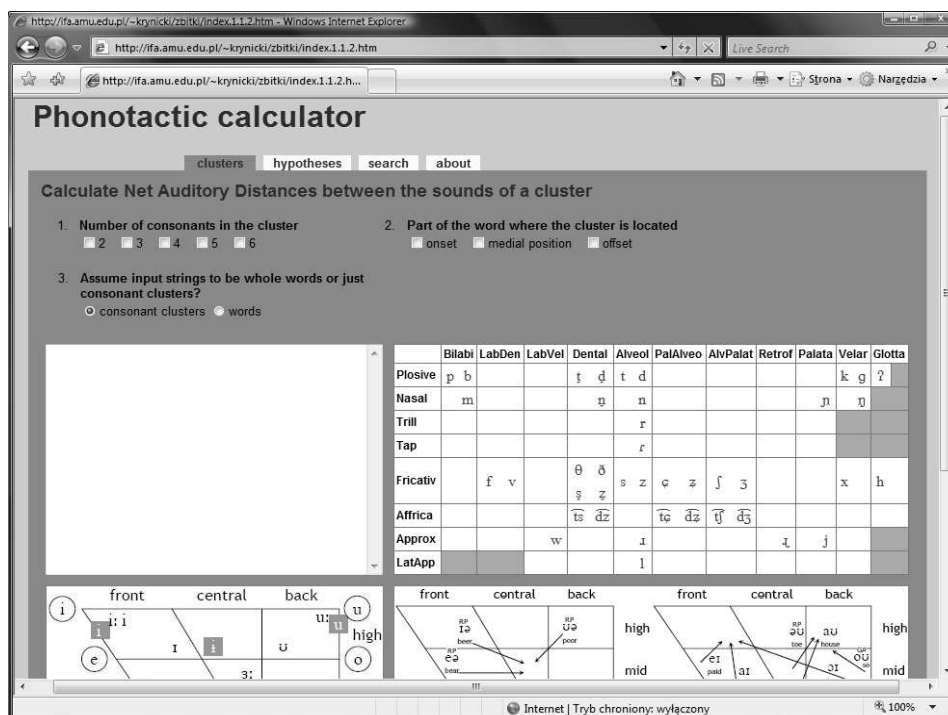


Figure 3. Phonotactic calculator: view of the website.

of the consonants to the respective neighbouring vowels).⁴ It remains to be investigated how to define it.

4. Phonotactic calculator⁵

For the purposes of B&B phonotactics, a prototype of a phonotactic calculator was developed (Dziubalska-Kořaczyk and Krynicki 2007b). Its purpose is to make it possible

⁴ Reviewer A points to “the maximal onset principle, coupled with the sonority sequencing rules for a particular language” which, within standard syllable theory, account for medial clusters. In fact, that account does not provide for: (a) differences between geminates and equal-sonority clusters, e.g. -pp- vs. -pt- or -mn- (unless very fine sonority distinctions are drawn, not specified in standard sonority scales); (b) differences between types of geminates, e.g. -pp- vs. -ll-; (c) differences between genuinely medial clusters and those which would fare better as initials or finals. All those differences find explanation under the respective B&B preference for medials ($NAD(V1, C1) \geq NAD(C1, C2) < NAD(C2, V2)$) and thanks to NAD including more features than just sonority.

⁵ The research on the calculator is work in progress. The prototype version by Dziubalska-Kořaczyk and Krynicki (2007b) is being revised and further developed by Dziubalska-Kořaczyk and Pietrala (in prep.).

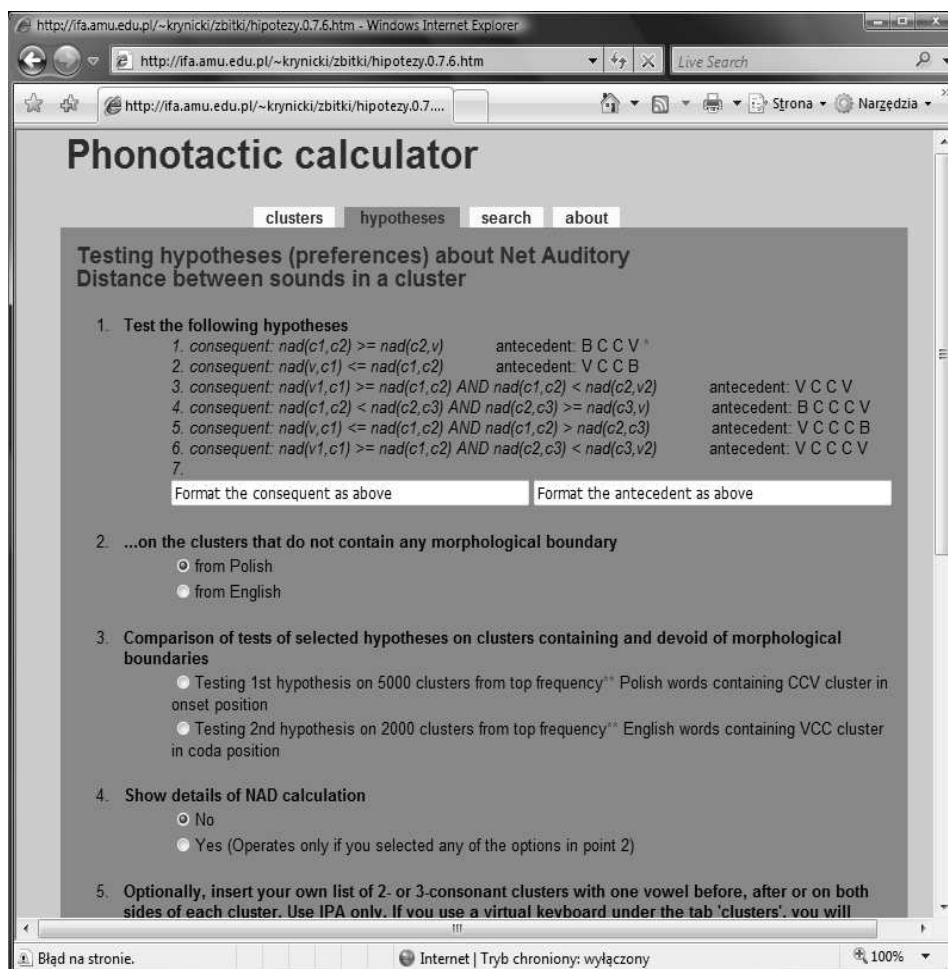


Figure 4. Phonotactic calculator: view of the website (continued).

to perform statistical analysis of large quantities of phonetic data, such as phonetic dictionaries and phonetically annotated corpora from various languages. The calculator will work on various lengths of clusters in all word positions (initial, medial and final) and estimate them with respect to the universal phonotactic preferences/constraints formulated to define each cluster type in each position (cf. Dziubalska-Kołaczyk 2002, and Section 4 above). It provides fast feedback on the predictability value of those preferences/constraints.

As mentioned in the Introduction, the calculator is merely a tool facilitating computation of NAD. Thanks to the calculator, one will be able to evaluate the “goodness” of clusters measured in NAD with reference to the universal phonotactic preferences in all

word positions. The data may come from any source, be it corpora or dictionaries, or typed-in clusters. The sources may be synchronic or diachronic, cover child or adult speech, healthy or impaired, native or foreign, formal or casual, standard or dialect, and so on. The aim is to look for convergence of the data around a particular set of phonetic criteria assumed in the measurement. The criteria may be changed or expanded, and even the formulation of the preferences may get modified, with a view to constructing the optimally uniform model of universal phonotactics.⁶

5. B&B phonotactics in the NL theory

Let me now view B&B phonotactics from the epistemological perspective of the Natural Linguistic theory (cf. Dziubalska-Kořaczyk 2002, 2006). The explanatory system of Natural Linguistics may be envisaged as in Figure 5.

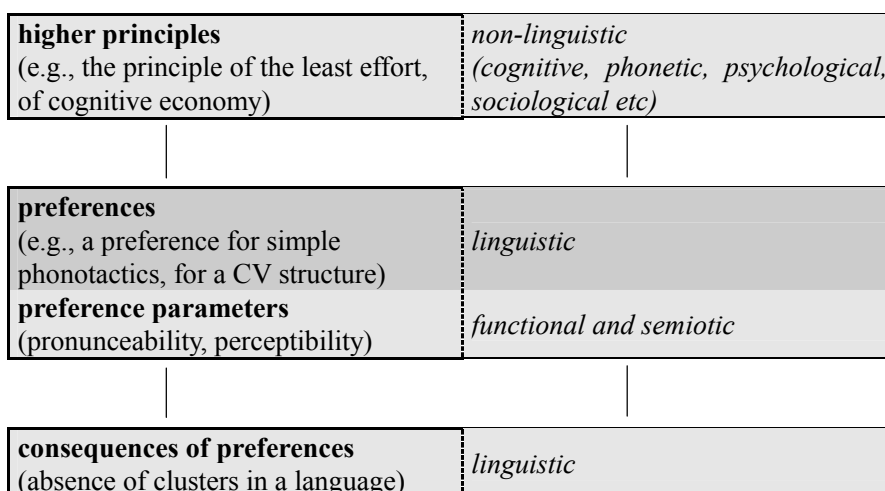


Figure 5. The explanatory system of Natural Linguistics.

The higher, non-linguistic principles involved in B&B phonotactics are:

- the cognitive principle of least effort (it is less effortful to produce a single consonant than a cluster; the effort is better managed when the produced cluster is well perceived);

⁶ This paragraph is a short answer to Reviewer A's question about "what the calculator is intended to do with the data that is fed to it".

- the semiotic principle of figure and ground (the contrast between a single consonant and a vowel is a better figure-against-ground structure than a cluster);
- the phonetic principle of alternation (louder/quieter sounds, jaw movements, cf. Maddieson 2006).

At the level of preferences and preference parameters, the linguistic CV preference is derivable directly from phonetics as well as from the other two of the above principles. A universal preference for a well-formed cluster is then defined with reference to the CV preference (i.e. it necessarily needs to counteract it). The functional parameter used to measure the phonotactic preferences is that of perceptibility, i.e. perceptual distance measured in MOA (manner of articulation), POA (place of articulation) and Lx (voicing). It is perceptibility rather than pronounceability since phonotactics is prelexical.

The linguistic consequences of the universal phonotactics are:

- a typological absence/avoidance of clusters more complex than CCVC (only 30% of the languages have clusters more complex than that, cf. Maddieson 2008);
- a typological occurrence of preferred clusters;
- universal and language-specific processes reducing dispreferred clusters (in diachrony, acquisition, phonostylistics, speech pathology, etc).

As demonstrated, B&B phonotactics fits well into the framework of Natural Linguistics.

7. Morphonotactics of clusters⁷

Phonotactic studies of the languages of the world have not been considering morphological domains or boundaries as a relevant criterion. Phonotactics has been taken as belonging to phonology, and consequently as being independent of morphology. Most commonly, a syllable or a (phonological or lexical) word would be considered a relevant domain for phonotactic well-formedness conditions (with the notable exception of “morpheme structure constraints”, lacking however inter-morphemic conditions).

The semiotic metatheory of Natural Linguistics situates morphology as prior to phonology. Consequently, a morphological function may override a phonological one. In the case of phonotactics, signaling a morphological boundary may override a pho-

⁷ The section on morphonotactics has been expanded in response to Reviewer A’s suggestion. However, the reader is referred to Dressler and Dziubalska-Kořaczyk (2006), and Dressler et al. (in press) for an elaborate treatment and rich illustration from several languages.

nologically driven phonotactic preference and, as a result, lead to the creation of a marked cluster. Therefore, one expects relatively marked clusters across morpheme boundaries and relatively unmarked ones within morphemes (cf. Dressler and Dziubalska-Kořaczyk 2006).

Language-specific morphonotactics provides therefore an additional parameter constraining the actual outcome of universal phonotactic preferences. This is an example of the holistic non-isolationist view on language represented by Natural Linguistics. Morphonotactics has been defined as the area of interaction between morphotactics and phonotactics (cf. Dressler and Dziubalska-Kořaczyk 2006) and represents a subfield of morphonology (cf. Dressler 1985, 1996). Morphonotactics is about studying the phonological structure of morphemes and morpheme combinations. Among single morphemes, lexical roots show the highest degree of phonological variation, and inflectional affixes – the lowest, while derivation affixes are in between (cf. Dressler and Dziubalska-Kořaczyk 2006 for more discussion and references). Most interesting for phonotactic studies are morpheme combinations, when morphonotactic clusters arise. They are expected to be more marked than the morpheme-internal clusters, due to the morphological function they signal. Not all morphological operations will produce marked phonotactics, though. Thus, one may talk of:

- (less common) cooperative interaction between morphotactics and phonotactics (when a morphological operation produces a cluster already existent within morphemes in a language, e.g. *screen+ed* vs. *find*);
- (predominating) conflicting interaction between morphotactics and phonotactics (when various types of marked clusters are produced, having different proportions of morphological vs. phonological motivation).

In this paper, the focus is on phonotactics, and in this section – specifically on the influence of morphotactics on phonotactics. Let me illustrate this with two studies, one on the acquisition of L1 clusters (Zydorowicz 2008), and the other on Polish and English word final clusters (Orzechowska 2008).

Zydorowicz (2008) showed the following tendencies for Polish and English first language acquisition. In Polish (the data comes from Zosia, aged 2;8–3;2), NAD works best for lexical medial and final cluster types and tokens; dispreferred clusters are reduced more frequently than preferred ones: 29% preferred vs. 44% dispreferred medials; 36% preferred vs. 40% dispreferred finals. Thus, unmarked phonotactic clusters are preserved. In the morphonotactic clusters, dispreferred clusters are produced more frequently than preferred ones, especially initially: 94% dispreferred vs. 25% preferred. Thus, marked morphonotactic clusters are preserved.

In English (the data comes from William, aged 2;4–3;4), NAD works for lexical initial and medial cluster types and tokens (i.e., more preferred clusters are produced); in finals, NAD works for types but not for tokens. In morphonotactic clusters, medial and

especially final preferred types and tokens are reduced more frequently: medials: 58% vs. 49 %, finals: 57% vs. 37.5%.

Another example comes from the study of the phonotactics and morphonotactics of word final clusters in Polish and English by Orzechowska (2008). In the corpus study of English data it was evident that intramorphemic clusters are in the majority preferred according to NAD (Table 2; values above 0), while the situation is exactly opposite among the intermorphemic clusters, which are mostly marked (Table 3; values below 0).

Table 2. Intra-morphemic word final clusters in English.

IPA transcription	NAD for VC	NAD for CC	Difference between NAD(VC) and NAD(CC)
ant	2	3	1
ans	2	2	0
and	2	2	0
akt	4	1	-3
a.t	1	4	3
ald	1	3	2
a.m	1	2	1
a.s	1	3	2
aks	4	2	-2

Table 3. Inter-morphemic word final clusters in English.

IPA transcription	NAD for VC	NAD for CC	Difference between NAD(VC) and NAD(CC)
anz	2	1	-1
ats	4	1	-3
alz	1	2	1
adz	4	1	-3
amz	2	2	0
azd	3	1	-2

Polish dictionary and corpus data showed similar tendencies (see Table 4, overleaf).

Both studies confirm the general expectation for relatively marked clusters to appear across morpheme boundaries and relatively unmarked ones within morphemes.

Table 4. Intra-morphemic (1–4) vs. inter-morphemic (5–8) word final clusters in Polish.

IPA transcription	NAD for VC	NAD for CC	Difference between NAD(VC) and NAD(CC)
(1) aŋt͡s̄	2	2.5	0.5
(2) aŋt͡e	2	3	1
(3) amp	2	3	1
(4) aŋt͡ʃ	2	2.5	0.5
(5) aʂm	3	3	0
(6) aʂr	4	4	0
(7) aʂk	3	2	–1
(8) akʂ	4	2	–2

8. Summary and further research perspectives

In this paper, I have presented a model of phonotactics stemming from Beats-and-Binding Phonology, a theory constituting an extension of standard Natural Phonology and its European relative, Natural Linguistics. B&B Phonology is syllable-less. Beats, non-beats, bindings and intersegmental cohesion are proposed to account for the structure of sequences. In particular, phonotactics is explained in terms of universal phonotactic preferences, derived from the basic CV preference, and measured in terms of Net Auditory Distance (NAD). The illustrations provided in the paper constitute guidelines for further research based on the NAD Principle. The measurements are supported by means of the computer tool developed for this purpose – the phonotactic calculator. The study of phonotactics is conducted in parallel to the study of morphotactics to arrive at morphonotactics – a subfield of morphonology showing interactions between phonotactics and morphotactics. Initial positive evidence demonstrated in the paper encourages further development as well as modification of the presented model of phonotactics and morphonotactics. Analysis of new data by the calculator will provide constant feedback allowing to both modify the calculator itself and adapt it to the growing scope of data as well as modify the phonotactic preferences themselves in order to maintain their universal predictive power.

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