Studies in Polish Linguistics
vol. 12, 2017, issue 2, pp. 97–121
doi: 10.4467/23005920SPL.17.005.7023
www.ejournals.eu/SPL

Paulina Zydorowicz, Paula Orzechowska
Adam Mickiewicz University, Poznań

The study of Polish phonotactics: Measures of phonotactic preferability

Abstract
The goal of this paper is to investigate Polish phonotactics from the point of view of different measures of phonotactic preferability. The inventory of word-initial and -final clusters is extracted from a dictionary and analysed in accordance with two principles of phonotactic complexity, namely, the Sonority Sequencing Generalisation and Net Auditory Distance. Sonority entails measurements of distances between consonants expressed by the manner of articulation, whereas NAD uses the manner of articulation, place of articulation as well as the obstruent/sonorant distinction. These differences are likely to contribute to a different assessment of clusters, which is the main focus of this paper. Moreover, since a set of Polish clusters arise due to morphology, a distinction is drawn between phonotactic and morphonotactic clusters, i.e. phonologically and morphologically motivated. We are interested in verifying to what extent the principles under investigation reflect the relation between cluster preferability and morphological complexity. The analysis shows that NAD, as a more restrictive measure of phonotactics, rejects a larger portion of word-initial and -final clusters on well-formedness grounds. Secondly, we demonstrate that both principles generally show a strong relation between cluster preferability and morphological complexity.

Keywords
consonant clusters, morphological boundaries, phonotactic preferability, Polish

Streszczenie
Celem niniejszej pracy jest zbadanie polskiej fonotaktyki z punktu widzenia różnych modeli preferencyjności. Inwentarz zbitek spółgłoskowych występujących na początku i na końcu słowa został wyekstrahowany ze słownika oraz zanalizowany na podstawie założeń Zasady Sonorności oraz Zasady Audiodystansu Netto. Zasada Sonorności określa dystanse między spółgłoskami na podstawie sposobu artykulacji, podczas gdy Zasada Audiodystansu Netto bierze pod uwagę dystanse w sposobie i miejscu artykulacji oraz pomiędzy obstruentami a sonorantami. Ponadto znaczna część zbitek spółgłoskowych w języku polskim jest wynikiem działania morfologii. Drugim celem jest zatem zbadanie stopnia zależności między preferencyjnością zbitek a ich morfologiczną strukturą. Analiza pokazuje, że Zasada Audiodystansu Netto, jako bardziej restrykcyjna miara, odrzuca większą grupę zbitek. Obie zasady natomiast potwier-

dzają związek między preferencyjnością zbitek spółgłoskowych a ich morfologiczną złożonością.

Słowa kluczowe
zbitki spółgłoskowe, granice morfologiczne, preferencyjność w fonotaktyce, język polski

Introduction[1]

The objective of this contribution is to juxtapose different approaches to evaluating consonant clusters at word edges in Polish. The alternative principles used in the study involve the traditional measure of the Sonority Sequencing Generalization (henceforth SSG) and a refined version of Net Auditory Distance (henceforth NAD). The explanatory power of the two principles will be tested on the basis of dictionary data. In the analysis to follow, morphology plays a crucial role. All clusters are classified as either morphologically simple or complex, and all observations are made with respect to this criterion. The key question is how the two approaches capture the relation between cluster preferability and morphological complexity.

1. Polish (mor)phonotactics

Phonotactics investigates permissible sound combinations in a language. It defines restrictions on the occurrence of single phonemes (segmental restrictions) or consonant clusters (sequential restrictions). As regards sequential phonotactics, Polish allows for clusters of varying size: double (CC), triple (CCC), quadruple (CCCC) as well as 5- and 6-member clusters. With respect to word position, there can be as many as 4 consonants word-initially, 6 consonants word-medially, and 5 consonants word-finally (Dziubalska-Kołaczyk and Zydorowicz 2014). Moreover, sandhi phenomena allow for up to 11 consonants. Table 1 below provides examples of phonotactic possibilities in Polish in terms of cluster size. The first example in a cell presents a phonologically motivated cluster, whereas the second example contains a morphological boundary indicted by '+'.

Polish consonant clusters can be phonologically or morphologically motivated (Dressler and Dziubalska-Kołaczyk 2006). The former ones, referred to as phonotactic or lexical, occur within a single morpheme, e.g. /skl-/ in *sklep* 'shop', whereas the latter, referred to as morphonotactic, arise due to

[1] We would like to thank the anonymous *SPL* reviewers for their suggestions and critical remarks. The text has benefited greatly from this exchange. Moreover, we are grateful to Katarzyna Dziubalska-Kołaczyk for her insightful comments, and Waldemar Wołyński for statistical consulting.

Size	Initial	Medial	Final
2	/pt/ ptak ‘bird’ /sp/ s+pić ‘to drink out’ (PERF)	/kt/ aktor ‘actor’ /dr/ od+robić ‘to make up for’	/tr/ wiatr ‘wind’ /ɕʨ/ iś+ć ‘to go’
3	/pştş/ *pszczoła* ‘bee’ /vgr/ w+grać ‘to load’ (PERF)	/str/ ostry ‘sharp’ /tkr/ od+kryć ‘to discover’	/kst/ tekst ‘text’ /jɕʨ/ zejś+ć ‘to go down’
4	/pstr/ pstry ‘motley’ /fstş/ ws+trzymać ‘to stop’	/kstr/ ekstra ‘extra’ /strf/ roz+trwonić ‘to squander’	– /pstf/ głup+stw ‘silliness’ (GEN.PL)
5	–	– /zvzgl/ bez+względny ‘ruthless’	– /mpstf/ przestęp+stw ‘crime’ (GEN.PL)
6	–	– /ntşzvj/ wewnątrz+związkowy ‘union-internal’	–
sandhi	/mpstf f strfj/ przestępstw w Strwiążu ‘crime (GEN.PL) in Strwiąż’		

Table 1. Phonotactic and morphonotactic possibilities in Polish in terms of cluster size (Dziubalska-Kołaczyk *et al.* 2012).

concatenative and non-concatenative morphology. Concatenation as a morphological pattern involves affixation, e.g. in /skl-/ the meaning is changed from imperfective *kleić* ‘to glue’ to perfective *s+kleić* ‘to glue up’. As regards non-concatenative morphology, it can be illustrated by vowel ~ zero alternations. For instance, /ps-/ in *psy* ‘dogs’ is inflected from *pies* /pjes/ ‘dog’, where the thematic vowel is dropped. Another example is zero-Genitive-plural formation, where the final cluster /-ʦstf/ in *bogactw* ‘riches’ (Genitive plural) is triggered by the deletion of the vocalic suffix in *bogactw+o* ‘riches’ (Nominative singular). Morphologically motivated clusters tend to be more complex in terms of length (resulting in 4-, 5-, or 6-member sequences), as well as their phonological structure (some morphonotactic clusters never occur intramorphemically, e.g. /fx-/ in *w+chodzić* ‘to go inside’). Table 2 below illustrates the sources of morphonotactic clusters.

Previous research on Polish phonotactics focused on the classification, frequency and ranking of clusters in written and spoken texts (Bargiełówna 1950; Dobrogowska 1984, 1990, 1992; Dukiewicz 1980, 1985; Dunaj 1985, 1986; Durand and Gubrynowicz 1999; Madejowa 1990, Orzechowska 2009, 2012; Orzechowska and Wiese 2015; Śledziński 2005; Zydorowicz *et al.* 2016). Polish phonotactics has also supplied material for the study of first language acquisition (Jarosz *et al.* 2016; Łukaszewicz 2007; Milewski 2005; Tamburelli *et al.*

Pronunciation	Source of a cluster	Example
s / ɕ	prefixation (semantic change)	s+kończyć 'to end' ś+cierać 'to wipe off'
z	prefixation (semantic change)	z+robić 'to do'
f	prefixation (semantic change)	w+chodzić 'to enter'
v	prefixation (semantic change)	w+jechać 'to drive into'
tɕ	suffixation (infinitive)	iś+ć 'to go'
ø	vowel ~ zero alternation	pies vs. psy 'dog' vs 'dogs'
ø	zero suffixation (imperative)	puś+ć 'to let go' (imperative)
ø	zero suffixation (GEN.PL)	miejsc+ 'places' (GEN.PL)

Table 2. The list of Polish affixes and morphological operations generating morphonotactic clusters

2015; Yavaş and Marecka 2014; Zydorowicz 2010), second language acquisition (Dziubalska-Kołaczyk and Zielińska 2011; Dziubalska-Kołaczyk and Zydorowicz 2014) and neural processing (Wiese *et al.* 2017). Theory-oriented accounts of phonotactics involved, for instance, Bethin (1992); Cyran and Gussmann (1999); Dressler and Dziubalska-Kołaczyk (2006); Dziubalska-Kołaczyk (2001, 2002); Gussmann and Cyran (1998); Rochoń (2000); and Scheer (2007, 2008).

Since the main aim of the present study is the analysis of consonant clusters which are phonologically and morphologically motivated, let us refer to the earliest work on Polish phonotactics, namely, that of Bargiełówna (1950), who investigated clusters in terms of word position and morphological make-up. Tables 3–5 present the summary of the data compiled by Bargiełówna (1950) for word-initial, -medial and -final clusters, respectively. For each cluster size (2: CC, 3: CCC, 4: CCCC and longer), we provide the number of intramorphemic and intermorphemic[2] clusters.

Size	Intra-morphemic	Inter-morphemic
2	191	59
3	65	110
4 and longer	6	9

Table 3. Initial cluster types (Bargiełówna 1950)

Size	Intra-morphemic	Inter-morphemic
2	305	353
3	97	518
4 and longer	11	98

Table 4. Medial cluster types (Bargiełówna 1950)

[2] The terms *intramorphemic* largely corresponds to our understanding of phonotactic/lexical, while intermorphemic to morphonotactic.

Size	Intra-morphemic	Inter-morphemic
2	76	2[3]
3	9	7
4 and longer	2	11

Table 5. Final cluster types (Bargiełówna 1950)

Tables 3–5 point to the richness of Polish phonotactics. A large portion of the data is morphological in nature. This means that clusters arise at morpheme boundaries due to affixation. As the number of constituent elements in a cluster grows, the cluster is more likely to contain a morphological boundary. For instance, according to the data presented above, there are 59 initial double clusters containing a morpheme boundary compared to 191 lexical clusters. However, in the case of initial triples one can notice that there are almost twice as many morphonotactic clusters (110) as lexical ones (65). In the case of 4-member initials, a slight majority of them are morphological in nature. Similar observations hold for the medial position. As far as final clusters are concerned, doubles are strongly phonotactic, 4-(and more) member clusters tend to be strongly morphonotactic, while triples have an equally distributed realization. The occurrence of such regularities and patterns in Polish indicates that complex clusters are well-integrated into the Polish lexicon, especially when they fulfil a morphological function.[3]

Similar findings were reported by Zydorowicz *et al.* (2016), whose study investigated Polish word-initial and word-final morphonotactics in different types of linguistic sources. The authors concluded that cluster length in Polish is a predictor of the presence of a morphological boundary. The summary of their results for cluster types is given in Tables 6 and 7, whereas the data for word types are tabulated in Tables 8 and 9. The term *cluster type* refers to an individual cluster with a unique composition, e.g. the initial Polish CC /st/. This specific cluster can occur in different *word types*, such as *stać* 'to stand', *sto* 'one hundred', *stan* 'state', and *stary* 'old'. A cluster type can have three realizations; purely lexical, purely morphonotactic and mixed. The latter appear in both phonotactic and morphonotactic contexts, for example, /vw-/ in *władza* 'power' and *w+łamanie* 'break-in' respectively. The data on word types presented below does not include the mixed group, as one cluster can be either phonotactic or morphonotactic.

Apart from the impressive number and length of clusters, Polish features consonant clusters whose phonological make-up is complex. This make-up has been captured by the notion of markedness (Trubetzkoy 1939; Jakobson 1941; Battistella 1990; de Lacy 2006). Traditionally, markedness has been associated with universality of linguistic phenomena, which can be represented by two values, one of which is marked and the other is unmarked, or by a continuum between the two extremes. Following Dressler *et al.* (1987), diagnostics

[3] Data in the original source is inconclusive and inconsistent (sic!).

Size		Lexical	Morphonotactic	Mixed
2	no.	106	21	18
	%	73	14	12
3	no.	36	35	14
	%	42	41	16
4	no.	2	6	0
	%	25	75	0

Table 6. Size vs. morphological composition (initial cluster types)

Size		Lexical	Morphonotactic	Mixed
2	no.	52	0	2
	%	96	0	
3	no.	8	1	1
	%	80	10	

Table 7. Size vs. morphological composition (final cluster types)

Size		Lexical	Morphonotactic
2	no.	1 884	253
	%	88	12
3	no.	189	192
	%	50	50
4	no.	3	11
	%	21	79

Table 8. Size vs. morphological composition (initial clusters in word types)

Size		Lexical	Morphonotactic
2	no.	359	209
	%	63	37
3	no.	14	20
	%	41	59

Table 9. Size vs. morphological composition (final clusters in word types)

of an unmarked or less marked (i.e. more natural) structure involve, among others, acquisition at earlier stages, higher frequency in child-directed speech, greater stability among aphasics and in diachrony, cross-linguistic prevalence as well as ease in perception. In terms of phonotactics, markedness tends to be expressed by the notion of sonority. In this paper, however, apart from the Sonority Sequencing Generalization, we analyse the data by means of an alternative method, namely the Net Auditory Distance principle. The two approaches to phonotactic complexity can be seen as tools for assessing markedness, and are discussed in the section to follow.

2. Phonotactic principles

2.1. Sonority Sequencing Generalization

The concept of sonority dates back to Whitney (1865), Sievers (1901) and Jespersen (1913). Although over the past century, phonologists and phoneticians have not been able to propose a uniform definition of sonority, the term has been associated with segment "loudness relative to that of other sounds with the same length, stress, and pitch" (Ladefoged 2011: 245). Generally, the larger the constriction in the vocal tract, the less sonorous the sound. Various versions of the sonority scale have been proposed throughout the course of time (e.g. Vennemann 1988; Selkirk 1984; Clements 1990; Parker 2012). In spite of the varying degree of detail, all scales place vowels and obstruents at the most and least sonorous ends of the hierarchy respectively. The sonority scale used in this contribution is based on Foley (1972), who posits 6 classes of segments illustrated below.

oral stop – fricative – nasal – liquid – glide – vowel
(5) – (4) – (3) – (2) – (1) – (0)

→

Figure 1. Sonority scale (Foley 1972)

This scale is considered to be neutral in that it relies on neither too specific nor too broad distinctions. Secondly, it is closest to the manner of articulation features (sonority) used in the Net Auditory Distance principle, where 5 intervening distances are found between vowels and plosives. Therefore, applying the scale of Foley (1972) ensures a direct and adequate comparison between sonority and NAD. As can be seen, the scale does not contain affricates, which due to their articulatory properties are considered to be a category merging between plosives and fricatives. This treatment of affricates goes in line with the manner of articulation scale in NAD (for details, see section 2.2).

Traditionally, sonority has been used to evaluate the structure of the syllable. The principle which determines the preferred organization of segments from the onset through the nucleus to the coda is the *Sonority Sequencing Generalisation* (Selkirk 1984), which states that sonority of adjacent segments should decrease from the nucleus outward. To take English as an example, a plosive+fricative sequence /st/ constitutes a legitimate and well-formed (preferred) coda in *waste* but an ill-formed (dispreferred) onset in *stay.* As regards Polish, its phonotactic complexity goes far beyond the SSG. Polish (mor)phonotactics has been discussed with reference to the syllable and word structure. Here, we follow the idea that the word, next to the syllable, constitutes an equally relevant unit for formulating phonotactic generalizations, which has been discussed in Rubach (1996), Steriade (1999), Dziubalska-Kołaczyk (2002). Therefore, now and in the empirical part of the paper, the word will constitute the basic unit of analysis. The (dis)preferred sonority contour of word-initial and -final clusters is demonstrated in Table 10, which contains examples of clusters of varying size (from 2 to 5 adjacent segments) and morphological complexity (marked with '+').

Sonority	Onset		Coda	
	size	example	size	example
well-formed	2	/tr/ *trud* 'hardship'	2	/rt/ sort 'sort'
	3	/pxw/ *pchła* 'flee'	3	/jɕtɕ/ zejść 'to go down'
	4	/gʐ̩mj/ *grzmieć* 'to thunder'		
ill-formed	2	/rt/ *rtęć* 'mercury'	2	/kt/ *nikt* 'nobody'
	3	/str/ *strach* 'feat'	3	/stʂ̩/ *mistrz* 'master'
	4	/pstr/ *pstrykać* 'to snap'	4	/pstf/ *głupstw+* 'stupidity' (GEN.PL)
			5	/mpstf/ *przestępstw+* 'crime' (GEN.PL)

Table 10. Types of consonant clusters according to Foley's (1972) sonority hierarchy

As shown above, Polish allows for consonant sequences with a rising and falling sonority profile in the initial- and final position. Interestingly, among some longer clusters, not only ill-formed but also well-formed sequences are found. Additionally, the phonotactic inventory of Polish contains some plateau clusters, in which sonority remains unchanged throughout the cluster, e.g. /pt-/ in *ptak* 'bird', /fsx-/ in *wschodzić* 'to rise' (for a more detailed discussion, see 2.2). These clusters can be assigned a different formedness status depending on the phonotactic measure used. In the section to follow, we present the Net Auditory Distance principle as an alternative method of cluster evaluation.

2.2. Net Auditory Distance

Net Auditory Distance (Dziubalska-Kołaczyk 2009, 2014, 2015) is a measure of auditory distances between neighbouring pairs of segments. NAD constitutes a refined version of Beats-and-Binding Phonology (Dziubalska-Kołaczyk 2002), which is a model of phonotactics based on the universal preference for the canonical CV structure. The principle of NAD (Dziubalska-Kołaczyk 2009) is expressed by well-formedness conditions for consonant clusters of varying size (CC, CCC) and found in different word-positions (initial, medial, final). Calculations are performed on the basis of the manner of articulation (MOA), place of articulation (POA) and the sonorant-obstruent contrast (S/O), resulting in the formula:

NAD = |MOA| + |POA| + |S/O|.

Previous versions of NAD involved distinguishing between voiced and voiceless segments, a criterion which is now replaced by the S/O contrast. The general table used for calculating auditory distances is shown below.

<table>
<tr><th colspan="3">OBSTRUENT</th><th colspan="5">SONORANT</th><th colspan="3" rowspan="3">VOWEL</th></tr>
<tr><th>STOP</th><th colspan="2">FRICATIVE</th><th>NASAL</th><th colspan="2">LIQUID</th><th colspan="2">GLIDE</th></tr>
<tr><th></th><th>AFFRICATE</th><th></th><th></th><th>lateral</th><th>rhotic</th><th colspan="2"></th></tr>
<tr><td>5.0</td><td>4.5</td><td>4.0</td><td>3.0</td><td>2.5</td><td>2.0</td><td>1.5</td><td>1.0</td><td colspan="3">0</td></tr>
<tr><td>p b</td><td></td><td></td><td>m</td><td></td><td></td><td>w</td><td>w̃</td><td>1.0</td><td>bilabial</td><td rowspan="2">LABIAL</td></tr>
<tr><td></td><td></td><td>f v</td><td></td><td></td><td></td><td></td><td></td><td>1.5</td><td>labio-dental</td></tr>
<tr><td>t d</td><td>ʦ ʣ</td><td>s z</td><td>n</td><td colspan="2">l</td><td></td><td></td><td>2.0</td><td>(post-)dental</td><td rowspan="3">CORONAL</td></tr>
<tr><td></td><td>tʂ dʐ</td><td>ʂ ʐ</td><td></td><td></td><td>r</td><td></td><td></td><td>2.3</td><td>alveolar</td></tr>
<tr><td></td><td>ʨ ʥ</td><td>ɕ ʑ</td><td>ɲ</td><td></td><td></td><td></td><td></td><td>2.6</td><td>alveolo-palatal</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>j</td><td>j̃</td><td>3.0</td><td>palatal</td><td rowspan="2">DORSAL</td></tr>
<tr><td>k g</td><td></td><td>x</td><td>ŋ</td><td></td><td></td><td>w</td><td>w̃</td><td>3.5</td><td>velar</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>4.0</td><td></td><td>RADICAL</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>5.0</td><td></td><td>GLOTTAL</td></tr>
</table>

Table 11. POA and MOA distances for Polish (Dziubalska-Kołaczyk 2014)

For each dimension, the distances rise by 1 from vowels towards the most extreme place and manner categories. For MOA, the distance of 1 holds between vowels – glides – liquids – nasals – fricatives – plosives, which corresponds to the sonority hierarchy of Foley (1972) discussed earlier. For example, the MOA distance between segments /p/ and /w/ in *płacić* /pwaʨiʨ/ 'pay' is the following: |5|-|1.5|=3.5. For the estimation of the distance, only absolute numbers are taken into consideration, therefore the MOA distance between /m/ and /ʂ/ in *msza* /mʂ-/ 'mass' is |3.0|-|4.0|=|-1.0|=1. The class of affricates is treated here as intervening between plosives and fricatives, which results in the distance of 0.5 holding between plosive-affricate and fricative-affricate articulations as in /tʂt-/ in *cztery* 'four' or /ʂtʂ-/ in *szczery* 'sincere'. Similarly, as regards the POA dimension, the maximal distance of 5 holds between extreme articulations on the scale between placeless vowels – labial – coronal – dorsal – radical – glottal segments. For example, POA distances of 1, 1.5, 2.5 hold between /pl-/ in *plama* 'stain', /fj-/ in *fiołek* 'violet', /kp-/ in *kpić* 'mock'. The S/O distinction is expressed by values 0 and 1, depending on whether adjacent segments are both sonorants / obstruents, or whether they belong to different classes.

For the calculation of cluster preferability, well-formedness conditions are specified for each word position and sequences of 2 and 3 consonants. No conditions are established for clusters longer than CCC due to their excessive length. The conditions for initial CC and CCC clusters are the following:[4]

CC: NAD (C1,C2) ≥ NAD (C2,V)
CCC: NAD (C1,C2) < NAD (C2,V) ≥ NAD (C3,V), where:
NAD CC = |(MOA1 – MOA2)| + |(POA1 – POA2)| + |S/O|, and
NAD CV = |(MOA1 – MOA2)| + |S/O|.

Let us illustrate the working of the well-formedness conditions on the basis of several clusters; preferred /pr- spl-/ and two dispreferred /dv- ʂtʂ-/.

CC(C)	C1C2	C2C3	C2V / C3V	NAD
/pr/	|5-2|+|1-2.3|+|1|=5.3	---	|2-0|+0=2	5.3≥2
/spl/	|4-5|+|2-1|+|0|=2	|5-2.5|+|1-2|+1=4.5	|2.5-0|+0=2.5	2<4.5≥2.5
/dv/	|5.0-4.0|+|2-1.5|+|0|=1.5	---	|4-0|+1=5	1.5≥5
/ʂtʂ/	|4-5|+|2.3-2|+|0|=1.3	|5-4|+|2-2.3|+0=1.3	|4-0|+1=5	1.3<1.3 ≥ 5

Table 12. Examples of NAD calculations for Polish word initial clusters

The cluster /dv-/ fails to meets the conditions of NAD for initial doubles, since the distance between the pair of consonants is smaller than between the last consonant of a cluster and the following vowel. Interestingly, this cluster is well-formed in terms of sonority as it displays the rising sonority profile from C1 towards the vowel. Below, we present a list of selected double and triple clusters which are assigned a different preferability status (P=preferred, D=dispreferred) by the SSG and NAD.

Word-initial			Word-final		
clusters	SSG	NAD	clusters	SSG	NAD
/pʂ/	P	D	/ɲtɕ/	P	D
/ml/	P	D	/sk/	P	D
/sn/	P	D	/mf/	P	D
/stw/	D	P	/nft/	D	P

Table 13. Examples of initial and final clusters which differ in terms of the SSG and NAD

As has been mentioned in the previous sections, the sonority hierarchy is mainly based on the manner of articulation, whereas NAD takes into consideration the manner and place of articulation as well as the distinction between

[4] Well-formedness conditions for final clusters are the following: NAD (V, C1) ≤ NAD (C1,C2) for CC and NAD (V,C1) ≤ NAD (C1,C2) > NAD (C2, C3) for CCC.

a sonorant and an obstruent. Both methods rely on well-formedness conditions but in a different way. Constraints are position-dependent (where word-medial clusters can be evaluated only in terms of NAD as sonority splits medial clusters into onsets and codas) specifying cluster preferability. Additionally, another criterion which enters calculations in NAD is the distance between the final consonant in a cluster and the adjacent vowel. This might suggest that NAD, based on a wider set of criteria than sonority, is more detailed in evaluating phonotactic well-formedness. This can be well illustrated on the basis of plateau clusters, which were briefly mentioned in the previous section. For example, /sf-/ in *sfera* 'sphere', /ss-/ in *ssać* 'to suck', /tk-/ in *tkać* 'to weave' and /pt-/ in *ptak* 'bird' are dispreferred in terms of the SSG as they are composed of identical segments (fricative+fricative, plosive+plosive) and violate the principle of minimal distance (Clements 1990). Following Figure 1, the distance between such cluster members amounts to 0. In contrast, NAD provides a gradient characterization of the clusters by specifying their auditory distances C1C2 vs. C2V, namely /sf-/=0.5–5, /ss-/=0–6, /tk-/=1.5–6, /pt-/=1–6. The larger the distance between the segment pairs, the more preferred the cluster, which results in the following goodness scale: /ss/ > /pt/ > /sf/, /tk/. In this sense, NAD is expected to be a more accurate method of cluster evaluation.

3. Methodology

3.1. Data

The data was originally extracted for the purpose of a morphonotactic project (Zydorowicz *et al.* 2016). In this contribution, we build on the earlier findings Dziubalska-Kołaczyk (2014), and expand the analysis by comparing NAD with the SSG. We select a subset of the data extracted from the dictionary, *Słownik Podstawowego Języka Polskiego dla Cudzoziemców* (Essential Polish Dictionary for Foreign Learners) by Bartnicka-Dąbkowska and Sinielnikoff (1999), which contains approximately 8 000 entries. The selection of this resource was motivated by the attempt to obtain a representative collection of clusters. Since one of the tasks was manual morphological parsing of words, no larger resource (such as a sizable dictionary or a corpus) could be considered. As a result, the extracted list of both word-initial and word-final phonotactic and morphonotactic clusters is not exhaustive. The cluster inventory does not include a range of rare phonotactic clusters such as /rt-/ in *rtęć* 'mercury' or morphonotactic concatenative clusters such as /-dw/ in *szed+ł* 'he was going' or non-concatenative clusters such as /-mpstf/ in *przestępstw* (Genitive plural) or /ln-/ in *lnu* 'linen' (Genitive singular). This study is restricted to double clusters only.

	Cluster types
Initial	bj, bl, br, bw, bʐ, ɕf, ɕl, ɕm, ɕɲ, ɕp, ɕr, ɕʨ, db, dj, dl, dm, dn, dr, dv, dw, dʐ, ʣb, ʣv, ʥv, fɕ, fj, fl, fp, fr, fs, fʂ, ft, ftʂ, fʨ, fʦ, fx, gd, gʥ, gj, gl, gm, gɲ, gr, gv, gw, gʐ, kɕ, kf, kj, kl, kr, kʂ, kt, kw, lɲ, lv, lʐ, mj, ml, mn, mr, mw, pɕ, pj, pl, pr, ps, pʂ, pt, pw, px, rʥ, rv, sɕ, sf, sk, ʂk, ʂl, sm, ʂm, sn, ʂn, sp, ʂp, sr, ʂr, ss, sʂ, st, ʂt, ʂtʂ, sʦ, sw, sx, tf, tʂf, ʨf, tk, tl, ʨm, tr, tʂ, tʂʨ, tw, tʂw, tx, ʦm, ʦw, vd, vʥ, vj, vl, vm, vn, vɲ, vr, vw, vz, vʑ, vʐ, wz, xf, xl, xm, xr, xʂ, xʨ, xw, zb, zd, zʥ, zg, zj, zl, ʑl, zm, zn, zɲ, zr, ʑr, zv, zw, zʐ, ʐm, ʐɲ
Final	ɕɲ, ɕʨ, ft, j̃ɕ, jk, jm, jt, kl, ks, kt, lk, lm, lʂ, lt, lʦ, mf, mn, mp, mʂ, ns, nʂ, nt, ntʂ, ɲʨ, nʦ, ŋk, pr, ps, pʂ, rɕ, rf, rk, rm, rp, rs, rʂ, rt, rʨ, sk, st, ʂt, ʂtʂ, sw, ʂx, tm, tr, wf, wk, wm, w̃s, w̃ʂ, wt, w̃x, zm

Table 14. The list of Polish word-initial and -final clusters extracted from the dictionary

3.2. Goal of the study

The objective of the paper is to trace the difference between the two phonotactic principles, namely the Sonority Sequencing Generalization and Net Auditory Distance, in evaluating Polish consonant clusters. To provide a fine-grained analysis, we perform morphological parsing of word-initial and final clusters and draw conclusions within each category of clusters separately. Since the SSG and NAD differ in a set of criteria and well-formedness requirements which determine cluster goodness, we expect to observe different outcomes in cluster evaluation. However, we are particularly interested in testing the extent to which these approaches differ, which cluster types are affected and in what way. The resulting difference in cluster status can be illustrated with the example of word-initial /sn-/ as in *sny* 'dreams'. According to the SSG, sonority rises from the fricative /s/ through the nasal /n/ to the following vowel, which is in accordance with the preferred sonority profile. In terms of NAD, /sn-/ is dispreferred since the distance between the adjacent consonants C1C2 is smaller than the distance between C2 and the vowel.

The assessment of the two approaches will be performed in the following way. Firstly, we compare how clusters are evaluated by the SSG and NAD. In other words, we check how well the structure of the extracted word-initial and -final clusters meets the criteria imposed by the two methods. As a result, we obtain two sets of clusters for each word position, namely preferred or dispreferred. Emphasis is placed on clusters which are evaluated differently by the two principles. Secondly, in our analysis we maintain the division into phonotactic and morphonotactic clusters, the latter of which happen to be more complex. Therefore, we are interested in checking whether both measures capture the relation between cluster preferability and morphological complexity. Each analysis is performed on the basis of cluster types and word types.

4. Results

Below, we present the differences and similarities in the evaluation of clusters by the SSG and NAD. Tables 15 and 16 as well as Figures 2 and 3 provide the summary of results obtained for initial sequences. Tables 17 and 18 together with Figure 4 constitute an overview of results for final clusters. In each graph, the notation 'ct' stands for cluster types and 'wt' word types. The entire database analysed contains 199 cluster types, represented by 2705 word types. 42 cluster types, represented by 886 words, were evaluated differently. This constitutes a 21% difference in the case of cluster types, and a 33% difference in the group of word types.

In the word-initial position, 29 cluster types, represented by 529 words, were evaluated differently by the two approaches, indicated in gray-shaded cells in Tables 15 and 16.

		Preferred	Dispreferred
lex	NAD	54	52
	SSG	79	27
difference by		25	
morph	NAD	4	17
	SSG	7	14
difference by		3	
mixed	NAD	5	13
	SSG	6	12
difference by		1	

Table 15. NAD vs SSG juxtaposition: word-initial cluster types

		Preferred	Dispreferred
lex	NAD	1031	853
	SSG	1539	345
difference by		508	
morph	NAD	56	197
	SSG	77	176
difference by		21	

Table 16. NAD vs SSG juxtaposition: word-initial word types

As can be seen in Figure 2 (initial lexical clusters), 24% of cluster types are evaluated differently (25 out of 106), which corresponds to 27% of word types (508 out of 1884).

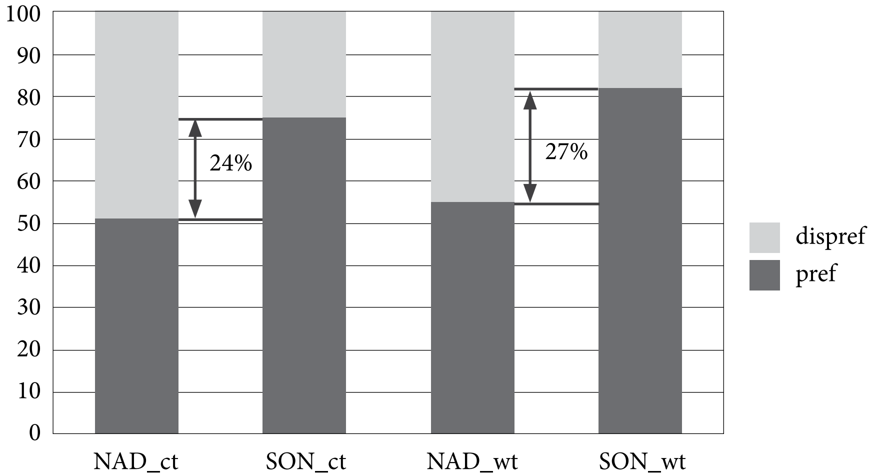

Figure 2. NAD vs SSG juxtaposition: word-initial lexical cluster types (ct) and word types (wt)

In Figure 3 (initial morphonotactic clusters), we can observe smaller differences in the evaluation of clusters. Only 14% of clusters (3 out of 21) changed their status from preferred by the SSG to dispreferred by NAD, which corresponds to 8% of word types (21 out of 253). On this basis, we conclude that the application of the two methods affects the class of lexical clusters to a larger extent than the morphonotactic class.

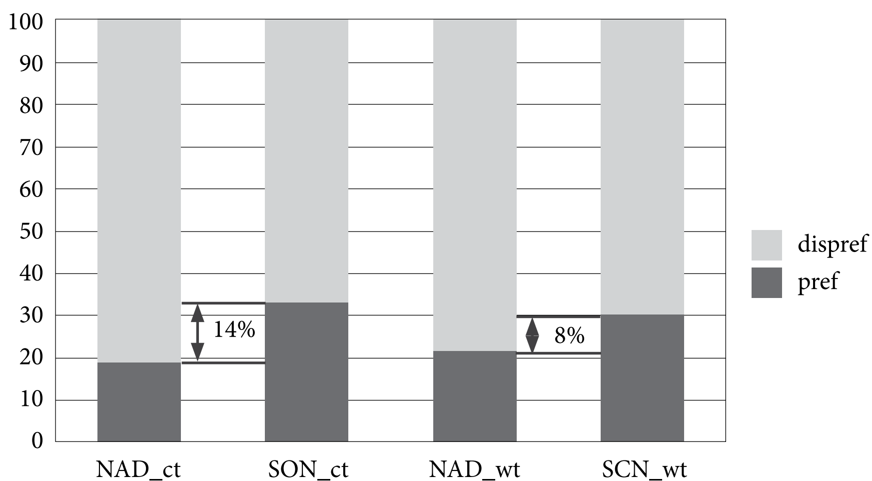

Figure 3. NAD vs SSG juxtaposition: word-initial morphonotactic cluster types (ct) and word types (wt)

The 29 cluster types which are evaluated differently (as dispreferred by NAD and preferred by the SSG) include: lexical /bʐ- ɕɲ- dv- ʤv- ʥv- dʐ- gʥ- gv- gʐ- kɕ- kf- kʂ- ml- ps- pʂ- px- sn- ʂn- ʨf- tf- tʂ- tʂf- tx- vn- ʐɲ-/, morphonotactic /pɕ- vm- zɲ-/ and mixed /zn-/. These clusters satisfy the condition of a rise in sonority minimally, by 0.5 or 1 point of distance. Therefore, when more-varied and strict criteria are imposed, as is the case in NAD, the borderline preferred clusters change the status to dispreferred. NAD, being a more sensitive and more differentiating measure of cluster goodness, has a greater chance of rejecting clusters on perceptual grounds.

In Table 17, which presents word-final phonotactics, we can observe that 13 out of the total of 54 cluster types (24%) have a different preference status in terms of the SSG and NAD. This corresponds to 357 out of 568 words (63%), shown in Table 18. The clusters are dispreferred by NAD, but compatible with the preferred sonority profile minimally; the sonority distances amount to 0.5, 1 or 1.5 for, e.g. /-ʂtʂ/, /-lm/ and /-ntʂ/, respectively.

Size		Preferred	Dispreferred
lex	NAD	28	24
	SSG	39	13
difference by		11	
morph	NAD	0	0
	SSG	0	0
difference by		0	
mixed	NAD	0	2
	SSG	2	0
difference by		2	

Table 17. NAD vs SSG juxtaposition: word-final cluster types

Size		Preferred	Dispreferred
lex	NAD	151	208
	SSG	299	60
difference by		148	
morph	NAD	0	209
	SSG	209	0
difference by		209	

Table 18. NAD vs SSG juxtaposition: word-final word types

Figure 4 presents word-final lexical cluster types and word types. As can be seen, there are 11 out of 52 (20%) lexical cluster types /-ft -lm -mf -ns -nʂ -nʦ -ntʂ -sk -st -ʂt -ʂtʂ/, which are represented by 148 out of 359 (41%). Additionally, there and 2 mixed cluster types /ɕʨ ɲʨ/ which change the preferability status. The data does not contain exclusively morphonotactic clusters; /-ɕtɕ -ɲtɕ/ can be both morphonotactic and lexical as in *iś+ć* 'to go' and *miłość* 'love', *znikną+ć* 'to disappear' and *chęć* 'willingness', and are thus classified under the mixed category.

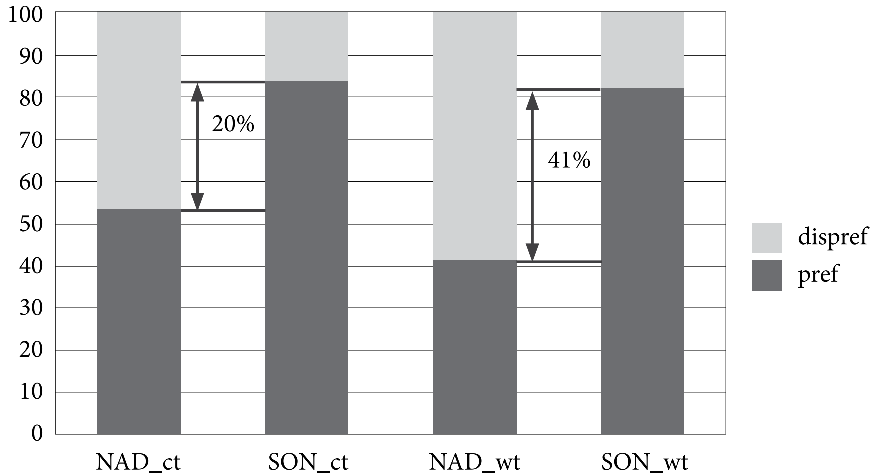

Figure 4. NAD vs SSG juxtaposition: word-final lexical cluster types (ct) and word types (wt)

As regards the second goal of our analysis, we tested whether both the SSG and NAD capture the relation between cluster preferability and morphological complexity. Our previous work based on a large database revealed that the degree of phonological preferability measured by NAD is related to the morphological status of a cluster (Dziubalska-Kołaczyk 2014; Orzechowska 2009; Zydorowicz *et al.* 2016). I.e., morphonotactic clusters are expected to be dispreferred and phonotactic preferred in terms of NAD. The initial statistical testing assumed performing Pearson's Chi-squared analyses (with Yeate's correction for continuity when necessary) of the relationship between the morphological status of a cluster and cluster preferability. Due to insufficient data (numbers below 5), some of the calculations could not be performed. Therefore, in the following discussion, we include the Chi-square values only when possible. Figures 5 and 6 present the classification of lexical and morphonotactic clusters as preferred and dispreferred according to NAD. Firstly, we report on the results obtained for word-initial cluster types, and next proceed to the discussion on words containing such clusters.

The results for word-initial double clusters have shown a correlation between the morphological status of a cluster and its preferability, both in cluster types and word types. As for cluster types, exclusively morphonotactic clusters

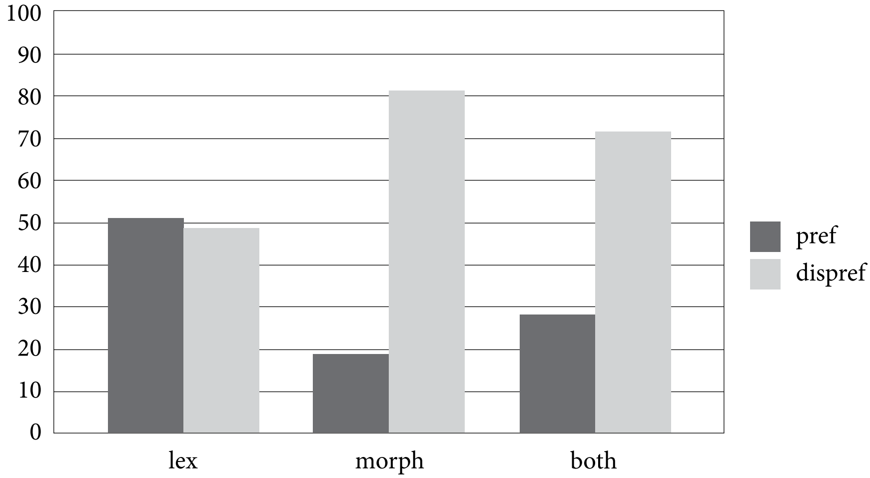

Figure 5. Word-initial CC clusters according to NAD: cluster types

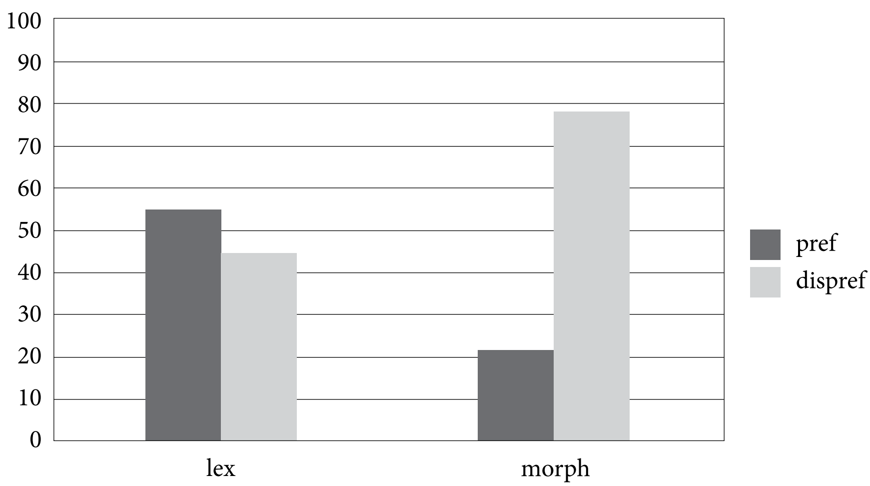

Figure 6. Word-initial CC clusters according to NAD: word types

are dispreferred in terms of NAD (81%). Similarly, clusters which may take both realizations, are largely dispreferred (72%). Interestingly, in the group of lexical clusters we can observe that the proportion of preferred and dispreferred clusters is comparable; 51% of lexical clusters are preferred and 49% are dispreferred. As regards word types, morphonotactic clusters are strongly dispreferred (78%), while lexical clusters are again preferred / dispreferred to a similar degree (55% and 45% respectively). For word types, $p < 0.001$.

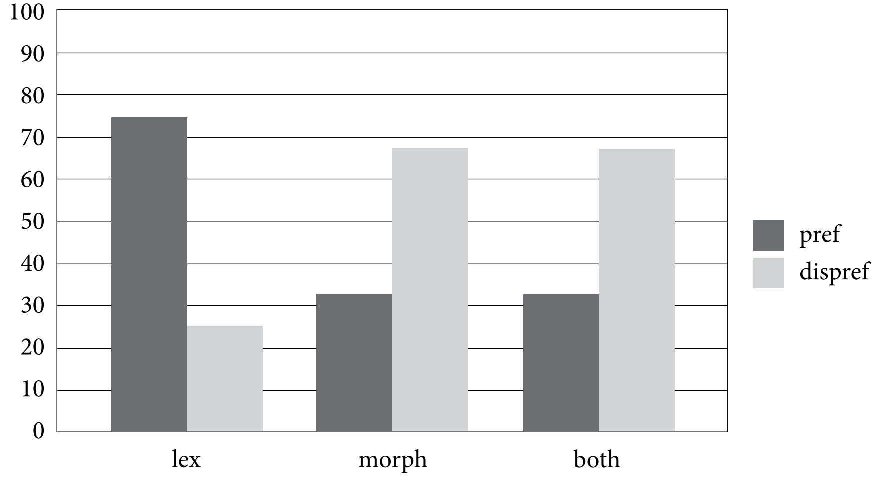

Figure 7. Word-initial CC clusters according to the SSG: cluster types

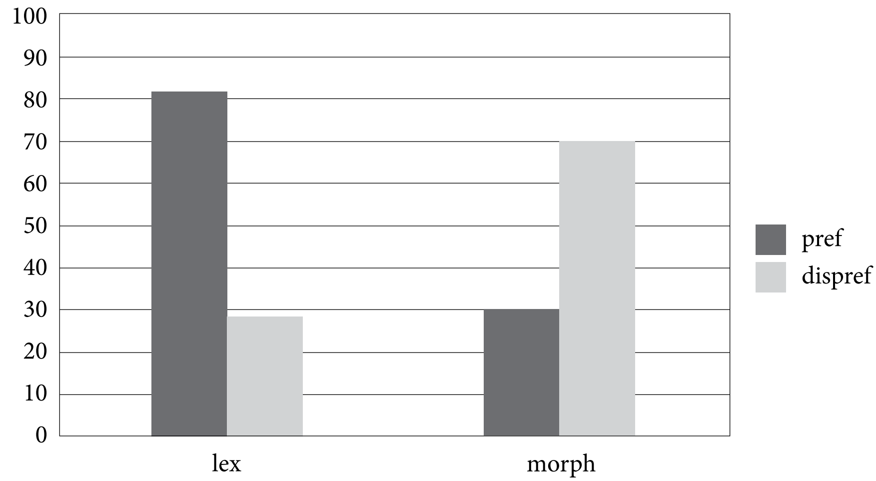

Figure 8. Word-initial CC clusters according to the SSG: word types

The results obtained for the sonority measure differ from NAD for lexical clusters. The vast majority of lexical cluster types are preferred (75%) in terms of the SSG. As in the case of NAD, among morphonotactic and mixed cluster types, dispreferred clusters prevail (67% in both cases). Here, the p-value amounts to < 0.001. A similar distribution can be observed for word types, where most lexical clusters are preferred (82%), whereas morphonotactic clusters are dispreferred (70%); $p < 0.001$.

Now we move on to the discussion of clusters in the word-final position. The results for double cluster types as well as word types are presented in Figures 9–12. Figure 9 illustrates the preferability of cluster types in the lexical, morphonotactic and mixed groups. The lexical group comprises both preferred and dispreferred clusters (54% and 46% respectively). Mixed cluster types are exclusively dispreferred, however, it must be born in mind that only 2 types fall into this category, namely, /-ɲɕ/ and /-ɕtɕ/). No exclusively morphonotactic cluster types are found in the dictionary. The analysis of word types shown in Figure 10 reveals that morphonotactic clusters violate the NAD principle by being dispreferred. By the same token, they confirm our hypothesis that morphologically motivated clusters tend to be dispreferred. Lexical clusters display a mixed character, with dispreferred clusters prevailing (58%).

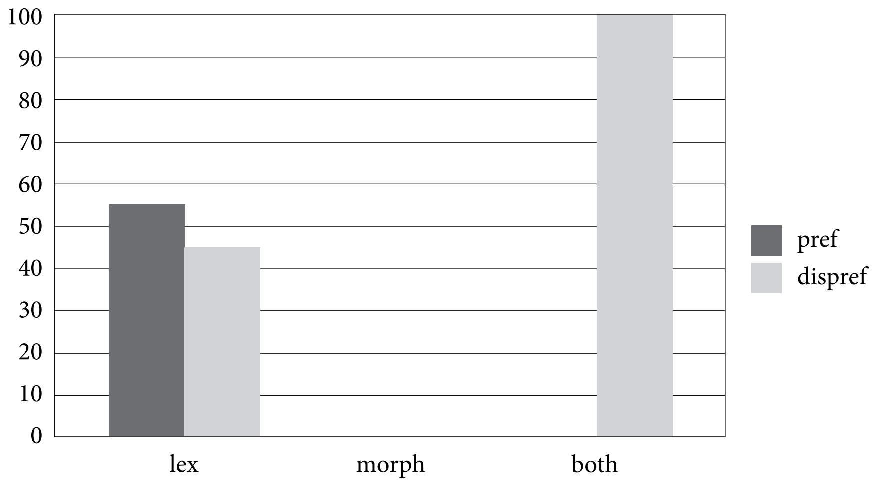

Figure 9. Word-final CC clusters according to NAD: cluster types

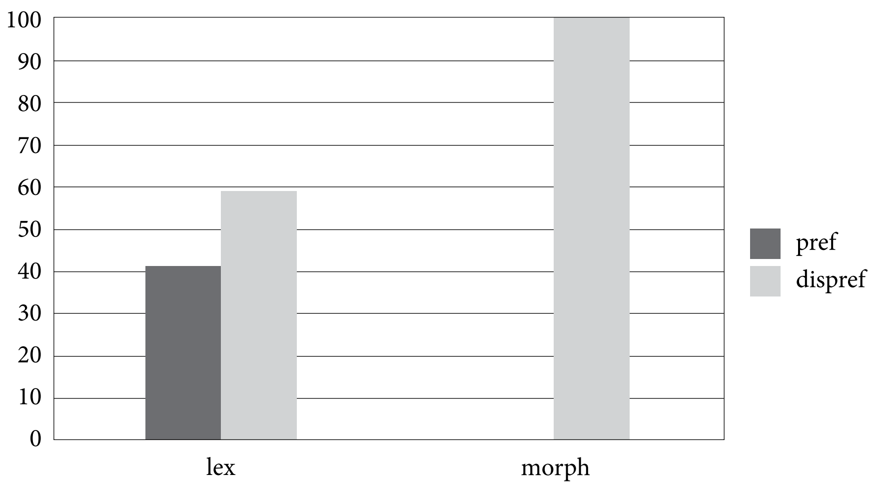

Figure 10. Word-final CC clusters according to NAD: word types

The evaluation of clusters in terms of the SSG is given in Figures 11 and 12. As far as sonority is concerned, the majority of lexical clusters are preferred (75% for cluster types and 85% for word types). Two mixed cluster types (/-ɲɕ/ and /-ɕtɕ/) follow the preferred sonority profile, but violate the NAD well-formedness conditions.

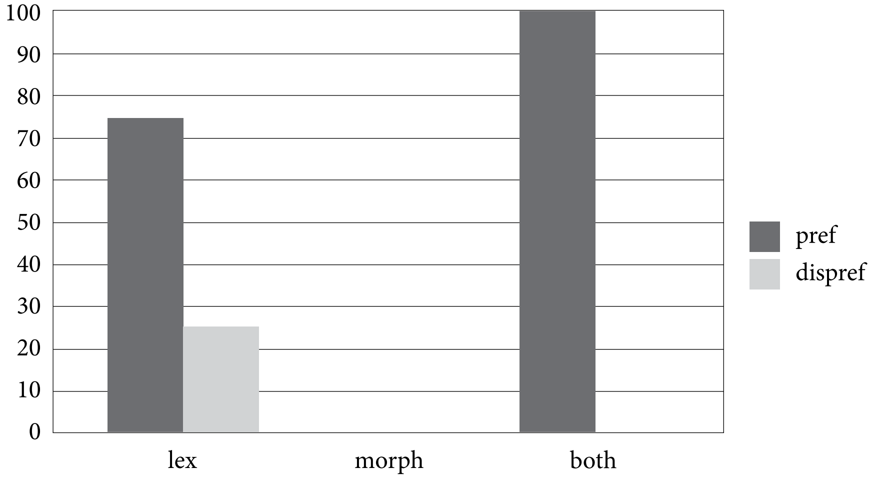

Figure 11. Word-final CC clusters according to the SSG: cluster types

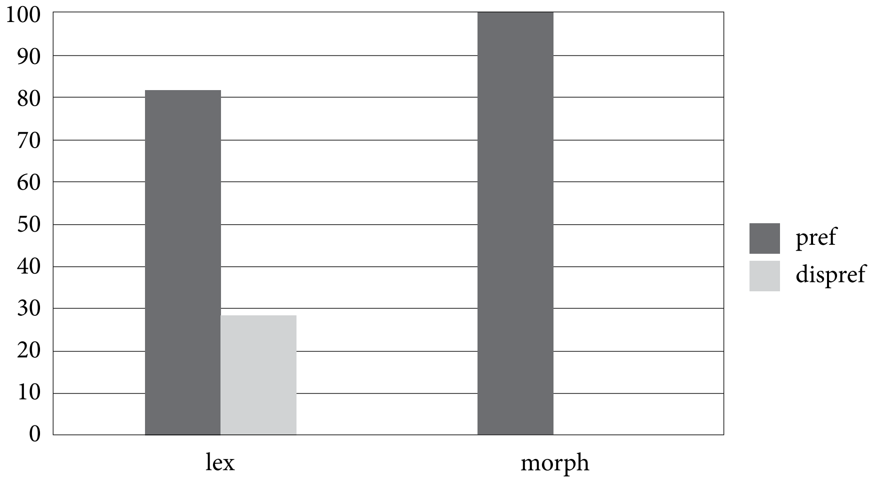

Figure 12. Word-final CC clusters according to the SSG: word types

5. Discussion

In this contribution, we analysed Polish word-initial and -final (mor)phonotactics according to two principles assessing phonotactic preferability; the Sonority Sequencing Generalisation and Net Auditory Distance. The sonority hierarchy we selected entails measurements based on the manner of articulation, whereas NAD uses a wider range of criteria of phonotactic description, namely the manner and place of articulation, and obstruent / sonorant distinction. The goal of the paper was to evaluate Polish word-initial and final clusters by means of two different measures of phonotactic acceptability. The first step of our analysis consisted in comparing the differences in the evaluation of clusters within the two phonotactic measures by checking how well Polish clusters conform to the criteria imposed by the two principles. Next, we determined whether the SSG and NAD capture the correlation between cluster preferability and morphological complexity.

The general picture is that approximately a fifth of cluster types and a third of words were classified differently by the two approaches. All types which were marginally acceptable by the SSG turned out to violate the NAD requirements. With more criteria to satisfy, NAD transpires to be a more restrictive model for Polish phonotactics. As stated earlier, the NAD principle is based on several criteria (place of articulation, manner of articulation and the sonorant / obstruent distinction), while the sonority hierarchy mainly relies on the manner of articulation features. What is more, an increase in the manner of articulation towards the vowel is a sufficient criterion in the SSG but not in NAD. The NAD principle is based on a complex interplay of distances between adjacent consonants as well as preceding or following vowels. That is, the distance between a pair of consonants must be greater than or equal to the distance between a consonant and the neighouring vowel. For these reasons, the well-formedness conditions imposed by NAD are more difficult to satisfy. The results of the study show that NAD should be seen as a more analytic and sensitive measure, which pertains to greater phonetic detail than the SSG, and allows for classifying clusters according to more specific criteria. More clusters tend to be rejected in terms of well-formedness conditions by NAD than by the SSG, even more so word-finally. This means that we will observe a tendency for evaluating a large portion of clusters as dispreferred, particularly in phonotactically complex languages. NAD is also more differentiating in nature than sonority. This is manifested by different evaluations of clusters such as /pl tl kl/; in sonority they would be treated equally and classified as well-formed, while in NAD they could be placed on a scale from the most to the least preferred /pl/ > /kl/ > /tl/.

As regards the second goal of our study, we demonstrated that both principles confirm a relation between cluster preferability and morphological complexity. The intervention of morphology generated dispreferred clusters. The only exception is the treatment of final morphonotactic clusters, which are evaluated as dipreferred by NAD and preferred by the SSG. However, due to the limited data in the present sample (only 2 final morphonotactic types), no generalization can be drawn.

The predictions of the SSG and NAD, as discussed in this paper, should be tested empirically within areas of external evidence. It would be interesting to verify the results of this paper on the basis of the data coming from the first and second language acquisition, as well as connected speech processes. It might be the case that cluster reduction strategies will be based on a more restrictive approach. For instance, a frequent final cluster such as /-ɕtɕ/ tends to be simplified in adult spontaneous speech (108 reduced instances out of 159 potential occurrences in the corpus, Madelska 2005) in spite of being preferred by sonority and dispreferred in terms of NAD. Another set of empirically interesting data would entail the comparison of word and cluster types with token frequencies. To take the previous example, the final cluster /-ɕtɕ/ demonstrates a high token frequency in the written corpus but also a high reduction rate in the spoken corpus. This means that sonority provides a better evaluation of cluster goodness in terms of lexical statistics, while NAD may turn out to be more accurate for predicting the actual realization in production. Therefore, in order to verify which method provides a more adequate theoretical account of Polish phonotactics, a multilayered analysis as exemplified above is required. The behaviour of clusters in performance could shed some light on their actual preferability status.

References

Bargiełówna Maria (1950). Grupy fonemów spółgłoskowych współczesnej polszczyzny kulturalnej. *Biuletyn Polskiego Towarzystwa Językoznawczego* 10, 1–25.

Bartnicka-Dąbkowska Barbara, Sinielnikoff Roxana (1999). *Słownik podstawowy języka polskiego dla cudzoziemców*. Kielce: Wydawnictwo Takt.

Battistella Edwin L. (1990). *Markedness: The Evaluative Superstructure of Language*. Albany: State University of New York Press.

Bethin Christina Y. (1992). *Polish Syllables: The Role of Prosody in Phonology and Morphology*. Colombus, Ohio: Slavica Publishers.

Clements George N. (1990). The role of the sonority cycle in core syllabification. In *Papers in Laboratory Phonology*, vol. 1: *Between the Grammar and Physics of Speech*, John Kingston, Mary E. Beckman (eds.), 283–333. Cambridge: Cambridge University Press.

Cyran Eugeniusz, Gussmann Edmund (1999). Consonantal clusters and governing relations: Polish initial consonant sequences. In *The Syllable. Views and Facts*, Harry van der Hulst, A. Nancy Ritter (eds.), 219–249. Berlin: Mouton de Gruyter.

Dobrogowska Katarzyna (1984). Śródgłosowe grupy spółgłosek w polskich tekstach popularnonaukowych. *Polonica* 10, 15–34.

Dobrogowska Katarzyna (1990). Word internal consonant clusters in Polish artistic prose. *Studia Phonetica Posnaniensia* 2, 43–67.

Dobrogowska Katarzyna (1992). Word initial and word final consonant clusters in Polish popular science text and in artistic prose. *Studia Phonetica Posnaniensia* 3, 47–121.

Dressler Wolfgang U., Dziubalska-Kołaczyk Katarzyna (2006). Proposing morphonotactics. *Rivista di Linguistica* 18(2), 249–266.

Dressler Wolfgang U., Mayerthaler Willi, Panagl Oswald, Wurzel Wolfgang U. (1987). In *Leitmotifs in Natural Morphology*, Wolfgang U. Dressler (ed.), 3–24. Philadelphia: Benjamins.

Dukiewicz Leokadia (1980). Rodzaje i częstość występowania nagłosowych grup fonemów typu CC(V)-, CCC(V)- i CCCC(V)- w polskich tekstach prasowych. *Lětopis Instituta za Serbski Ludospyt* 27(2), 142–157.

Dukiewicz Leokadia (1985). Nagłosowe grupy spółgłosek w polskich tekstach popularnonaukowych i prasowych. *Studia Gramatyczne* 6, 17–34.

Dunaj Bogusław (1985). *Grupy spółgłoskowe współczesnej polszczyzny mówionej*. Warszawa: Polska Akademia Nauk.

Dunaj Bogusław (1986). Wygłosowe grupy spółgłoskowe współczesnej polszczyzny mówionej. *Zeszyty Naukowe Uniwersytetu Jagiellońskiego: Prace Językoznawcze* 82, 103–117.

Durand Pierre, Gubrynowicz Ryszard (1999). On the reduction of consonant clusters in Polish according to emotional situation. *Proceedings of the 14th International Congress of Phonetic Sciences*, 2113–2115.

Dziubalska-Kołaczyk Katarzyna (ed.) (2001). *Constraints and Preferences*. Berlin: Mouton de Gruyter.

Dziubalska-Kołaczyk Katarzyna (2002). *Beats-and-Binding Phonology.* Frankfurt am Main: Peter Lang.

Dziubalska-Kołaczyk Katarzyna (2009). NP extension: B&B phonotactics. *Poznań Studies in Contemporary Linguistics* 45(1), 55–71.

Dziubalska-Kołaczyk Katarzyna (2014). Explaining phonotactics using NAD. *Language Sciences* 46, part A, 6–17.

Dziubalska-Kołaczyk Katarzyna (2015). Are frequent, early and easy clusters also unmarked? *Italian Journal of Linguistics* 27(1), 29–44.

Dziubalska-Kołaczyk Katarzyna, Zielińska Daria (2011). Universal phonotactic and morphonotactic preferences in second language acquisition. In *Achievements and Perspectives in SLA of Speech: New Sounds 2010*, Katarzyna Dziubalska-Kołaczyk, Magdalena Wrembel, Małgorzata Kul (eds.), 53–63. Frankfurt am Main: Peter Lang Verlag.

Dziubalska-Kołaczyk Katarzyna, Wierzchoń Piotr, Jankowski Michał, Orzechowska Paula, Zydorowicz Paulina, Pietrala Dawid (2012). Phonotactics and morphonotactics of Polish and English: description, tools and applications. Unpublished research project report: Adam Mickiewicz University, Poznań.

Dziubalska-Kołaczyk Katarzyna, Zydorowicz Paulina (2014). The production of high-frequency clusters by native and non-native users of Polish. *Concordia Working Papers in Applied Linguistics* 5, 130–144.

Foley James (1972). Rule precursors and phonological change by meta-rule. In *Linguistic Change and Generative Theory*, Robert Stockwell, Ronald Macauley (eds.), 96–100. Bloomington: Indiana University Press.

Gussmann Edmund, Cyran Eugeniusz (1998). Polish consonantal sequences: A phonological testing ground. In *Structure and Interpretation. Studies in Phonology*, Eugeniusz Cyran (ed.), 127–138. Lublin: Folium.

Jakobson Roman (1941). *Child Language, Aphasia and Phonological Universals*. The Hague: Mouton.

Jarosz Gaja, Calamaro Shira, Zentz Jason (2016). Input frequency and the acquisition of syllable structure in Polish. *Language Acquisition*, 1–39. (URL: ttp://dx.doi.org/10.1080/10489223.2016.1179743, accessed April 29, 2017)

Jespersen Otto. 1913. *Lehrbuch der Phonetik*, 2nd edn. Leipzig: Teubner.

de Lacy Paul (2006). *Markedness: Reduction and Preservation in Phonology*. Cambridge: Cambridge University Press.

Ladefoged Peter (2011). *A Course in Phonetics*. Boston: Thomson Higher Education.

Łukaszewicz Beata (2007). Reduction in syllable onsets in the acquisition of Polish: deletion, coalescence, metathesis and gemination. *Journal of Child Language* 34(1), 53–82.

Madejowa Maria (1990). Modern Polish linguistic norms with reference to the pronunciation of consonant clusters. *Studia Phonetica Posnaniensia* 2, 69–105.

Madelska Liliana (2005). *Słownik wariantywności fonetycznej współczesnej polszczyzny*. Kraków: Collegium Columbinum.

Milewski Stanisław (2005). Grupy spółgłoskowe w języku mówionym dzieci przedszkolnych. *Logopeda* 1, 5–32.

Orzechowska Paula (2009). Morphonotactics in English and Polish. A dictionary- and corpus-based study of word-final consonant clusters. Poznań: Adam Mickiewicz University, Ph.D. dissertation.

Orzechowska Paula (2012). Effects of morphology on the syllables structure. In *Monosyllables: From Phonology to Typology*, Thomas Stolz, Nicole Nau & Caroline Stroh (eds.), 93–113. Berlin: Akademie Verlag.

Orzechowska Paula, Wiese Richard (2015). Preferences and variation in word-initial phonotactics: a multi-dimensional evaluation of German and Polish. *Folia Linguistica* 49, 439–486.

Parker Steve (ed.) (2012). *The Sonority Controversy*. Berlin: Walter de Gruyter.

Rochoń Marzena (2000). *Optimality in Complexity: The Case of Polish Consonant Clusters* (*Studia Grammatica* 48). Berlin: Akademie Verlag.

Rubach Jerzy (1996). Nonsyllabic analysis of voice assimilation in Polish. *Linguistic Inquiry* 27(1), 69–110.

Scheer Tobias (2007). On the status of word-initial clusters in Slavic (and elsewhere). In *Annual Workshop on Formal Approaches to Slavic Linguistics. The Toronto Meeting 2006*, Richard Compton, Magdalena Goledzinowska, Ulyana Savchenko (eds.), 346–364. Ann Arbor: Michigan Slavic Publications.

Scheer Tobias (2008). Syllabic and trapped consonants in (Western) Slavic: Different but still the same. In *Formal Description of Slavic Languages: The Fifth Conference, Leipzig 2003*, Gerhild Zybatow, Luka Szucsich, Uwe Junghanns, Roland Meyer (eds.), 149–167. Frankfurt am Main: Peter Lang.

Selkirk Elisabeth O. (1984). On the major class features and syllable theory. In *Language Sound Structure*, Mark Aronoff, Richard T. Oehrle (eds.), 107–136. Cambridge, MA: MIT Press.

SIEVERS Eduard (1901). *Grundzüge der Phonetik: Zur Einführung in das Studium der Lautlehre der Indogermanischen Sprachen*. Leipzig: Breitkopf & Härtel.

STERIADE Donca (1999). Alternatives to the syllabic interpretation of consonantal phonotactics. In *Item Order in Language and Speech*, Osamu FUJIMURA, Brian D. JOSEPH, Bohumil PALEK (eds.), 205–242. Columbus, OH: The Karolinum Press.

ŚLEDZIŃSKI Daniel (2005). Indeks zbitek spółgłoskowych języka polskiego z przykładami. Poznań: Adam Mickiewicz University, Instytut Językoznawstwa, unpublished MS.

TAMBURELLI Marco, SANOUDAKI Eirini, JONES Gary, SOWINSKA Michelle (2015). Acceleration in the bilingual acquisition of phonological structure: Evidence from Polish–English bilingual children. *Bilingualism: Language and Cognition* 18(4), 713–725.

TRUBETZKOY Nikolai (1939). *Grundzuge der phonologie*. Göttingen: Vandenhoeck und Ruprecht [*Principles of Phonology*, translated by C. Baltaxe. Berkeley and Los Angeles: University of California Press, 1969].

VENNEMANN Theo (1988). *Preference Laws for Syllable Structure and the Explanation of Sound Change*. Berlin: Mouton de Gruyter.

WHITNEY William D. (1865). The relation of vowel and consonant. *Journal of the American Oriental Society* 8, 277–300.

WIESE Richard, ORZECHOWSKA Paula, ALDAY Phillip, ULBRICH Christiane (2017). Structural principles or frequency of use? An ERP experiment on the learnability of Polish consonant clusters. *Frontiers in Psychology – Auditory Cognitive Neuroscience* 7:2005. doi: 10.3389/fpsyg.2016.02005.

YAVAŞ Mehmet, MARECKA Marta (2014). Acquisition of Polish #sC clusters in typically-developing children and children with phonological disorders. *International Journal of Speech-Language Pathology* 16(2), 132–141.

ZYDOROWICZ Paulina (2010). Consonant clusters across morpheme boundaries: Polish morphonotactic inventory and its acquisition. *Poznań Studies in Contemporary Linguistics* 46(4), 565–588.

ZYDOROWICZ, Paulina, ORZECHOWSKA Paula, JANKOWSKI Michał, DZIUBALSKA--KOŁACZYK Katarzyna, WIERZCHOŃ Piotr, PIETRALA Dawid (2016). *Phonotactics and Morphonotactics of Polish and English: Description, Tools and Applications*. Poznań: Wydawnictwo Naukowe UAM.

Paulina Zydorowicz (corresponding author)
zpaula(at)wa.amu.edu.pl
Faculty of English
Adam Mickiewicz University
al. Niepodległości 4
61-874 Poznań, Poland

Paula Orzechowska
paulao(at)wa.amu.edu.pl
Faculty of English
Adam Mickiewicz University
al. Niepodległości 4
61-874 Poznań, Poland