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# The Production of High-Frequency Clusters by Native and Non- Native Users of Polish

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## Abstract

In this contribution we investigate the production of Polish high-frequency consonant clusters by learners of Polish as a second language in comparison to native speakers of Polish. For the purpose of the study we choose the most frequent clusters of different sizes in the word initial, medial and final position. The frequency of clusters (understood as corpus frequency) is determined on the basis of a newspaper corpus containing nearly 50 million word tokens (Dziubalska-Kořaczyk et al., 2012). The target clusters are embedded in a text, which the non-native speakers, whose L1 is a CV language, are asked to read casually, whereas the native subjects are asked to read using first casual and then accelerated speech tempo. The production of clusters in the reading task is also investigated from the point of view of markedness. The model used for the analysis of cluster production vs simplification is the Net Auditory Distance principle (NAD). It is hypothesised that clusters which are preferred from the point of view of NAD will be produced more successfully than dispreferred clusters.

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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 as many as 4 consonants word-initially, 6 consonants word-medially, and 5 consonants word-finally (Dziubalska-Kończak et al., 2012). Moreover, sandhi phenomena allow up to 11 consonants. Table 1 below provides examples of phonotactic possibilities in Polish in terms of cluster size.

**Table 1.** Phonotactic and morphonotactic possibilities in Polish in terms of cluster size.

cluster size	initial	medial	final
CC	ptak s kończyć	aktor od dać	wiatr iś ć
CCC	stres s tracić	ostrzy od kryć	tekst zejś ć
CCCC	pstry ws trzymać	ekstra roz trwonić	- głup stw
CCCCC	-	- bez względny	- przestęp stw
CCCCCC	-	- wewnątrz związkowy	-
CCCCCCCCC (sandhi)	-	przestępstw z pstrągiem /pʃestempstf s pstrongiem/	-

Polish consonant clusters can be phonotactic or morphonotactic. (Dressler & Dziubalska-Kończak, 2006). The former ones are phonologically motivated and occur within a single morpheme, e.g. /str-/ in *stres* 'stress', whereas the latter ones arise due to concatenative and non-concatenative morphology. Concatenation is a morphological process, which involves affixation, e.g. /str-/ in *s|tracić* 'to lose'. Non-concatenative morphology may be illustrated by the rule of vowel ~ zero alternation, e.g. /ln/ in *lnu* 'linen'-GEN.SG. (from *len* 'linen'-NOM.SG.) or zero-Genitive-Plural formation, in which case a medial cluster changes into a final one, and as such is more difficult to pronounce, e.g. /-pstf/ in *głupstw* 'silliness'-GEN.PL. (from *głupstwo* 'silliness'-NOM.SG.) (Dressler & Dziubalska-Kończak, 2006). Morphonotactic clusters may be more complex in terms of length (resulting in the emergence of 4-, 5-, or 6-member clusters), as well as their phonological structure (some morphonotactic clusters never occur intramorphemically, e.g. initial /fx/ in *wchodzić* 'to go inside'). The examples presented in Table 1 include phonotactic as well as morphonotactic clusters (the presence of a morphological boundary is indicated by the following notation: x|x).

In casual speech of native speakers of Polish these impressive sequences

are often simplified (cf. Dukiewicz & Sawicka, 1995; Dunaj, 1985; Madejowa, 1993; Madelska, 2005). Complex consonant sequences often pose difficulties for second language learners whose L1 phonotactic inventories are less complex. Possible cluster modification strategies include: deletion of one or more elements in a cluster, epenthesis, metathesis, substitution, pause insertion as well as cluster extension.

The aim of this contribution is to investigate the production of Polish high-frequency consonant clusters by learners of Polish as a foreign language in comparison to native speakers of Polish. Moreover, consonant cluster production will be analysed from the point of view of cluster markedness, as defined by the Net Auditory Distance principle.

## THE FRAMEWORK

The theoretical framework for measuring cluster markedness is that of Beats-and-Binding phonotactics (cf. Dziubalska-Kořaczyk 2002, 2009). It specifies phonotactic preferences as well as the way to evaluate clusters according to them. The rationale behind this model of phonotactics is to counteract the preference for CV. Since CV is a preferred phonological structure and clusters of consonants tend to be avoided across languages and in performance, there must be a phonological means to let them function in the lexicon relatively naturally. This is achieved by auditory contrast and its proper distribution across the word. It is believed that auditory (perceptual) distance can be expressed by respective combinations of articulatory features which eventually bring about the auditory effect.

Any cluster in a structure which is more complex than CV is susceptible to change leading to CV, e.g. via cluster reduction (consonant deletion)  $CCV \rightarrow CV$  or vowel epenthesis  $CCV \rightarrow CVCV$  or at least vowel prothesis  $CCV \rightarrow VCCV$ . A way to counteract this tendency is to increase the perceptual distance between the consonants (CC of the CCV) to counterbalance the distance between the C and the V (CV of the CCV). This distance will be expressed by NAD. Besides, cluster size remains an obvious measure of cluster complexity: longer clusters are unanimously more complex than the shorter ones.

NAD (Net Auditory Distance) is a measure of distance between two neighbouring elements of a cluster in terms of differences in MOA (manner of articulation) and POA (place of articulation). A general NAD table includes MOAs and 5 POAs, in which manners refer to the most generally acknowledged version of the so-called sonority scale, while

places are taken from Ladefoged (2006, p. 258). For particular languages, more detailed tables can be devised, reflecting the differences between systems as well as including more detailed MOA and POA scales, as in the table for Polish (see Table 2). Tentatively<sup>1</sup>, also voice value was included in the calculation (designated as Lx, and the values 0 for voiceless and 1 for voiced).

As an example, let us consider the preference concerning word initial two-consonant clusters C1C2V, which reads:

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

*In word-initial double clusters, NAD between the two consonants should be greater than or equal to NAD between a vowel and a consonant neighbouring on it.*

The calculation of distances according to the values in the table is illustrated below.

$$\text{NAD CC} = |(\text{MOA1} - \text{MOA2})| + |(\text{POA1} - \text{POA2})| + |(\text{Lx1} - \text{Lx2})|$$

$$\text{NAD CV} = |\text{MOA1} - \text{MOA2}| + |(\text{Lx1} - \text{Lx2})|$$

e.g., *prV* in Polish

$$\text{pr: } |(\text{MOA1} - \text{MOA2})| + |(\text{POA1} - \text{POA2})| + |(\text{Lx1} - \text{Lx2})|$$

$$|5 - 2| + |1 - 2.3| + |0 - 1| = |3| + |1.3| + |1| = 5.3$$

so, NAD CC = 5.3

$$\text{rV: } |\text{MOA1} - \text{MOA2}| + |(\text{Lx1} - \text{Lx2})| = |2 - 0| + |1 - 1| = 2$$

$$\text{NAD CV} = 2$$

so, the preference NAD (C1,C2) ≥ NAD (C2,V) is observed since 5.3 > 2.

Phonotactic complexity is thus measured by NAD and cluster size, and responds to position in a word. Even more complexity is created when a need to signal a morphological boundary overrides a phonologically driven phonotactic preference and, consequently, leads to the creation of a marked cluster. Therefore, one expects relatively marked clusters across morpheme boundaries and relatively unmarked ones within morphemes.

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<sup>1</sup> Although the difference in voicing (Lx) has been considered, laryngeal features are non-redundant within subclasses of sounds only (e.g., they are non-redundant within obstruents and largely redundant within sonorants) and as such will have to be included in more refined, class-specific calculations in the future research.

**Table 2.** Distances in MOA and POA: Polish

OBSTRUENT			SONORANT					VOWEL		
PLOSIVE	FRICATIVE		NASAL	LIQUID		GLIDE				
	AFFRICATE			lateral	rhotic					
5.0	4.5	4.0	3.0	2.5	2.0	1.5	1.0	0		
p b			m			w	wɸ	1.0 bilabial	LABIAL	
		f v						1.5 labio-dental		
t d	ts ɖ	s z	n	l				2.0 (post-)dental	CORONAL	
	tʂ dzʲ	ʂ zʲ			r			2.3 alveolar		
	tɕ ɕ	ɕ ʐ	ɲ					2.6 alveolo-palatal		
						j	jɸ	3.0 palatal	DORSAL	
k g		x	ŋ			w	wɸ	3.5 velar		
								4.0	RADICAL	
								5.0	GLOTTAL	

## THE EMPIRICAL STUDY

### Predictions

The aim of this contribution is the investigation of cluster simplification processes in the spoken performance of native speakers and non-native speakers of Polish. Several parameters are investigated, namely, cluster size, cluster position in a word, markedness, reading tempo, as well as native and non-native production. It is predicted that the number of cluster simplification processes will increase along with cluster length. As regards the position of a cluster in a word, word-final position is likely to be the most vulnerable to change, word-initial most salient, and word-medial most tolerant of clusters. These cluster production patterns may interact with other parameters, namely cluster size and morphotactic complexity, the latter of which is not considered in this study due to the character of the sample (see below section *Materials*). Accelerated reading tempo will trigger cluster simplification. Finally, cluster simplification will be analysed from the point of view of phonological preferability / markedness. It is predicted that consonant clusters which are preferred in terms of NAD will be preserved in production more successfully than dispreferred clusters.

### Materials

For the purpose of the study we selected the most frequent consonant clusters of all sizes in all word positions (initial, medial and final). Cluster selection was based on a corpus study of Polish phonotactics and morphotactics (Dziubalska-Kotaczyk et al., 2012). Table 3 below presents the selection of target clusters.<sup>2</sup>

**Table 3.** Cluster selection.

position	size	selected clusters
initial	double	<u>pʃ</u> , <b>pr</b> , <b>st</b> , <u>mj</u> , <b>sp</b> , <u>vj</u>
	triple	<u>spr</u> , <u>ɕfj</u> , <b>fsp</b> , <u>zvj</u> , <b>spʃ</b> , <b>trf</b>
	quadruple	<u>stfj</u> , <u>vzgl</u> , <u>fstʃ</u> , <u>fspj</u> , <b>bʒmj</b>
medial	double	<u>st</u> , <b>vj</b> , <b>tsj</b> , <u>nt</u> , <u>ɕtɕ</u> , <b>rt</b>

<sup>2</sup> Underlined clusters = preferred according to NAD, clusters marked in bold = dispreferred according to NAD, gray-shaded clusters = not evaluated by NAD, as the criterion of size overrides phonological preference.

	triple	lsk, <b>str</b> , fsk, <b>ntsj</b> , <b>jsk</b> , tst
	quadruple	řstf, lskj, fskj, řskj, rstf
	5-member	mpstf, řstfj, rstfj, wstrj, zvzgl
	6-member	mpstfj
final	double	<b>st</b> , <del>ctc</del> , nt, <b>nts</b> , nk, rt
	triple	řctc, jctc, jsts, stf, kst, stf
	quadruple	pstf, řstf, řstf, jstf, msft
	5-member	mpstf

As regards doubles and triples, 6 clusters for each word position were selected, three of which conform to the NAD conditions and are considered preferred / unmarked. The remaining three clusters do not fulfil the NAD condition, and as a result, are considered dispreferred. Quadruple and 5-member clusters were represented by 5 different types (with the exception of final 5-member clusters, in which case the only representative is /mpstf/). Finally, one 6-member medial cluster was tested. Upon selecting consonant clusters presented in Table 3, the most frequent words featuring these clusters were extracted from the corpus (Dziubalska-Kořaczyk et al., 2012) and embedded in a text of 633 words (out of which 117 words were the targets of the study).<sup>3</sup> Frequency-based selection was to increase the probability of the non-native subjects' familiarity with the vocabulary included in the text. Only two- or three-beat words were selected in order to balance the pronunciation burden. In order to eliminate the emergence of sandhi phenomena, word-initial clusters were placed after a pause or a vowel, whereas word-final clusters were placed before a pause or a vowel.

It must be added that among the selected clusters there were purely phonotactic or purely morphonotactic clusters or clusters of the mixed type. A vast majority of longer (4-, 5-, and 6-member) clusters contained a morphological boundary, which is an inherent feature of this cluster size in Polish. Among doubles and triples there were test words containing phonotactic or morphonotactic clusters. Morphological status of a cluster may be a factor affecting cluster reduction rates, however, this variable is beyond the scope of the present study.<sup>4</sup>

<sup>3</sup> See appendix 1.

<sup>4</sup> The feedback received after carrying out the reading task revealed that the non-native subjects considered the text challenging and admitted that some words turned out to be unfamiliar to them. Word familiarity is a prerequisite for the study of the influence of morphology as a factor affecting cluster reduction.

In total we tested 58 clusters embedded in 117 words (41 words with initial clusters, 47 words with medial clusters, and 34 words with final clusters).<sup>5</sup> The non-native subjects provided 1220 cluster tokens (15 tokens were disqualified due to technical hitches or mispronunciations), whereas Polish native speakers provided 732 cluster tokens (15 tokens were disqualified due to technical hitches or mispronunciations).

### Subjects and the Task

The subjects of the study were 10 non-native speakers of Polish, whose native language shows a preference for a CV structure (the languages in question are Chinese, Japanese and Korean). The subjects, aged 21-47 (mean age 27.8) had been learning Polish as a foreign language for 2-5 years. Their length of residence in Poland ranged from 2 months to 6 years. The control group consisted of 3 native speakers of Polish whose mean age was 26.6.

The non-native speakers were asked to read the text using a casual speech tempo. The native speakers read the text twice: using casual and then accelerated speech tempo.

### RESULTS

Tables 4 and 5 show the reading time of the non-native and native users of Polish, which is indicative of the general fluency of each speaker.

**Table 4.** Reading time: non-native rendition (mean reading time: 699.5 sec)

	reading time
S1	8:34
S2	12:13
S3	12:49
S5	19:31
S6	9:35
S7	8:28
S8	8:50
S9	10:44
S10	9:34
S11	16:17

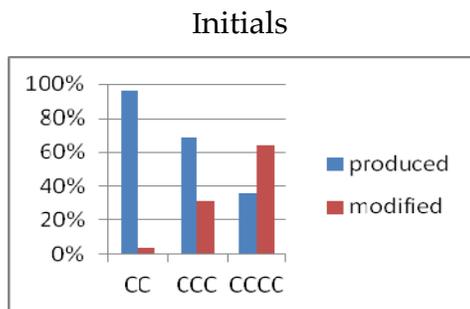
<sup>5</sup> The numbers do not sum up to 117 as 5 words contained 2 clusters (thus each subject produced 122 clusters).

**Table 5.** Reading time: native rendition (mean natural reading time: 274.3 sec mean accelerated reading time: 228.3 sec)

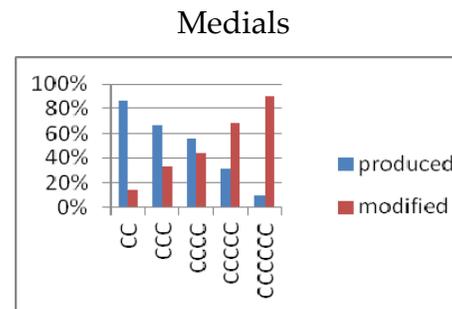
	reading time	
	natural	accelerated
S1	5:05	4:46
S2	4:32	3:33
S3	4:06	3:06

**Non-native Data**

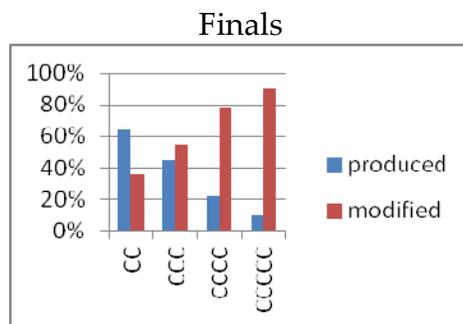
Figures 1-3 below present the percentage of accurate cluster production as well as cluster simplification in the performance of the non-native speakers. Figure 4 summarises the results of cluster simplification processes of doubles, triples and quadruples in all word positions.



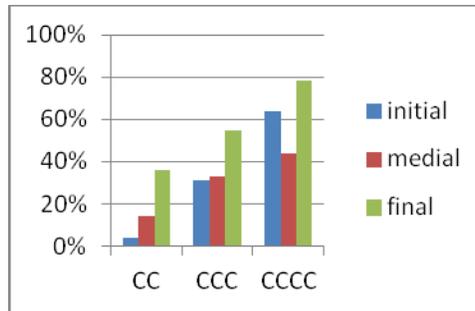
**Figure 1.** Non-native rendition of initials



**Figure 2.** Non-native rendition of medials



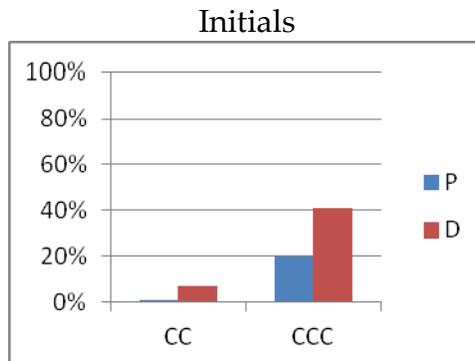
**Figure 3.** Non-native rendition of finals



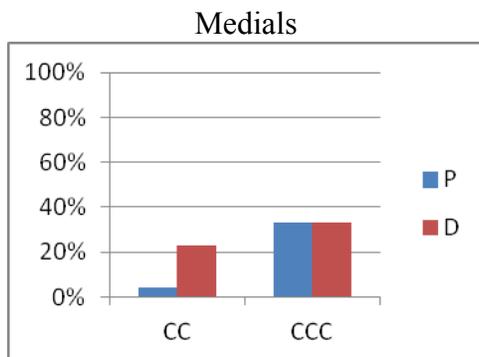
**Figure 4.** Cluster simplification vs cluster length

The results show that in all word positions, shorter clusters are produced more accurately than longer sequences. The number of correct productions decreases as clusters become longer. Secondly, double, triple and quadruple clusters in the word final position turned out to be the most susceptible to simplification processes. As regards the “safety” of medials, double medials turned out to be modified more frequently than initials, whereas triple medials were simplified as frequently as triple initials. Only in the group of quadruples were medials more stable than initials and finals. Double initials pose the least difficulty for second language learners, probably due to the salience of the initial position, which carries high informational load.

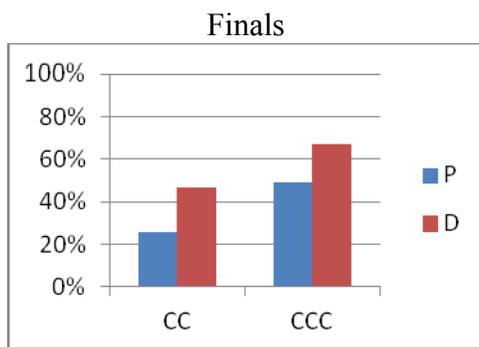
Figures 5-7 present the simplification rates of preferred and dispreferred clusters. The abbreviations “P” and “D” stand for preferred and dispreferred in terms of NAD, respectively.



**Figure 5.** Cluster simplification of preferred and dispreferred initials



**Figure 6.** Cluster simplification of preferred and dispreferred medials



**Figure 7.** Cluster simplification of preferred and dispreferred finals

The data show that dispreferred clusters undergo simplification more frequently than preferred clusters in all word positions, with the exception of triple medials (here the reduction rates are equal in both groups), for which phonological preference is less important than the position itself.

The non-native subjects applied numerous cluster simplification strategies, which have been listed below according to the frequency of application.

- Vowel insertion: *wolność* 'freedom' /volnoɛt/ > /volnoɛci/ or /volnozite/
- Substitution: *sprzęty* 'equipment' /spʃenti/ > /sprenti/
- Consonant deletion: *stacja* 'station' /statsja/ > /statea/
- Pause insertion: *kontaktów* 'contacts' /kontaktuf/ > /kon taktuf/
- Cluster extension: *stacja* 'station' /statsja/ > /stratsja/
- Metathesis: *trwają* 'they last' /trfajow̃/ > /tvarjow̃/

At times several strategies co-occurred, e.g. pause and epenthesis in *przestępstwie* /pʃestempstfje/ > /pʃestemp stovje/. The overall cluster modification rate amounted to 34%.

## Native Data

The Polish native speakers produced 672 word tokens (15 tokens were disqualified due to technical hitches or mispronunciations). Table 7 below presents native production of the tested clusters.<sup>6</sup>

**Table 7.** The percentage of correct cluster renditions produced by native subjects

	<b>initials</b>		<b>medials</b>		<b>finals</b>	
	N	A	N	A	N	A
double	100%	100%	98%	94%	87%	87%
triple	98%	100%	94%	92%	80%	61%
quadruple	93%	80%	100%	80%	79%	27%
5-member	-	-	73%	47%	33%	33%
6-member	-	-	0%	0%	-	-

N = natural speech tempo

A = accelerated speech tempo

Polish data show that initial clusters rarely undergo reduction. 4-member initial clusters are sporadically reduced in the accelerated reading style. As regards clusters in the word medial position, simplifications of doubles and triples are negligible. Longer medial clusters do become affected, especially in the accelerated reading style. Word-final clusters are most susceptible to reduction. Final cluster reduction occurs in both reading styles, however, more frequently in the accelerated reading style. The collected data show that Polish speakers simplify clusters more frequently as the speech tempo increases (there were 31 modifications in the natural reading style and 55 modifications in the accelerated reading style). The prevailing cluster modification strategy is consonant deletion. In contrast to the non-native data, epenthesis is not common. The total cluster simplification rate in the native speakers of Polish amounts to 13%.

## CONCLUSION

The aim of this study was to test the production of high-frequency consonant clusters in Polish among non-native and native speakers of Polish. The study showed that clusters in a word final position are the most susceptible to reduction in both groups of subjects. Secondly, in both

<sup>6</sup> The analysis of the native data comprises general cluster production rates in all word positions. Due to a limited number of native participants as well as rather low cluster reduction rates of doubles and triples, the analysis of preferred vs dispreferred cluster production / simplification will be possible when more data has been collected.

groups of subjects the rate of cluster simplification processes increases along with cluster length.

Although the non-native speakers were asked to read the text naturally, their competence in Polish allowed them to read it at a significantly slower pace than the native speakers. It is worth mentioning that although the Polish subjects read the text faster, they applied fewer cluster simplification processes than the non-native speakers. It is also noteworthy that the two groups of speakers resorted to different strategies of cluster simplification. The non-native subjects, who tried to preserve as much of the input as possible, applied epenthesis or substitution (deletion was only the third most popular strategy) whereas Polish speakers modified the cluster structure mainly through deletion. As regards the reading styles, accelerated reading tempo, adopted by the native subjects, triggered cluster reduction.

The data concerning the non-native production of clusters revealed the tendency for phonologically preferred clusters to be preserved in production more frequently than dispreferred clusters.

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## APPENDIX

## Vocabulary selection

position	size	cluster	words
initial	2	pf	przedstawię, przyszłości, przecież
		pr	prawie, prace, program
		st	stycznia, stacja, stanowi
		mj	między, mieszkania, miałam
		sp	spotkać, sposób, społeczna
		vj	wieczory, więcej, wiedzy
	3	spr	sprawia, sprawdzić, sprawa
		efj	świecie, świątecznym, świetny
		fsp	wspólnym, wspomnieć, współpracy
		zvj	zwiedzić, związki, zwierząt
		spf	sprzedać, sprzęty, sprzętaniu
		trf	trwałe, trwają (2x)
	4	stfj	stwierdzam
		vzgl	względu
		fstf	wstrząsnął
		fspj	wspieramy
		bzmj	brzmiało
medial	2	st	wzrostu, jestem, ostatnio
		vj	prawie, człowiek, zdrowiu
		tsj	specjalny, stacja, policję
		nt	konto, kontaktów, klientów
		ete	treści, wolności, przyszłości
		rt	sportu, artystów, warto
	3	lsk	Polski, góralskich, polskich
		str	nastrój, siostry, ostrych
		fsk	warszawskim, królewskich, myśliwskich
		ntsj	tendencja, prowincja, gwarancją
		jsk	żeńską, małżeńskich, słowiańskich
tst	przedstawię, podstawą, przedstawia		
	4	jstf	państwach
		lskj	polskiego
		fskj	uczniowskiej
		jskj	panieńskie
		rstf	malarstwa
	5	mpstf	przestępstwa
		jstfj	małżeństwie
		rstfj	aktorstwie
		wstrj	austriackiej
		zwzgl	bezwzględnie
	6	mpstfj	następstwie
final	2	st	zamiast, przejazd, dojazd
		ete	znaleźć, wolność, możliwość
		nt	procent, zwierząt, dotąd

		nts	mówiąc, miesiąc, biorąc
		ɲk	zasięg, pociąg, parking
		rt	transport, koncert, eksport
	3	ɶtc	prze سیاć, wysiąć, nieszczęć
		jetc	obejć, odejć, nadejć
		jsts	miejsce
		stf	mistrzostw
		kst	pretekst
		stɶ	mistrz
	4	rstf	przedsiębiorstw
		ɶstf	małżeństw
		ɰstf	zwycięstw
		jstf	zabójstw
		mstf	kłamstw
	5	mpstf	przestępstw