A complexity-based typology of consonant clusters

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implicational hierarchy of consonant+plosive clusters

- MARKEDNESS HIERARCHY: linear ordering of clusters by the type of C_1
- IMPLICATION: more "marked" clusters imply less "marked" ones
- ACCESSIBLE CT CONSTRUCTIONS may be ordered

NT	<	RT	<	ST	<	PT
homorg. nasal		liquid		fricative		heterorg. plosive
{nt ŋk mp}		{rt lt rk lp}		{st sk ft fp xt}		{kt pt tk pk tp}

- extending the hierarchy

TT	< NT < RT < ST < PT <	**MT**
homorg. plosive		heterorg. nasal
{pp tt kk}		{mt mk nk np ŋt ŋp}

language typology by accessible CT constructions

	TT	NT	RT	ST	PT	MT	example
0							Hawaiian (Maddieson 2013)
1		↔					Manam (Piggott 1999)
1+	←	→					Japanese (Prince 1984), Pali (Zec 1998)
2		←	→				Diola Fogny (Piggott 1999)
2+	←		→				Sidamo (Gouskova 2004)
3		←		→			Basque (Egurtzegi 2003)
3+	←			→			Italian (Krämer 2009)
4		←			→		Spanish (Hualde 2014)
4+	←				→		Hungarian (Siptár & Törkenczy)
5		←				→	Kashmiri (Wali & Koul 1997)
5+	←					→	Hindi (Kachru 2006)

difference in the extensions

- MT implies all other types, it is the "most marked" type
- TT is not implied by any type, it occurs independently

what is "complexity"?

informational complexity

- the information required to define the ENTIRE cluster
- schematic calculation of the phonetic "content" of C_1 wrt C_2

phonetic information	TT 0	NT 1	RT 1–2	ST 1–2	PT 3	MT 3	remarks
place			(+)	(+)	+	+	not needed for homorganic CTs
nasality		+				+	
"sonority"			+				"sonority" or "aperture"
"noise"				+	+		aperiodic noise
closure					+	+	not needed for (partial) geminates, TT/NT

perceptual distinctiveness (Steriade 1994)

the greater the complexity, the less the distinctiveness

- ST can be perceived easily
- PT is more difficult to perceive (low distinctiveness from TT)
- MT is even more difficult to perceive (low distinctiveness from NT)

maximal and minimal complexity

defining accessible CC constructions

- "traditional" view: accessible CC constructions definable by their MAXIMAL COMPLEXITY
- no implications about geminates ⇒ MINIMAL COMPLEXITY is also needed
- restrictions
  - MAXIMAL MINIMUM REQUIREMENT: minimal complexity can require 0 (TT) or 1 (nasality, NT), ie no language with {RT} or {RT, ST}, etc
  - MINIMAL INVENTORY REQUIREMENT: geminates imply other types (at least NT), ie no language with only TT
- minimality and maximality requirements define CONTIGUOUS INTERVALS within a hierarchy

possible intervals defined by min–max requirements

	0	1	2	3	min–max	violates
	↔				0–0	*minimal inventory
1		↔			1–1	
			↔		2–2	*maximal minimum
				↔	3–3	*maximal minimum
1+	⟷	⟷			0–1	
2		⟷	⟷		1–2	
			⟷	⟷	2–3	*maximal minimum
2+	⟷	⟷	⟷		0–2	
3		⟷	⟷	⟷	1–3	
3+	⟷	⟷	⟷	⟷	0–3	
		↔		↔	1,3	*min–max (noncontiguous)

analogous implicational scales

	zero	minimal nonzero	others
C+plosive cluster	tt kk pp	nt ŋk mp	rt rp rk lt lp lk...
oral stops (place)	ʔ	t k p	q c ʈ k͡p k^w...
vowels (place)	ə/ɨ	i a u	e o y ø ɯ...
approx's (manner)	w/j	r l	ʊ ɣ β...
fricatives (place)	h	s	f ʃ x θ...
diphthongs (?)	ej/ow	aj aw	oj ew uj iw...

plosives and the glottal stop

	ʔ	p t k	other	examples
0				(no plosive: not attested)
0+	↔			(only glottal stop: not attested)
1		↔		French, Karok, Ainu, Avar, Chuvash
1+	←	→		Nama, Chamorro, Kanuri, Luo, Tagalog
2		←	→	Hungarian, Breton (c), Inuit, Uzbek (q), Diyari (c ʈ)
2+	←		→	Bashkir (q), Wolof (c), Haida (c q), Hindi (q ʈ)

vowels

	ə	i a u	other	examples
0				(no vowel: not attested)
0+	↔			(only central vowel: not attested)
1		↔		Classical Arabic
1+	←	→		Yupik
2		←	→	Czech (e o), Hungarian (e o y ø)
2+	←		→	Bulgarian (e o), Albanian (e o y)

approximants

	w	l r	other	examples
0				Pirahã (very rare)
0+	↔			Fe?fe? (very rare)
1		↔		Nama (r), Vietnamese (l), Russian, Finnish (l r)
1+	← →	← →		Japanese (r), Navajo (l), Ainu (r), English (l r)
2		← →	← →	Hungarian (ʋ), Fijian, Ewe (ɣ), Koryak, Nahuatl (β)
2+	← →	← →	← →	Arrente, Lenakel (ɣ), Spanish (ɣ β)

fricatives

	h	s	other	examples
0				Dyirbal (very rare)
0+	↔			Hawaiian (very rare)
1		↔		Even, Pohnpeian, Akawaio, Kunimaipa
1+	← →	↔		Ainu, A. Greek, Javanese, Kiowa, Khmer, Nepali, Pirahã
2		← →	← →	Maasai (ʃ), Songhai (f), French (f ʃ), Castilian (f θ x), Serbo-Croat (f ʃ x)
2+	← →	← →	← →	Chamorro (f), Yucatec (ʃ), Yoruba (f ʃ), Dutch (f x), Czech (f ʃ x), Eng (f ʃ θ)

markedness is multidimensional within a type

RT type: C_2: coronal < noncoronal; C_1: r < l

RT	+coronal	−coronal
−lateral	rt	rk rp
+lateral	lt	lk lp

ST type: C_2 and C_1: coronal < noncoronal

ST	+coronal	−coronal
+coronal	st	sk sp
−coronal	ft xt	fk xp

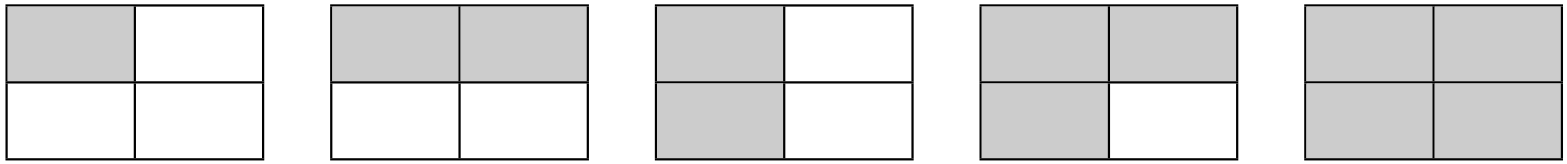
PT type: C_2 and C_1: coronal < noncoronal (coronal+coronal, ie TT, excluded)

PT	+coronal	−coronal
+coronal	—	tk tp
−coronal	pt kt	pk kp

incomplete accessibility

- the accessibility of a CT-type can be INCOMPLETE
- the various CT subsets accessible are not random
- 5 (of 15) cases are predicted based on markedness:

1 2a 2b 3 4



- examples of ST subsets:

1: Eng lenis

zd	*zg
*vd	*vg

2a: Latin

st	sk
*ft	*fk

2b: Hun #

st#	*sp#
ft#	*fp#

3: Eng, Finn

st	sk
ft/ht	*fk

4: Hun

st	sk
ft	fk

- examples of PT subsets:

1: Hun vd #

(dd)	*dg
*bd	*bg

2a: Hun affr #

(tsts#)	tsk#
*pts#	*pk#

2b: Lat, Eng

(X)	*tp
pt kt	*pk

3: Finnish

(tt)	tk
pt	*pk

4: Hun

(tt)	tk
pt kt	pk

gradual patterning of well-formed clusters

markedness differences between coronals (t ʦ ʧ) and between noncoronals (k p/c) in Hungarian ST clusters

ST	__t	__k	__p	__c	__ʦ	__ʧ
s__	st	sk	sp	sc	sʦ	*sʧ
ʃ__	ʃt	ʃk	ʃp	ʃc	*ʃʦ	*ʃʧ
f__	ft	fk	*fp	*fc	*fʦ	*fʧ
x__	xt	*xk	*xp	*xc	*xʦ	*xʧ

accessibility statistics

ratio of accessible and potential clusters in CT types in Hungarian

	TT	NT	RT	ST	PT	MT	all
potential CTs	6	6	12	24/18	30	15	95/87
voiceless	1	1	1	.50	.40	.07	.53
voiced	1	1	.83	.50	.13	0	.40

* no voiced counterpart for x

consonants are better off before a vowel

__V < __#, __C

- the perception of consonant(al properties/clusters) deteriorates word finally and preconsonantally (Steriade 1999)
- Cs are best licensed by V than word finally or preconsonantally (Harris 1997, Cyran 2010)

consequence

- CT# clusters are expected to form a subinterval of CTV
- CTC clusters are expected to form a subinterval of CTV
- the ratios are expected to decrease

context affects the accessibility of clusters

consequence: monotonically decreasing intervals of well-formed CTs

min. complexity will not be lower and max. complexity will not be higher

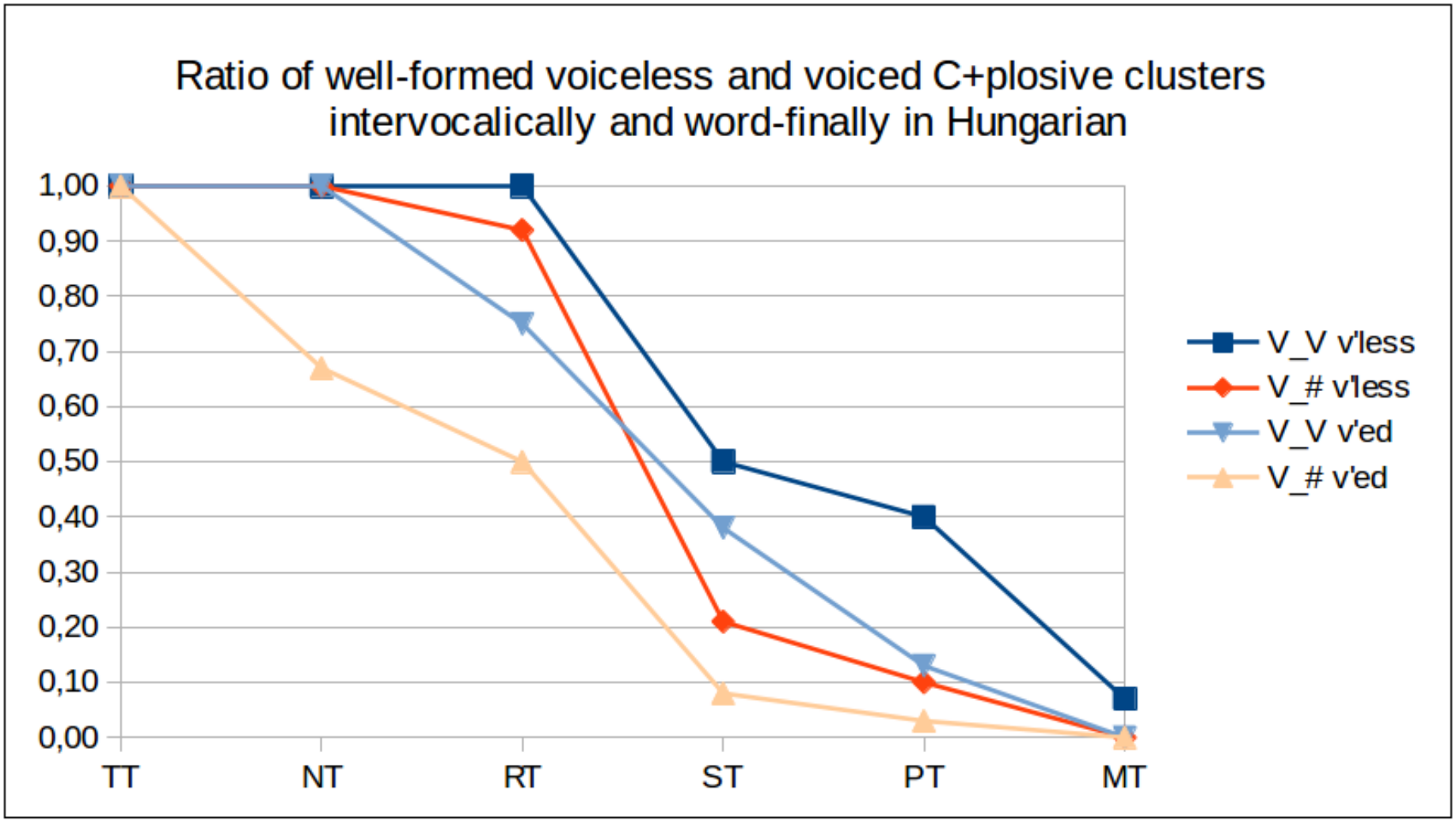
	TT	NT	RT	ST	PT	MT	
_V	←	→					Japanese: no CC#
_#							
_V		←	—	→			Spanish: no CC#
_#							
_V		←	—	—	—	→	Serbo-Croatian: limited CTs before #
_#		←	—	→			
_V		←	—	—	—	→	German: same CTs before V and #
_#		←	—	—	—	→	
_V	←	—	—	—	→		Estonian: final geminates
_#	←	—	—	→			
_V	←	—	—	—	→		Finnish: no final CC#
_#							

Hungarian CTs

ratios of intervocalic and word-final voiceless and voiced CTs

	TT	NT	RT	ST	PT	MT	all
all CTs	6	6	12	24	30	15	93
V__V	1	1	1	.50	.40	.07	.53
V__#	1	1	.92	.21	.10	0	.33

	DD	ND	RD	ZD	BD	MD	all
all CTs	6	6	12	18	30	15	87
V__V	1	1	.75	.50	.13	0	.39
V__#	1	.67	.50	.11	.03	0	.22


Ratio of well-formed voiceless and voiced C+plosive clusters intervocalically and word-finally in Hungarian
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
TT
NT
RT
ST
PT
MT
V_V v'less
V_# v'less
V_V v'ed
V_# v'ed

preconsonantally

like for CTV vs CT#, we find monotonically decreasing intervals in CTC

min. complexity will not be lower and max. complexity will not be higher

	TT	NT	RT	ST	PT	MT	
__V	←	→					Japanese: no CCC
__r							
__V	←			→			Italian: pre-r geminates
__r	←			→			
__V		←			→		Spanish: same CTs before V and r
__r		←			→		
__V	←				→		Hungarian: no pre-r geminates
__r		←			→		
__V	←				→		Hungarian: PTl limited (*ktl, *ptl)
__l		←		→			

CTC clusters in Hungarian

“sonority” and voicing hierarchies

	TT	NT	RT	ST	PT	MT	maximally complex example
__V	←				→	→	lɑbdɑ ‘ball’, tʃaːmtʃog ‘munch’
__r		←	→		→		ɛlɛktromoʃ ‘electric’, gɑrdroːb ‘wardrobe’
__l		←	→	→			ʃmirgli ‘sandpaper’, muskli ‘muscle’
__ʊ		←	→	→			hɑrdʊɛr ‘hardware’, uskʊɛ ‘about’
__n		←	→				—, pɑrtnɛr ‘partner’
__s		←	→				—, sfiŋks ‘sphynx’/mɑrksiʃtɑ ‘Marxist’
__t/ts		←	→				—, infɑrktuʃ ‘infarct’/apsorptsijoː ‘absorption’
__k		↔					—, pilintskaːzik ‘hesitate’
__p/c/f/ʃ							—, —

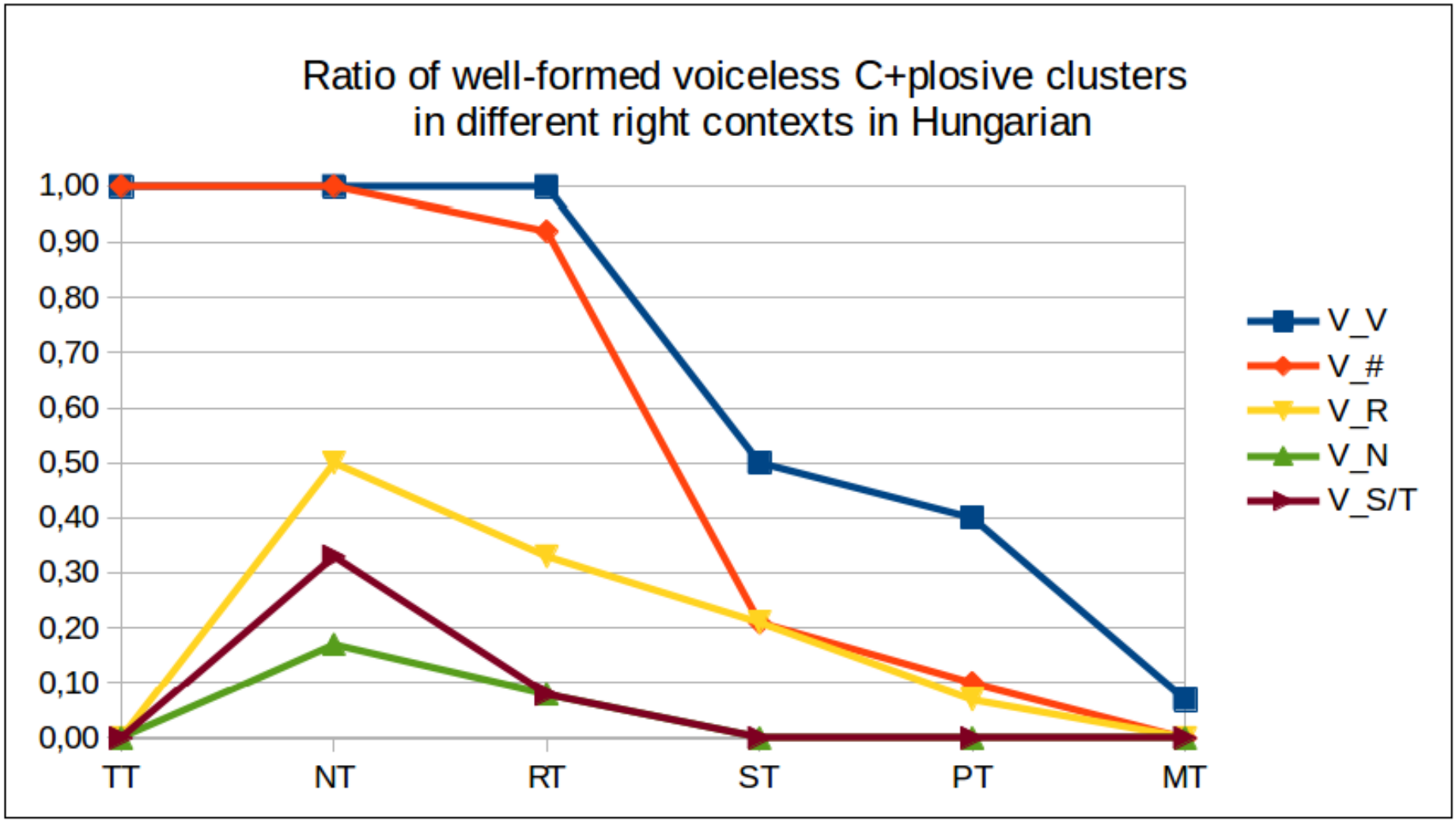
Hungarian CTs

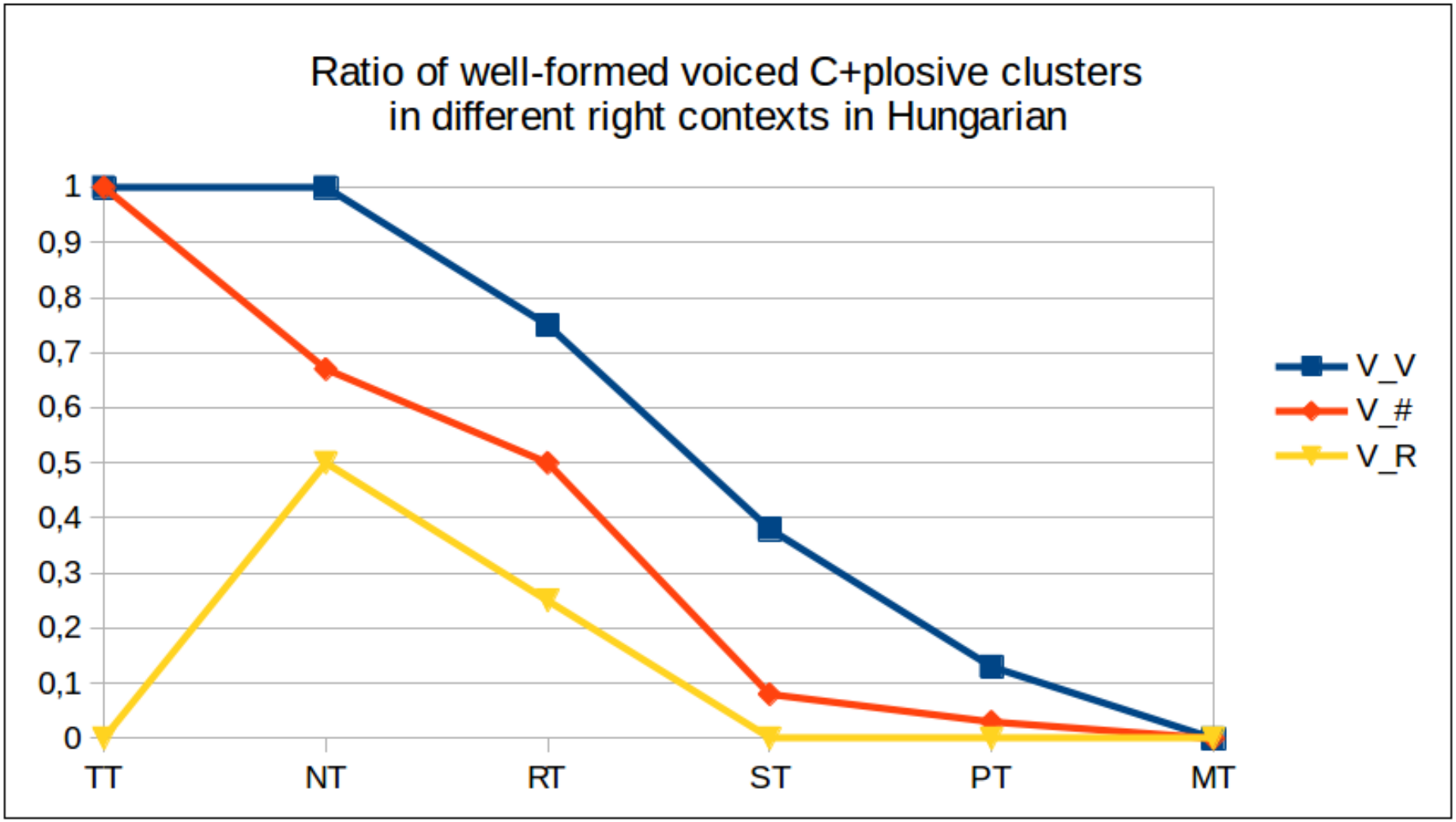
ratios of prevocalic and preconsonantal voiceless and voiced CTs

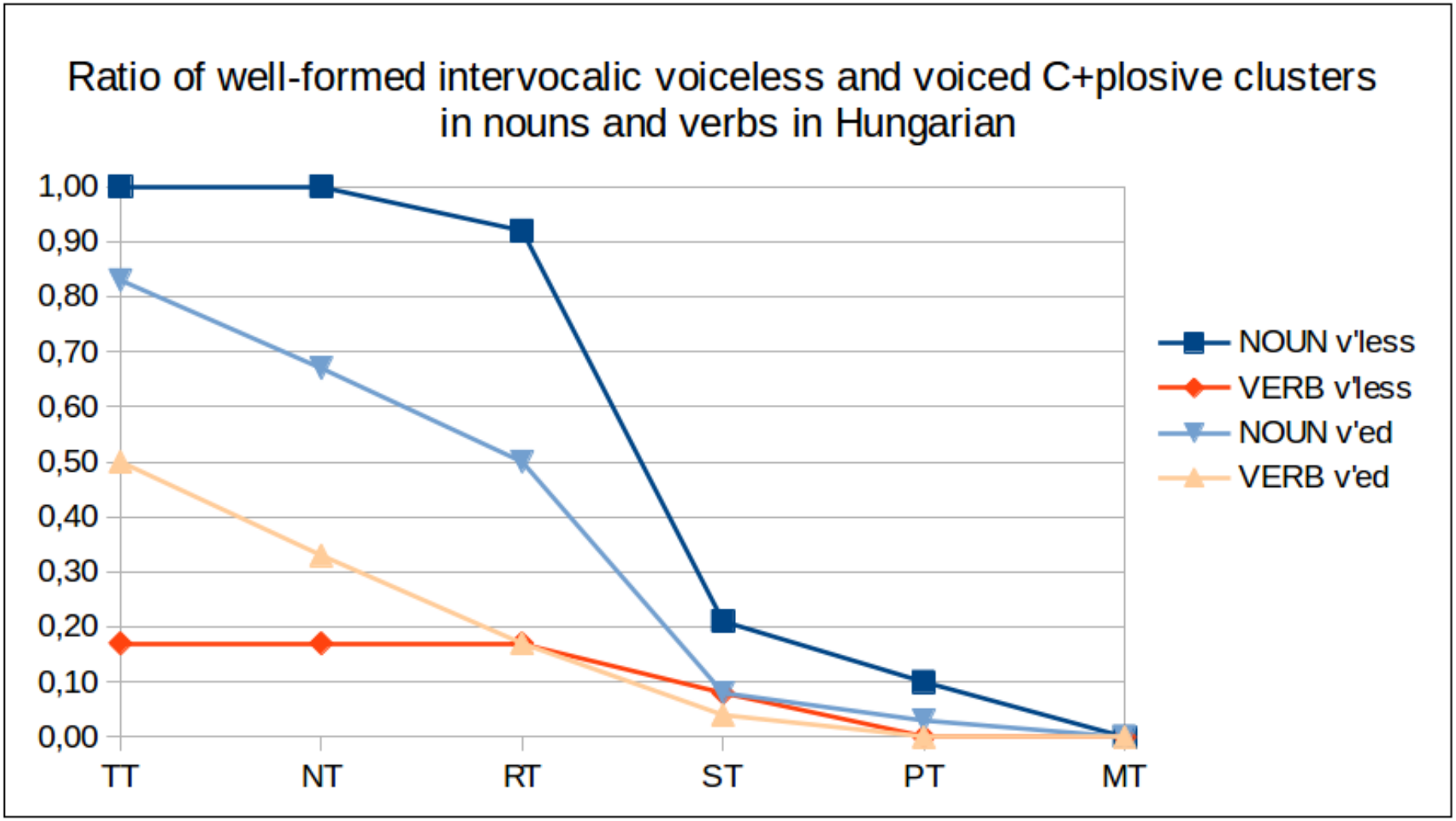
all CTs	TT 6	NT 6	RT 12	ST 24	PT 30	MT 15
V__V	1	1	1	.50	.40	.07
V__r	0	.50	.17	.21	.07	0
V__l	0	.50	.33	.08	0	0
V__ʊ	0	.33	.17	.08	0	0
V__n	0	.17	.08	0	0	0
V__s	0	.33	.08	0	0	0
V__t/ts	0	.33	.08	0	0	0
V__k	0	.17	0	0	0	0
V__p/c/f/ʃ0		0	0	0	0	0

all CTs	DD 6	ND 6	RD 12	ZD 18	BD 30	MD 15
V__V	1	1	.75	.50	.13	0
V__r	0	.33	.08	0	0	0
V__l	0	.50	.25	0	0	0
V__ʊ	0	.33	.08	0	0	0
V__n	0	0	0	0	0	0
V__s	0	0	0	0	0	0
V__t/ts	0	0	0	0	0	0
V__k	0	0	0	0	0	0
V__p/c/f/ʃ0		0	0	0	0	0

all	
v'less	v'ced
.53	.39
.13	.03
.10	.07
.06	.03
.02	0
.03	0
.03	0
.01	0
0	0


Ratio of well-formed voiceless C+plosive clusters
in different right contexts in Hungarian
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
TT
NT
RT
ST
PT
MT
V_V
V_#
V_R
V_N
V_S/T


Ratio of well-formed voiced C+plosive clusters
in different right contexts in Hungarian
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
TT
NT
RT
ST
PT
MT
V_V
V_#
V_R


Ratio of well-formed intervocalic voiceless and voiced C+plosive clusters in nouns and verbs in Hungarian
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
TT
NT
RT
ST
PT
MT
NOUN v'less
VERB v'less
NOUN v'ed
VERB v'ed

conclusions

- phonotactics is too gradual to be captured in a categorical manner (ie by syllable structure): the description of accessible clusters needs a very fine-grained scale
- the sets of CT clusters in a language can be profiled by contiguous intervals defined by minimal and maximal complexity
- a further refinement: the edges of the intervals are characterized by gradually descending ratios

thanks to

- you all
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slideshow available at

http://seas3.elte.hu/szigetva/papers.html#sinfonija10