Razvoj morfonotaktičkih i fonotaktičkih zatvorničkih skupina u usvajanju hrvatskoga kao materinskoga jezika

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The development of morphonotactic and phonotactic word–initial consonant clusters in Croatian first–language acquisition

We study first language acquisition of Croatian morphonotactic vs. phonotactic word–initial consonant clusters. Morphonotactic clusters cross a morpheme boundary, such as /sl/ in *s+ložiti* 'to arrange', whereas phonotactic clusters occur within a morpheme, as in *slad+o+led* 'ice–cream'. With a new method we show that, similarly to equally morphology–rich Polish and Lithuanian, the three investigated Croatian children acquire morphonotactic clusters earlier than homophonous phonotactic clusters. We also study preferences of double and triple word–initial consonant clusters via the concept of Net Auditory Distance (NAD), never before used for Croatian, with partially unexpected results. When dealing for the first time in studies of (mor)phonotactic development with the rise of cluster complexity, we will show that morphonotactics creates new complexity. Since children do not learn directly the target language, as represented in grammars, dictionaries and electronic corpora of written or oral adult language, we compare the development of child speech (CS) systematically with the children's language input, i.e. child–directed speech (CDS) of their caretakers. In this way, we can achieve a higher degree of ecological validity than with formal transversal tests. The three longitudinal corpora of spontaneous interaction between a child and a caretaker (Croatian Corpus of Child Language, Kovačević 2002) have been recorded, transcribed and coded according to the methodologies of the international project CHILDES and the Crosslinguistic Project on Pre– and Protomorphology in Language Acquisition headed by the second author. The results are compared with those of the acquisition of morphonotactic vs. phonotactic clusters by Polish children. Diverging results are due to structural differences between these two Slavic languages.

1. **Introduction**

This contribution presents the acquisition of Croatian morphonotactic vs. phonotactic word–initial consonant clusters in the most intense and dynamic period of first language acquisition, which lays the basis for adult language processing, i.e. before the age of 3 years. We limit this study to word–initial consonant clusters, because first, in contrast to other Slavic languages, there are few word–final consonant clusters (Turk 1992) and, due to the absence of genitive zero plurals, no morphonotactic ones. The second reason for this limitation is the lack of space and the much greater difficulty of corpus–linguistic analysis of word–medial clusters. Word–initial consonant clusters are, in contrast to many other language families, prominent in Slavic languages and are well represented because of mono–consonantal, often aspect–related verbal prefixes. We limit our investigation of morphonotactics to verb prefixation, because nominal prefixation is acquired only later, as in all other Indo–European languages studied so far (see Mattes et al. 2019).

We intend to show that also in this Slavic language the richness of morphology stimulates children to use the interaction with morphology in acquiring morphonotactic clusters, such as /sp/ in *s+pustiti* 'to put down', earlier than homophonous phonotactic clusters, such as in *spavati* 'to sleep'. Hereby we will use an improved criterion for identifying acquisition of a cluster within a longitudinal acquisition study of three Croatian children. We are going to investigate also cluster preferences according to the criteria of Net Auditory Distance (NAD). In contrast to previous studies of (mor)phonotactic development, we will also focus on the rise of cluster complexity (in the sense of a building–block model of complexity, cf. Zurek 1990; Dziubalska–Kołaczyk 2014b; Lieven 2008; Ravid et al. 2008)

The development of child speech (CS) will be compared less with the Croatian target language than with the children's language input, i.e. child–directed speech (CDS). As work on CDS (Maslen et al. 2004; Rowe 2008; Ko 2012; Ravid et al. 2008, 2019) has proved, young children do not learn directly the target language as represented in grammars, dictionaries and electronic corpora of written or oral adult language, but as filtered by their input, first nearly only due to child–directed speech (CDS) of their caretakers, which is their main language input. They are less attentive to adult speech they only overhear (cf. Boderé and Jaspaert 2016). Listening to the TV instead of conversing with parents is even detrimental to language acquisition (as our Viennese data show, cf. Nemestothy 2019). Only later on does the impact of the input by peer groups gain in importance for language acquisition.

2. Theoretical framework

Dressler and Dziubalska–Kołaczyk (2006) introduced the theoretical distinction between morphonotactics and phonotactics with the example of consonant clusters. Morphonotactic clusters differ from phonotactic ones by the interaction of morphotactics with phonotactics (cf. also Celata et al. 2015; Zydorowicz et al. 2016). Morphonotactic clusters are mainly due to the addition of a further morpheme, in our case of a prefix, as in *s+kuhati* 'to cook'. They may also be due to a subtractive morphotactic operation which leads to vowel deletion, as in Gen. *psa* from the lexical entry *pas* 'dog'. Moreover, Dressler and Dziubalska–Kołaczyk (2006) proposed the Strong Morphonotactic Hypothesis which states that the interaction of morphology with phonotactics facilitates both processing and acquisition. This hypothesis had to be restricted to systems of rich morphology, such as German compounding and verb prefixation, Polish and Lithuanian inflection and derivation (Sommer–Lolei et al. 2019), because only a rich amount of morphology stimulates the child to attribute priority to morphological learning (Xanthos et al. 2011). While there exist publications on morphonotactics vs. phonotactics in German, English, French, Lithuanian, Polish, Russian and Slovak (see the survey in Dressler et al. 2019), nothing has been published on Croatian so far.

Our linguistic approach is based on an interaction between Natural Morphology (cf. Dressler and Kilani–Schoch 2017) and Natural Phonology, the latter specifically in terms of the Beats–and–Binding phonotactics of Dziubalska–Kołaczyk (2002) and its basic concept of Net Auditory Distance (NAD, Dziubalska–Kołaczyk 2014). NAD measures the auditory distances between neighboring phonemes in a cluster in terms of place and manner of articulation plus sonority (Zydorowicz et al. 2016), regardless of syllable structure, with the presupposition that the bigger the combined distances are between two phonemes in a given position the more this sequence is preferred. Therefore, it is a superior tool to the traditional sonority scales. NAD allows building a hierarchy of preferences (cf. Dressler 1999) from the most to the least preferred cluster. A cluster is preferred if it satisfies a pattern of distances specified by the universal phonotactic preference according to its position in a word. In universally preferred word–initial double clusters, NAD within C1C2 is bigger than within C2V (thus NAD (C1,C2) ≥ NAD (C2,V)), in triple clusters (C1C2C3V) the NAD within C2C3 should be the biggest one (thus NAD (C1,C2) < NAD (C2,C3) ≥ NAD (C3,V)). More detailed information on the NAD calculations is provided in section 4.

Consonantal languages, such as contemporary Slavic languages, have more dispreferred consonant clusters than vocalic languages (such as many Romance languages and Old Church Slavonic). A morphonotactic function is liable to create more complex and less preferred clusters than a phonotactic function. Since no NAD calculation existed for Croatian, we calculated it according to the general NAD formulas in Zydorowicz and Dziubalska–Kołaczyk (2017, as expanded in Dziubalska–Kołaczyk 2019).

Our acquisitionist approach is constructivist, following Dressler and Karpf (1995) and in the tradition of the Crosslinguistic Project of Pre– and Protomorphology in Language Acquisition (cf. Dressler et al. 2017; Xanthos et al. 2011). Thus, we assume that children construct their steps of language acquisition (CS) in interaction with their input, which first consists mostly of their caretakers' child–directed speech (CDS, see the end of section 1). Therefore, the comparison of CS and CDS demands longitudinal investigations of verbal interaction between children and their caretakers, whereas transversal tests allow only a flashlight on children with different development paths and different inputs. Moreover, the overreliance on transversal tests violates the requirement of path dependency in social sciences.

Order of acquisition of (mor)phonotactic structures has so far been measured by a chronological order of their emergence or of their productive use in CS (e.g. Zydorowicz 2010; Freiberger 2014; Kamandulytė 2006). Although not negating the relevance of these steps of acquisition, we propose that, in accordance with the steps of acquisition established by Berman (2004), her final step, full mastery, should be the yardstick, which means in our case the time when either a morphonotactic consonant cluster or its homophonous phonotactic cluster are consistently produced correctly by the child. Acquisition of clusters is achieved only with full mastery, and this happens much earlier than with full mastery of all morphological or syntactic structures.

3. Croatian consonant clusters

All descriptions of Croatian consonant clusters published so far are based on syllable structure, but syllable structure is irrelevant in the Beats–and–Binding phonotactics of Dziubalska–Kołaczyk (2002, 2014a), which we adopt in our paper. Jelaska (2004) explains that prototypical Croatian syllables have one or two consonants in the onset and only one consonant in the coda. Škarić (1991) established that 60% of Croatian syllables are CV syllables, a general preference in the languages of the world. In the Croatian web corpus (hrWaC, Ljubešić and Klubička 2014), syllables starting with double consonant clusters represent around 20% of lexical words in the sample, whereas triple consonant clusters are very rare and appear at the beginning of the syllable only in 1% of lexical words (Kelić 2017). Prototypically, Croatian word–initial triple consonant clusters start with fricatives (/s/, /š/, /z/ or /ž/), followed by an obstruent or labial sonorant (/m/ or /v/) or by /h/ in the word *shvatiti* 'to comprehend' and its derivatives, whereas the third consonant is always a sonorant (Jelask, 2004). Thus, Croatian has less complex consonant clusters than most other Slavic languages.

Half of the initial triple consonant clusters begin with the phoneme /s/ (Jelaska 2004), which can indicate their morphonotactic nature. Initial morphonotactic clusters in Croatian come into being only through derivation, i.e. by adding the only monoconsonantal prefix s– to word–initial consonants. It has four variants: *s–, z–, š–* (e.g. *sletjeti 'to land'*, *zbaciti 'to throw off'* or *ščepati 'to catch'*) and *sa–* before sibilants. According to Barić et al. (1997) the principal meanings of this prefix are perfectivising, in addition to uniting and gathering or separating. Additionally to prefixation with the prefix s–, phonotactic complexity is increased in Kajkavian forms where the vowels in the prefixes *iz–* or *uz–* (variants: *is–, us–*) are deleted in lemmas such as *iz+gledati* → *z+gledati* 'to appear' or *uz+dići* → *z+dići 'to upraise'*. Since all three investigated children were exposed to the Zagreb Kajkavian dialect, also such forms are present in the data analyzed.

The double consonant clusters that have in the target language both a phonotactic and a morphonotactic function and are present in our Croatian Child Corpora in only one or in both of these functions, are:

phon *skV– stV– zdV– spV– svV– zvV– smV– smr̦ –snV– snjV– slV–*
mphon *s+kV–z+gV–s+tV–s+tr̦–s+pV–, s+mV–z+mV–s+lV–s+rV–*

4. Preferences of Croatian consonant clusters according to Net Auditory Distance

In order to establish the yet uninvestigated preferences among homophonous morphonotactic and phonotactic double consonant clusters, we calculated their NAD values. In our presentation, we divided them into NAD of manner of articulation (MOA), of place of articulation (POA), of sonority vs. obstruence (S/O), first the NAD values for C1C2, then for C2V and the resulting NAD product for word–initial clusters according to the principle indicated in § 1 and the formula:

NAD CC = |(MOA1 – MOA2)| + |(POA1 – POA2)| + |S/O| and
NAD CV = |(MOA1 – MOA2)| + |S/O|.

The NAD product expresses the degree to which a cluster meets the relevant preference condition. For double consonant clusters, the NAD product is a subtraction of the NAD between the vowel and the immediately following consonant from the NAD between the two consonants. Positive values indicate that the cluster is relatively preferred, and negative values that it is dispreferred. For triple consonant clusters, the final NAD product is the average of the outcome of the two NAD products within the cluster, as described in Dziubalska–Kołaczyk (2019). E.g. for the cluster /skr/, as showed in Table 2, the NAD product for /sk/ is 2.7 (5.2 – 2.5) and for /kr/ is 3.2 (5.2 – 2), the average, i.e. the final NAD product of the cluster /skr/ is 2.95.

Cluster		MOA	POA	S/O	NAD	NAD Product
skV	C1C2	1	1.5		2.5	–2.5
	C2V	5			5	
slV	C1C2	1.5	0.3	+1	2.8	0.3
	C2V	2.5			2.5	
smV	C1C2	1	1	+1	3	0
	C2V	3			3	
spV	C1C2	1	1		2	–3
	C2V	5			5	
srV	C1C2	2	0.3	+1	3.3	1.3
	C2V	2			2	
stV	C1C2	1	0.3		1.3	–3.7
	C2V	5			5	
zmV	C1C2	1	1	+1	3	0
	C2V	3			3	

Table 1. NAD values for double clusters being both phonotactic and morphonotactic

The clusters *zbV–*, *sfV–*, *sljV–* do not appear in the child corpora, *z+gV–*, *z+mV–*, *s+rV–* appear only in the morphonotactic function. The clusters *z+dV–*, *s+vV*, *s+nV–*, *s+njV–* do not appear in CS as morphonotactic, although all clusters except *snjV–* appear in the target language in morphonotactic function. Syllabic /r/ occurs in a morphonotactic cluster only in the target lemma *strgati* 'to break', with the NAD product –3.2.

The clusters *blV–*, *brV–*, *cvV–*, *čvV–*, *dlV–*, *dnV–*, *drV–*, *dvV–*, *flV–*, *frV–*, *glV–*, *gljV–*, *gnV–*, *grV–*, *hlV–*, *hrV–*, *htV–*, *hvV–*, *kćV–*, *klV–*, *kljV–*, *knV–*, *knjV–*, *krV–*, *kvV–*, *mlV–*, *mljV–*, *mrV–*, *pč–*, *plV–*, *prV*, *pt–*, *škV–*, *šlV–*, *šljV–*, *špV–*, *štV–*, *trV–*, *tvV–*, *vlV–*, *vrV–*, *zlV–*, *znV–*, *zrV–*, *žlV–*, *žnV–*, *žvV–* are purely phonotactic clusters with no potential of being also morphonotactic. The cluster *psV–* appears as morphonotactic, but in CS only in one token: *ps+a* [dog, G.sg], moreover only when repeating the adult interlocutor's correction, after the child spontaneously produced **pas+a*, in analogy to Nom. *pas*; afterwards the child produced spontaneously again **pasa*.

In CS ten triple consonant clusters appear, five being only morphonotactic, four only phonotactic. Only *zdrV–* has both functions:

phon *škrV– šprV– strV– štrV– zdrV–*
mphon *s+krV– s+klV– s+prV– stvV– z+drV– z+grV*

In the following table, the penultimate column is enriched by the NAD value for C2C3:

Cluster		MOA	POA	S/O	NAD	NAD Product
CCCV clusters						
sklV	C1C2	1	1.5		2.5	2.2
	C2C3	2.5	1.2	+1	4.7	
	C3V	2.5			2.5	
skrV	C1C2	1	1.5		2.5	2.95
	C2C3	3	1.2	+1	5.2	
	C3V	2			2	
sprV	C1C2	1	1		2	3.3
	C2C3	3	1.3	+1	5.3	
	C3V	2			2	
strV	C1C2	1	0.3		1.3	2.35
	C2C3	3		+1	4	
	C3V	2			2	
stvV	C1C2	1	0.3		1.3	4.65
	C2C3	4	0.8	+1	5.8	
	C3V	1			1	

štrV	C1C2	1	0.3		1.3	2.35
	C2C3	3	0	+1	4	
	C3V	2			2	
škrV	C1C2	1	0.9		1.9	3.25
	C2C3	3	1.2	+1	5.2	
	C3V	2			2	
zdrV	C1C2	1	0.3		1.3	2.35
	C2C3	3	0	+1	4	
	C3V	2			2	
zgrV	C1C2	1	1.5		2.5	2.95
	C2C3	3	1.2	+1	5.2	
	C3V	2			2	
CCV clusters's which are constituent to CCCV clusters (those not presented above)						
štV	C1C2	1	0.3		1.3	–3.7
	C2V	5			5	
škV	C1C2	1	0.9		1.9	–3.1
	C2V	5			5	
zdV	C1C2	1	0.3		1.3	–3.7
	C2V	5			5	
zgV	C1C2	1	1.5		2.5	–2.5
	C2V	5			5	
klV	C1C2	2.5	1.2	+1	4.7	2.2
	C2V	2.5			2.5	
krV	C1C2	3	1.2	+1	5.2	3.2
	C2V	2			2	
prV	C1C2	3	1.3	+1	5.3	3.3
	C2V	2			2	
trV	C1C2	3	0	+1	4	2
	C2V	2			2	
tvV	C1C2	4	0.8	+1	5.8	4.8
	C2V	1			1	
drV	C1C2	3	0	+1	4	2
	C2V	2			2	
grV	C1C2	3	1.2	+1	5.2	3.2
	C2V	2			2	

Table 2. NAD values for CCCV clusters and constituent CCV clusters (not presented in Table 1)

These tables show that the general principle stated in § 2 "A morphonotactic function is liable to create more complex and less preferred clusters than a phonotactic function" holds also for Croatian: Among the morphonotactic double clusters four are dispreferred clusters and only one is clearly preferred, another one slightly, two are neither preferred nor dispreferred. The more complex triple clusters are mostly morphonotactic. To our surprise they are all preferred triple clusters. This can be interpreted as higher complexity demanding more preferredness in terms of NAD by combining a mostly dispreferred initial double cluster with a preferred second cluster constituent.

5. Data and methodology

In this study, we analyzed the longitudinal corpora of three children (age period from 0;10 to 3;02) from Zagreb (CS) in spontaneous interaction with their caregivers (CDS). The variant of *Croatian Child Corpus*[1] available at Talkbank was used (Kovačević 2002; http://childes.psy.cmu.edu/data/Slavic/Croatian), where transcripts are linked to audio recordings. Children were recorded three times a month in duration of 45 minutes. All three children were growing up in Zagreb and their input is Croatian urban koine, i.e. Zagreb Kajkavian Dialect. They were monolingual speakers of Croatian from upper–middle–class families. For two children, Antonija and Marina, CDS includes utterances produced by their mothers, while in Vjeran's corpus, CDS includes three caregivers: mother, Rada (the caretaker) and Blaženka (child language investigator) because they equally contributed to Vjeran's input. Recordings have been transcribed by three transcribers and coded following the norms of CHILDES (MacWhinney 2000). Transcripts were recently revised, codes were systematically checked and unified (Ordulj and Hržica 2018).

All double and triple consonant clusters in CS were extracted and classified as morphonotactic or phonotactic, along with the age of emergence and each child's production of the cluster, classified as either correct or as omission of the first/second/third consonant or as commission (substitution) of the first/second/third consonant or as phonetic distortion of the first/second/third consonant. In order to classify the child's errors, the already existing transcriptions were auditorily controlled via the recordings by the first author. If she disagreed with a transcription, another native Croatian linguist decided.

In section 6 below, data from all three children and their analysis are presented. First, the target clusters which occur both as morphonotactic and phonotactic in CS of the largest corpus (Vjeran's) are presented followed by their analysis. Afterwards, data from the two smaller corpora (of Marina and Antonija) are compared with the analysis of Vjeran's data. In this study, different inflectional forms were not taken into account since, as explained above, inflectional morphology does not

1 We are grateful to the children and their caregivers who allowed to be recorded regularly, as well as to the experts who transcribed and coded the corpus.

change word–initial clusters. Following the typical development of first omission, then commission (substitution), finally correct production, the tables present the age when the first attempt to produce the cluster is observed in the corpus, the classification of the child's error for the first attempt and all the other types of errors which occur during the development of production of the target cluster, the age when the cluster is for the first time produced correctly and the age from which the production of the cluster is continuously and systematically correct. In this way the development of each complex consonant cluster present in CS can be followed.

Afterwards we will discuss the development of those two–consonant target clusters whose combined longitudinal data of all three children allow generalizations. Finally, the emergence of three–consonant clusters will be compared to their constituent two–consonant clusters.

6. Emergence and development of complex consonant clusters in CS

6.1. Double consonant clusters

In the following Table 3, covering the largest of the three CS corpora, Vjeran's word–initial consonant clusters which are relevant for the comparison of phonotactics and morphonotactics are presented. In the first row, phonotactic data are presented, and in the second row, morphonotactic data. Errors are classified as omission (OM), commission (COM) and distortion (DIST), specifying the target phoneme (e.g. COM/1 for commission of the first phoneme /s/ with the postdental affricate /c/ and OM/2 for the omission of /l/ in *sladoled* 'ice–cream' → *cadoled*). Distortion usually refers to phonetic weakening of [r] when this phoneme is produced with noticeably less vibration than in normal articulation or with no vibration at all. For each cluster number of lemmas (L), tokens (T) and lemma/token ratio (LTR) in CS and CDS are presented.

Until the age of 1;05 two–consonant clusters are in Vjeran's corpus generally reduced to one consonant. The first two–consonant cluster produced is /*sl*/ instead of the target cluster /*sr*/ in the lemma *srušiti* 'to knock down' (resulting in the output form *slušiti*). This cluster appears both as phonotactic and morphonotactic, but in Vjeran's corpus this first appearance of a two–consonant cluster is across a morpheme boundary in the target infinitive *s+rušiti*. It should be noted that simultaneously with such commission errors, omissions of /r/ and /l/ still occur in examples such as in the variant *sušiti*, in *složiti* 'to arrange' → *sožiti* or *gledati* 'to watch' → *gedati*.

In Vjeran's corpus, 8 clusters which appear both as phonotactic and morphonotactic were identified and in seven of them a difference in development between phonotactic and morphonotactic function can be observed (/*sl*, *sm*, *sp*, *sr*, *st*, *zm*/ and only 1 token of /*zdr*/). All morphonotactic clusters appeared in verbs and were created by adding the prefix *s*– or the prefix *(i)z*– in its Kajkavian variant.

	Vjeran's CS							Vjeran's CDS		
Clu-ster	L	T	LTR	1st pro-duc.	Error, Example	1st corr. produc.	Consi-stent corr. produc.	L	T	LTR
sk	7	61	0,11	1;10	e.g. skaka-vac	1;10	1;10	12	89	0,13
	6	80	0,08	1;10	e.g. s+kuhati	1;10	1;10	9	134	0,07
sl	11	76	0,14	1;06	OM/2 (1;06) slika – sika COM/1 OM/2 (1;10) sladoled – cadoled	1;10	2;09	29	372	0,08
	5	73	0,07	1;03	OM/2 (1;03) s+ložiti – sožiti COM/1 (2;02) s+letile – tletile	2;00	2;03	10	203	0,05
sm	7	130	0,05	1;04	OM/1 (1;04) smeće – meće OM/2 smije – sije	2;00	2;00	13	482	0,03
	2	3	0,67	1;10	s+miriti s+metati	1;10	1;10	7	65	0,11
sp	3	66	0,05	1;06	OM/1 (1;06) spava – pava	2;00	2;00	11	90	0,12
	5	20	0,25	1;10	s+pustiti	1;10	1;10	12	35	0,34
sr	4	7	0,57	2;04	COM/2 (2;04) sram – slam DIST (2;08)			8	48	0,17
	1	31	0,03	1;05	OM/2 (1;05) s+rušio – slušio COM/2 (2;01) s+rušio – slušio DIST (2;08)			2	65	0,03

st	15	254	0,06	1;03	OM/1 (1;03) stanu – tanu	1;07	1;09	34	793	0,04
	4	14	0,29	1;08	s+tiskati	1;08	1;08	7	54	0,13
zdr	1	2	0,50	2;08	DIST/3 (2;08) zdrav			1	3	0,33
	1	1	1,00	2;02	COM/3 (2;02) z+drobili – zdlobili			1	2	0,50
zm	2	8	0,25	1;07	OM/1 (1;07) zmaj – maj COM/2 (2;05) zmaj – smaj	2;05	2;05	4	16	0,25
	1	5	0,20	2;01	i(z)+mazati – zmazati	2;01	2;01	3	22	0,14

Table 3. Initial clusters in Vjeran's corpus which appeared as both phonotactic and morphonotactic

The first cluster from this group that Vjeran attempts to produce is the cluster */sl/* at the age of 1;03 when the cluster is reduced to the first consonant, e.g. *s+ložiti* 'to arrange' was produced as *sožiti*. The first correct production of the cluster appears at the age of 1;10 in its phonotactic function and at the age of 2;00 in its morphonotactic function. In both functions, correct production remains inconsistent. The correct production of the morphonotactic cluster becomes consistent at 2;03, whereas the phonotactic cluster is still occasionally reduced until 2;09. Since the first emergence of a correct production is less important than mastery of acquisition, we conclude that the acquisition of the morphonotactic cluster */s+l/* precedes acquisition of the phonotactic cluster */sl/*.

At 1;04 the cluster */sm/* is targeted by the child. The first production is in the phonotactic function and until the age of 2;00 the first or the second consonant is omitted (e.g. *smeće* 'garbage' → *meće*). The first morphonotactic production appears at the age of 1;10 and is immediately consistently correct. This means again morphonotactic precedence.

The cluster */sr/* appears at the age of 1;05. From that age until the age of 2;01 the cluster is interchangeably produced with the omission of the /r/ as in *srušiti* 'to knock down' → *sušiti* or /r/ is substituted by /l/ as in *slušiti*. From 2;01, substitution is a consistent way of producing this morphonotactic cluster until the age of 2;08 when /r/ is first produced, though in a distorted way. The first production of the cluster */sr/* as phonotactic is at the age of 2;04 and /r/ is substituted by /l/. At the age of 2;08 also phonotactic */sr/* is produced with distorted /r/.

The cluster /*s+t*/ as morphonotactic appears at the age of 1;08, with the correct production throughout the whole corpus, e.g. *s+tiskati* 'to press'. This cluster as phonotactic appears at the age of 1;03, but until the age of 1;09 (after the first morphonotactic cluster appears) the phoneme /s/ is omitted. Afterwards its production is systematically correct. Thus, also with this cluster a slight morphonotactic precedence is observed.

At the age of 1;10 cluster /*s+p*/ appears for the first time in the morphonotactic function, with the correct production throughout the corpus. This cluster appears in the word *s+parkirati* 'to park', which is a Kajkavian form created by adding the prefix *s–* where standard Croatian leaves the word without the prefix, or more rarely adds the prefix *u–*. The prefix *s–* is added also in the verb *s+pustiti* 'to put down', while other two examples are Kajkavian forms created by adding the prefix *iz–*, but without the vowel. The first appearance of this cluster as phonotactic is at the age of 1;06, and the /s/ is omitted, e.g. in *spava* → *pava* '(s)he sleeps' or *sportski* 'sportive'→ *poci*. After the age of 1;10, thus after the appearance of the cluster in morphonotactic function, production is correct also in phonotactic /*sp*/ clusters.

/*z+m*/ as a morphonotactic cluster appears at the age of 2;01 in the word *z+mazati* 'to make dirty', a Kajkavian form, most probably created by adding the prefix iz– without the vowel. It is produced correctly throughout the corpus. This cluster appears as phonotactic at the age of 1;07 with the reduced first consonant, thus *zmaj* 'a dragon' becoming *maj*. At the age of 2;02 when the morphonotactic production is correct, the lemma *zmaj* is produced with the substitution of /z/ by /s/, however in only one token. The correct production of this cluster in the phonotactic context is consistent from 2;05 onwards, thus slightly later than the cluster /*z+m*/ in the morphonotactic function.

Two more clusters appear simultaneously both as phonotactic and morphonotactic: the dispreferred cluster /*sk*/ at 1;10 (consistently correct) and the preferred cluster /*zdr*/ (with only one morphonotactic token and two in Vjeran's CDS).

In order to investigate whether the faster development of these clusters in their morphonotactic function might result from greater practice with morphonotactic than phonotactic clusters, we calculated their lemma and token frequency and LTR and found that morphonotactic clusters have both smaller lexical diversity and token frequency than the comparable phonotactic clusters: the average LTR for phonotactic clusters is 0.18, whereas LTR for morphonotactic clusters is 0.23. This result indicates that faster development of morphonotactic clusters is not due to more practice.

In Vjeran's speech non–prefixed forms are present for all morphonotactic clusters except /*s+m*/ and /*z+dr*/ (e.g. perfective *s+kuhati* 'to cook' and imperfective *kuhati* or perfective *s+pustiti* 'to put down' and imperfective *pustiti* 'to let') or there are examples of other prefixed verbs derived from the same basic form (e.g. *s+kinuti* 'to take off' and *pre+kinuti* 'to interrupt'). Vjeran's prefixed verbs *s+kuhati* 'to cook', *s+kupiti* 'to collect', *s+letjeti* 'to land', *s+lagati* 'to arrange', *s+parkirati* 'to park', *(i)z/*

s+puhati 'to blow out', *s+pustiti* 'to put down', *(i)z/s+peći* 'to bake', *s+padati* 'to fall', *s+rušiti* 'to knock down' *s+trgati* 'to break', and *(i)z+mazati* 'to make dirty' are accompanied by their base verbs. While for the cluster */s+m/* there is no basic verb form, there is a noun from the same root: *mir* 'peace' → *s+miriti (se)* 'to calm down'. The verbs *s+kinuti, s+kidati*, *s+lomiti* and *s+tisnuti* are accompanied by related verbs with other prefixations, e.g. *pre+kinuti*. Most of the prefixed verbs are morphosemantically transparent (e.g. *s+letjeti* 'to land' vs. *letjeti* 'to fly'), while others are opaque (e.g. *s+ kidati* 'to break' vs. *skidati* 'to take off'). Sometimes nonprefixed forms are not even attested in the target language, but only parallel prefixations (e.g. *s+tisnuti* 'to press/squeeze', *u+tisnuti* 'imprint', *pri+tisnuti* 'to press', *po+tisnuti* 'to repress'). Thus, the miniparadigm criterion developed in Dressler et al. 2003, Bittner et al. 2003, Savickiene and Dressler 2007) as a criterion for productivity of a pattern in child speech has been fulfilled, since the same prefix recurs with different bases and the same base autonomously and with prefixes. Lemmas which in Vjeran's CS appear without a derivationally related verb (*z+drobiti* 'to crash', *s+ložiti* 'to arrange', *s+metati* 'to disturb'), have none in his CDS as well.

Marina's and Antonija's corpora have less target clusters than Vjeran's corpus. Nevertheless, their distribution of phonotactic and morphonotactic clusters mainly confirms the differences observed in Vjeran's corpus.

In Marina's corpus, six clusters are both phonotactic and morphonotactic: */sk, sl, sm, sp, st/* and */sr/* with only one phonotactic token. The first–emerged morphonotactic cluster is */s+t/* at 1;11 in *s+trgati* 'to break'. Phonotactic */st/* emerged already at 1;07, once correctly produced, in another lemma /s/ was omitted. From 1;11 onwards, both */st/* and */s+t/* are consistently produced correctly. Thus, there is no clear precedence of either function. In contrast, a morphonotactic precedence found in Vjeran's corpus is confirmed by */s+m/* (in *s+močiti* 'to become wet') produced correctly from its emergence at 2;05. At the same age, the phonotactic target */sm/* appears in *smeće* 'garbage' as *meće* without /s/ and produced correctly only at 2;06.

Whereas in Vjeran's corpus there is a clear morphonotactic precedence for the cluster */sp/*, in Marina's corpus phonotactic */sp/* emerges slightly earlier and the correct production appears at the age of 1;09, a month earlier than morphonotactic */s+p/* appears (2;00). However, phonotactic */sp/* appears in 47 tokens of just one lemma and only in the first production at 1;08 the first phoneme is omitted (*spavati* 'to sleep' → *pavati*); the morphonotactic cluster */s+p/* appears in only 9 tokens of two lemmas (thus with less opportunity to practice the cluster), immediately with the consistently correct production. Thus, there is no clear phonotactic precedence.

There is also no clear precedence in the clusters */sk/* and */sl/*. Although */s+k/* emerges first (1;11) in the morphonotactic function and reappears only at 2;5, phonotactic */sk/* at 2;0, but all are always consistently correctly produced, comparable to Vjeran's corpus. Marina produces */sl/* correctly from 2;05 onwards in both functions, whereas in Vjeran's corpus there is a morphonotactic precedence.

Antonija's corpus has the lowest number of the target clusters due to her shorter period of recording (up to 2;08 vs. Marina up to 2;11 and Vjeran up to 3;02). In Antonija's corpus, there are five clusters with a morphonotactic and phonotactic function: /*sk, sl, sm, sp, st*/. The clusters /*s+l, s+p, s+t*/ show morphonotactic precedence in development: even though they first emerge in the phonotactic function (at 1;5 and 1;7 respectively), their consistent correct production in the morphonotactic function precedes that of their phonotactic function. /*sk*/ and /*s+k*/, as in Vjeran's and Marina's data, show no difference in development. But, only Antonija has incorrect productions of this cluster (e.g. *s+kiniti* 'to take off' → *kiniti, sko**čiti*** 'to jump' → *kočiti*) up to 2;04. There is a slight phonotactic precedence of /*sm*/ (emerged at 1;4 with omitted /*s*/) over /*s+m*/ (2;4 also without /*s*/). Consistent correct production starts for /*sm*/ at 2;05, for /*s+m*/ at 2;6.

Also in Marina's and Antonija's corpus there is a smaller average LTR for the phonotactic function (0.10 and 0.27, respectively) than for the morphonotactic function (0.28 and 0.38, respectively), which again indicates that faster development of morphonotactic clusters is not due to more practice. When comparing the phonotactic and morphonotactic clusters in CDS for all three children, it can be seen that the average LTR for morphonotactic clusters is also in the input always higher than for phonotactic clusters: Vjeran: 0.17 vs. 0.14; Marina: 0.16 vs. 0.11; Antonija: 0.23 vs. 0.11). Most of the time 1) CS LTRs are higher than CDS LTRs and 2) the difference between morphonotactic and phonotactic ones is greater. Thus, 1) children are less repetitive in tokens than their mothers in their language transmission strategy, 2) morphology appears to stimulate children to prefer morphonotactic lemmas. This last result supports our conclusion that morphonotactic clusters develop faster than homophonous phonotactic clusters, though only slightly in Marina's CS.

NAD plays a role in omissions within double (but not triple) consonant clusters: within the highly dispreferred s+stop clusters (irrespective of their phonotactic vs. morphonotactic function) always /s/ is omitted which preserves the highest possible NAD value between the initial consonant and the vowel. In /*sl, sr, sv*/ always /s/ is preserved, which again results in the highest possible NAD value. No generalization is possible for nasal clusters: in /*sm*/ always the nasal is preserved, in /*sn*/ each of the two consonants can be omitted.

Most of the commissions concern the substitution of /r/ with /l/, which is articulatorily determined. Syllabic /r/ in *strgati* 'to break' is replaced by a central vowel or by /u/ in *smrdi* 'it smells'. The second most frequent substitution is lenition of /l/ to [j]. The third frequent one is substitution of /s/ by alveopalatal affricate /**č**/. Examples of consonant fusions are rare, e.g. **štapić** → *čapić* 'little stick'.

6.2. Triple consonant clusters

After investigating word–initial double clusters, let us look at the more complex triple clusters and start again with the biggest corpus:

	Vjeran's CS							Vjeran's CDS		
Cluster	L	T	LTR	1st produc.	Error, Example	1st corr. produc.	Consist. corr. produc.	L	T	LTR
skl	–	–	–					1	1	1
	2	3	0.5	2;05	e.g. skližu	2;05	2;05	5	7	0.71
skr	–	–	–					2	3	0.66
	1	1	1	2;09	COM/2 skrenuti – sklenuti			5	13	0.38
spr	–	–	–					1	7	0.14
	3	41	0.07	1;07	OM/1/2 (1;07) spremio – pemio OM/3 (1;08) spremio – spemio COM/3 (2;01) spremio– splemio DIST/3 (2;10)			5	139	0.03
str	6	27	0.22	1;09	OM/1/3 (1;09) strana – tana OM/3 (1;09) striček – stiček COM/3 (2;0) striček – stliček DIST/3 (2;08)			8	211	0.03
	–	–	–					2	2	1
stv	–	–	–					–	–	–
	1	2	0.5	2;03	e.g. stvar	2;03	2;03	4	51	0.07
štr	1	1	1	2;07	DIS/3			1	4	0.25
škr	1	5	0.2	2;10	COM/3 (2;10) škripanje – šklipanje DIST/3 (2;10)			2	6	0.33
	–	–	–					–	–	–

zdr	1	2	0.5	2;08	DIST/3 (2;08) zdrav			1	3	0.33
	1	1	1	2;02	COM/3 (2;02) z+drobili – zdlobili			1	2	0.5
zgr	–	–	–					–	–	–
	3	8	0.37	2;00	OM/1 COM/3 (2;00) zgrada – glada COM/3 (2;01) zgrade – zglade			3	32	0.9

Table 4. Triple consonant clusters present in Vjeran's corpus

As expected much less triple than double consonant clusters appear in CS. In Vjeran's corpus there are only nine, symptomatically five of them are only morphonotactic: */s+kl, s+kr, s+pr, s+tv, z+gr/,* four of them with the biggest NAD between the two first consonants and between the second and the third. The clusters */s+tv/* and */z+gr/* appear also in CDS only in morphonotactic function. Thus, the difference between CS and CDS for the other three clusters supports our assumption on the positive impact of morphology on consonant cluster development in CS. This seems to be contradicted by */str/* being purely phonotactic in CS but not in CDS. However, */str/* appears in CDS only very rarely and in very rare words (*s+trovaliti* 'to fall down', *s+trusiti* 'to drink up in one sip'), which a child is rather not expected to use. The only triple consonant cluster which appears in CS as both phonotactic and morphonotactic (*/zdr/*) appears with just one morphonotactic token at 2;2 as */z+dl/*, in two phonotactic tokens at 2;8 with distortion of /r/, which is too little for establishing a precedence. */škr/* and */štr/ are* already in the target language only phonotactic.

The first triple consonant cluster in Vjeran's corpus is */s+pr/* (1;07). */s+pr/* and */str/* (emerging at 1;09) have the biggest number of lemmas and tokens in Vjeran's CS and CDS. Thus, as expected, CS mirrors CDS and the highest frequency in CDS appears to have an impact on early emergence in CS. The development of this cluster is linear and consistent: Vjeran is progressing within 4 months from the first production where both /s/ and /r/ are omitted to the commission of /r/ being substituted by /l/, thus */s+premio/* 'he put away' → *pemio* > *spemio* > *splemio* > finally *spremio* with distorted /r/.

The six triple consonant clusters which appear only in Vjeran's CDS (*/spl, shv, skv, špr, zgl, zbr/*), occur there only with one lemma and one or two tokens (except 6 tokens of */shv/* in the only rather abstract lemma *shvatiti* 'to comprehend'). Thus, their absence in CS is not surprising. Marina's CS includes seven triple consonant clusters: /*skl, skr, spr, str, špr, štr, zgr*/ with the same distribution of the morphonotactic vs. phonotactic function. Antonija uses only 4 triple consonant clusters: /*spr, str, zdr, zgr*/. Also in these two corpora /*spr*/ and /*str*/ are the most frequent triple consonant clusters.

When comparing triple consonant clusters in CS and CDS, it can be observed that there are small differences between CS and CDS in lemmas containing them, but there are much fewer tokens in CS than in CDS. This may be due to greater complexity of triple than of double consonant clusters and to children's avoidance of complexity. But the rise of complexity can only be studied when comparing triple clusters with their two constituent double clusters. The word–initial double clusters were already presented in Table 3 (except /*št, šk, zd, zg*/), thus the emergence and development of these three and of the second constituent clusters in Vjeran's corpus is given in Table 5:

Cluster	L	T	LTR	1st pro-duc.	Error, example	1st corr. produc.	Consist. corr. product.
št	6	233	0.02	1;03	OM/1 (1;03) štapić –tapić	2;04	2;04
šk	6	36	0.16	1;06	OM/1 (školi) školi – koli SUP/1 (2;00) školi – ckoli	1;07	2;02
zd	1	1	1	2;04	e.g. zdjelica		
zg	1	3	0,33	2;02	e.g. z+gubiti	2;02	2;02
kl	4	7	0.57	1;10	OM/2 (1;10) klaunovi – kau-novi	2;06	2;06
kr	28	120	0.23	1;02	OM/2 (1;02) krov – klov COM/2 (2;00) krenit – klenit DIST (2;08)		
pr	62	285	0.21	1;02	OM/2 (1;02) prozor – pozor COM/2 (1;11) prišao – plišao DIST (2;03)		
tr	21	182	0.11	1,03	OM/2 (1;03) trava – tava COM/2 (1;11) tražio – tlažio DIST (2;05)		

tv	1	20	0.05	1;07	OM/2 (1;07) tvoj – toj	2;05	2;05
dr	3	144	0.02	1;06	OM/2 (1;06) drugi – dugi COM/2 (1;10) drago – dlago DIST (2;07)		
gr	11	45	0.24	1;07	OM/2 (1;07) granu – ganu COM/2 (2;01) grabljao – glabao DIST (2;08)		

Table 5. The emergence and development of the second constituent clusters and clusters */št, šk, zd, zg/* in Vjeran's corpus

In order to study the rise of cluster complexity we adopt the new method of comparing the emergence of triple clusters and of their constituent double clusters. The result is that triple clusters emerge later than their constituent clusters with the exception of */zgr, zdr/*, whose first parts emerge later because of their smaller lemma and token frequencies and less preferred NAD, whereas the much more frequent and preferred second constituent clusters emerge earlier than the respective triple clusters. Substitution of /r/ by /l/ continues longer in triple than in double clusters. Consistent phonological correctness is reached earlier in double than in triple clusters. Phonetically /r/ is, as expected, always distorted by reduction or absence of vibration throughout the entire CS corpora. Antonija's corpus provides not enough data for the rise of complexity, but Marina's corpus confirms these conclusions.

6. Conclusion

In this first systematic investigation of emergence and development of Croatian word–initial consonant clusters in first language acquisition, we focused on the comparison between morphonotactic and phonotactic word–initial clusters. Our main result has been that, similar to the other morphology–rich languages studied, Polish and Lithuanian, morphonotactic clusters are mostly acquired earlier than phonotactic clusters. For establishing the order of acquisition, we introduced the new method of concentrating on the final period of acquisition, i.e. full mastery obtained when consistently correct production starts in CS. This is the case of morphonotactic clusters even when homophonous phonotactic clusters emerge first.

As expected, there is a positive relation between cluster complexity and morphonotactic function. Unless there is a disproportion in frequencies, complexity, both in terms of linguistic structure and in processing costs, rises in time from double clusters to triple clusters.

We also undertook for the first time the calculation of NAD preferences for Croatian consonant clusters. As expected, Croatian morphonotactics creates less preferred clusters than phonotactics and the more complex triple clusters are mostly morphonotactic. These are all, in stark contrast to double clusters, preferred clusters. They originate by combining a mostly dispreferred initial double cluster with a preferred second cluster constituent.

Our longitudinal study of spontaneous verbal interaction between children and their caregivers not only provides more ecological validity to our results than transversal group studies would, but also allows to compare CS with CDS. As expected, the quantitative distribution of clusters in CS mirrors that of CDS, but the order of emergence and mastery can be predicted only partially from frequency in CDS, in agreement with the conclusions in Ravid et al. (2019).

Since Croatian is a less consonantal language than most other Slavic languages, it has also fewer and less complex consonant clusters than Polish, Slovak and Russian. One consequence is that the paths of cluster acquisition by our three Croatian children are less varied than those of Polish children. They do not commit word–initial errors of consonant metathesis as well as vowel and consonant prothesis and epenthesis as attested in Zydorowicz's (2019: 169) Polish data.

Evidently our generalizations would become more reliable when further and longer child corpora can be investigated. The first author also plans a thorough analysis of electronic corpora of adult language in order to compare it with CDS, which would allow for the first time to study caretakers' fine–tuning and scaffolding in the acquisition of phonotactic and morphonotactic consonant clusters.

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Razvoj morfonotaktičkih i fonotaktičkih zatvorničkih skupina u usvajanju hrvatskoga kao materinskoga jezika

Ovaj se rad bavi usvajanjem početnih morfonotaktičkih i fonotaktičkih zatvorničkih skupina u hrvatskome. Morfonotaktičke se zatvorničke skupine protežu preko granice morfema, npr. */sl/* u *s+ložiti*, dok se fonotaktičke zatvorničke skupine nalaze unutar morfema, npr. *sladoled*. Analiziran je Hrvatski korpus dječjeg jezika (Kovačević 2002), longitudinalni korpus koji je prikupljen prema smjernicama međunarodnog projekta CHILDES te međujezičnog projekta Pre– i Protomorfologija u jezičnom usvajanju pod vodstvom drugog autora. Dosadašnja su istraživanja u području usvajanja morfonotaktike pokazala prednost u usvajanju morfonotaktičkih zatvorničkih skupina u morfološki bogatim jezicima, poljskom i litavskom. Ovaj rad proširuje dosadašnji pristup usmjeravajući se na proces ovladavanja proizvodnjom suglasničke skupine, a ne samo na vrijeme pojavljivanja u dječjem jeziku. Analiza Hrvatskog korpusa dječjeg jezika pokazala je da se u hrvatskome, usporedivo s podatcima dobivenim iz drugih morfološki bogatih jezika, morfonotaktičke zatvorničke skupine usvajaju ranije nego istozvučne fonotaktičke zatvorničke skupine. Istražena je i obilježenost dvočlanih i tročlanih početnih zatvorničkih skupina promatrajući ih u svjetlu koncepta *Net Auditory Distance* (NAD) koji do sada za hrvatski nije korišten. Dosadašnje su spoznaje u području usvajanja morfonotaktike proširene i istraživanjem razvoja složenosti zatvorničkih skupina te se pokazalo da morfonotaktika vodi k većoj složenosti, no složenije zatvorničke skupine nisu nužno i više obilježene. Dječji je jezik uspoređen s ulaznim jezikom te je na taj način postignuta veća ekološka valjanost. Dobiveni su rezultati uspoređeni s dosadašnjim istraživanjima usvajanja morfonotaktičkih i fonotaktičkih zatvorničkih skupina u poljskome te su pronađene određene razlike u tijeku usvajanju koje su rezultat strukturalnih razlika između ovih dvaju slavenskih jezika.

Keywords: first–language acquisition, morphonotactics, phonotactics, child corpora, Net Auditory Distance (NAD), Croatian language

Ključne riječi: jezično usvajanje, morfonotaktika, fonotaktika, korpus dječjeg jezika, Net Auditory Distance (NAD), hrvatski jezik