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Articulation accuracy in monolingual Latvian-speaking preschoolers: results of a large-scale population study

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Summary

This article reports the results of a large-scale articulation accuracy study based on a sample of 492 monolingual Latvian-speaking preschool children aged between 3;2 and 5;11. The study has been conducted using the Latvian Phoneme Test – a picture-based tool eliciting 25 consonant singletons in initial, medial and final position and 33 tauto- and heterosyllabic clusters word-initially and intervocalically. The article discusses some general developmental trends, and establishes the ages of acquisition and mastery of singleton consonants and consonant clusters. Being the first study of its kind, it represents a useful resource with a range of educational, clinical and research applications.

Keywords: articulation accuracy, Latvian, consonants, clusters, individual variation, reversals, phonological acquisition

1. Introduction

The study reported here is the first large-scale population investigation aimed at describing the actual course of articulation accuracy development in Latvian-speaking children. Earlier works addressing this topic – while very few - were based on either diary studies of individual children (Rūķe-Draviņa 1982, 1990, 1993, Markus 2003) or articulation norms developed for languages other than Latvian (Kušķe 2013a, 2013b). Diary studies yield very valuable (and often - very detailed) longitudinal information on the course and rate of phonological acquisition in individual children. However, their limited scope and pervasiveness of individual variation in early language development means that the patterns identified in such studies are not necessarily characteristic of the population as a whole. The use of articulation norms developed for other languages as a point of reference can potentially be very misleading: even though cross-linguistic tendencies do exist, the course and rate of phonemic acquisition varies across languages (e.g. Priester et al. 2011). This is not surprising considering that the sound inventory is acquired hand in hand with the language-specific system of phonological contrasts. Besides, recent studies indicate that young children are very sensitive to distributional properties of the ambient language and use those in sound acquisition. Thus, sounds and sound combinations that are more frequent in the ambient language can appear earlier and be produced more accurately in child speech (Kirk & Demuth 2003, Stites et al. 2003).

The data collection for this study has been carried out in 2015-2016 in kindergartens and daycare centers in Riga, Latvia. The results reported here are based on a gender-balanced sample of 492 typically developing monolingual children (239 boys, 253 girls) distributed across 12 age groups (from 3;2 to 5;11). Unlike in the previous studies, the large sample size allows us to identify developmental trends in the acquisition of singleton consonants and consonant clusters, as well as to estimate the range of individual variation. These results can be a useful resource for clinical and educational practitioners as well as researchers interested in phonological development and Latvian phonotactics and prosody.

This article is structured as follows. In Section 2, we describe the methodology and the participant sample of the present study. Section 3.1 reports the results based on the overall accuracy scores, while Section 3.2 and Section 3.3 focus on the results obtained for consonantal singletons and clusters respectively. Section 4 contains summary and conclusions.

2. Methodology

2.1. Instrument and procedure

The data reported in this article were collected with the help of the Latvian Phoneme Test (LPT) – a picture-based tool aimed at measuring production accuracy in monolingual children aged 3 years and older. LPT consists of 87 colored pictures of objects and actions familiar to children, and elicits single-word utterances (familiarity of items and recognizability of pictures included in the test was ascertained with a pilot study).

The test elicits 25 consonant singletons in initial, medial and (where possible) final position, 33 tauto- and heterosyllabic clusters word-initially and intervocalically, as well as two diphthongs. Vowels were not included in the test, because studies show that vowel productions are usually target-like by the age of 3;0 (e.g. Dodd et al. 2003). In total, LPT assesses the accuracy of production on 107 items. Most items included in the test are singular nouns. However, due to the rules of Latvian inflectional morphology, all singular nouns end in either [-a, -e] (feminine declensions) or [-s, - ʃ] (masculine declensions), which makes it impossible to test other word-final singletons in nouns. For this reason, we also included a number of third-person present tense verbs (e.g. [gri͜eʒ] ‘he/she cuts’) and two locational prepositions ([uz] ‘on’ and [zem] ‘under’).

Children were tested individually in a quiet room by two evaluators (both native speakers of Latvian). Nouns were elicited with the question “What is it?”, verbs were elicited with “What is he/she doing?”, and prepositions were elicited with “Where is he/she?”. Whenever possible, spontaneous productions were elicited. If a child could not name the picture spontaneously, the delayed imitation was used (“This is X. Can you repeat that?”). Both spontaneous and imitated productions are included in the results reported here. All responses were audio-recorded. In addition, response accuracy for each target sound was marked in the scoring sheet at the time of testing (Correct/Incorrect). All scoring sheets were later verified by an additional evaluator based on the audio recordings.

2.2. Participants

For the purposes of this study, monolingual pre-school children speaking Latvian (N=492) were recruited in kindergartens and daycare centers in Riga, Latvia. We defined “monolingual” as “coming from the family where all primary caregivers speak the target language natively, and attending the kindergarten where the target language is the primary language of instruction”. It has to be noted, however, that for most – if not all – children in our sample at least some exposure to non-target languages (usually Russian) has to be assumed due to a sizeable proportion of bilinguals in the population. For example, in the population census of 2011, 34% of all respondents reported that Russian is the main language they use at home (vs. 56% who named Latvian). In Riga - where the LPT was conducted - the proportion is even larger: 49% of respondents named Russian as their primary language, while only 38% said they mainly spoke Latvian at home (data provided by the Central Statistical Bureau).

(1) Table 1: Distribution of LPT participants by age and gender

	Age Groups												**TOTAL:**
	3;2	3;5	3;8	3;11	4;2	4;5	4;8	4;11	5;2	5;5	5;8	5;11	
Male	10	19	17	14	19	21	26	23	29	24	30	7	**239**
Female	12	16	16	23	25	18	26	27	26	28	21	15	**253**
TOTAL:	**22**	**35**	**33**	**37**	**44**	**39**	**52**	**50**	**55**	**52**	**51**	**22**	**492**

Participants were divided into 12 age groups, ranging from 3;2 to 5;11. Children in each age group are within one (full) month of target age, e.g. children grouped under “3;5” can be aged between 3;4 and 3;6. Distribution of children by age groups and gender is indicated in (1)[1].

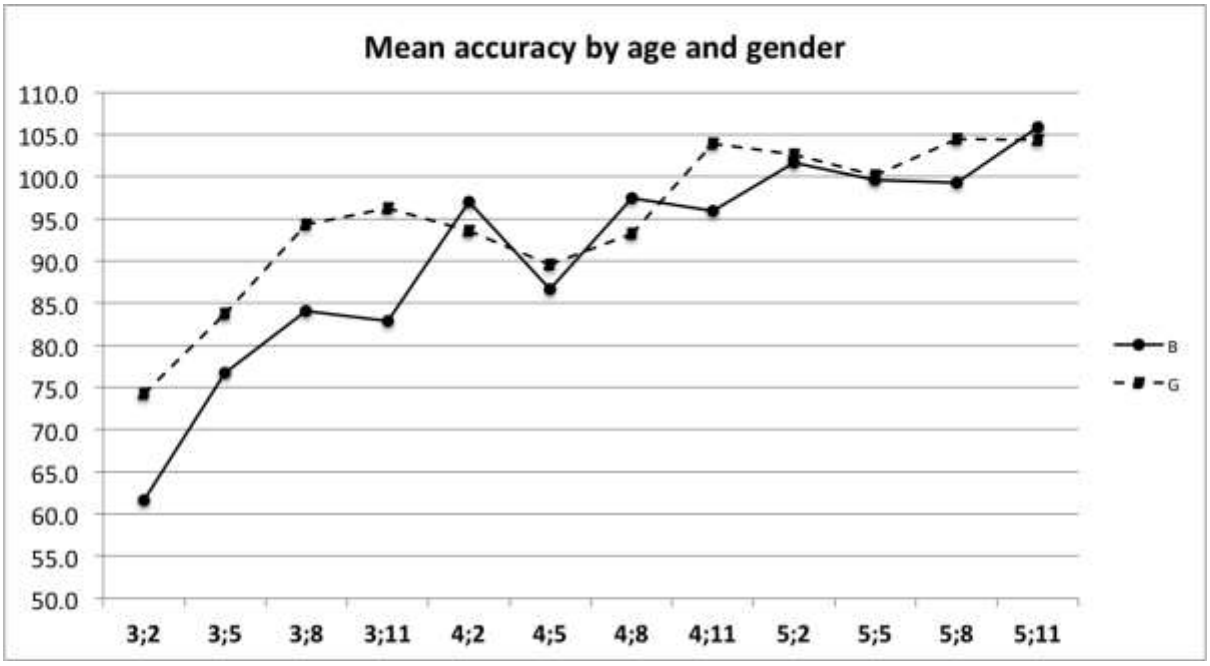
3. Results

3.1. Overall accuracy

In this section we examine the overall results of the LPT, based on the total number of correct responses. Figure 1 shows the mean total scores for boys and girls in each age group (maximum total score that could be achieved is 107). As expected, both curves indicate an increase over age in the mean number of acceptable responses from 61.6 to 105.9 for boys and from 74.3 to 104.4 for girls. Pearson´s product-moment correlation revealed that the positive correlation between age group and mean accuracy is highly significant, both for boys ($r = 0.85$, $p < 0.001$) and for girls ($r = 0.9$, $p < 0.001$).

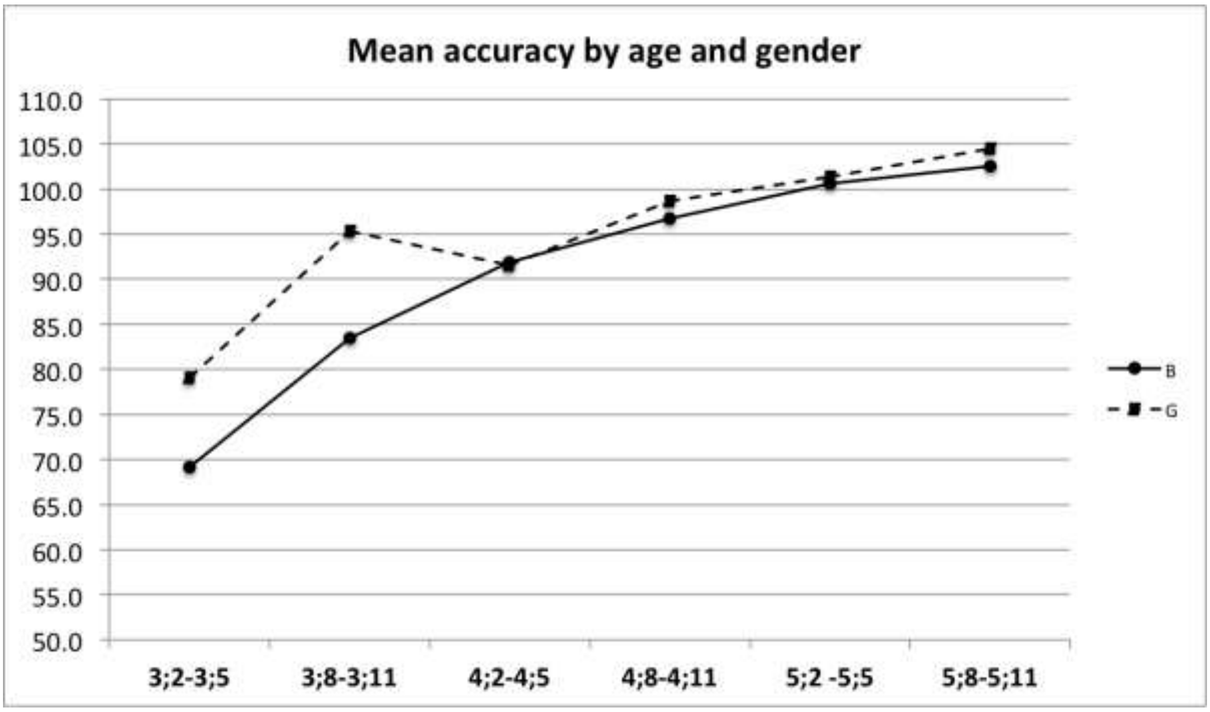
(2) Figure 1: Mean total scores by age and gender

[1] We did not control for demographic variables other than gender and place of residence (Riga for all participants). While a follow-up study might be needed to investigate how children from lower SES households compare to our sample, articulation studies comparable in scale (e.g. Smit et al. 1990, Dodd et al. 2003) report no correlation between articulation accuracy and demographic variables other than gender.



Although the general trend in the data is for the production accuracy to grow as age increases, the curves in (2) are not monotonic. For instance, we can observe a dip in the girls´ performance starting at age 3;11, as well as the significant spike for boys at age 4;2. Reversals (i.e. the situation where a certain accuracy level is reached in some age group but not in the older one) have been previously reported in normative articulation accuracy data for individual sounds (e.g. Prather et al. 1975, Smit et al. 1990, Goldman & Fristoe 2000, Moyle 2005, Owaida 2015). The majority of cross-sectional studies, however, found that overall accuracy increases monotonically over age (but see Mayr et al. 2015), and in this light the developmental curves in Figure 1 are somewhat surprising. Note, however, that in most previous studies (Smit et al. 1990 for American English, Dodd et al. 2003 for British English, Owaida 2015 for Syrian Arabic) the accuracy scores were reported for 6-month bands, while in (2) the scores for every three months of age are reported. As you can see below, when the same grouping principle is applied to our data, the improvement in performance over age becomes essentially monotonic for both genders.

(3) Figure 2: Mean accuracy by age and gender for every 6 months of age



As evident from Figure 1, Latvian-speaking girls tend to show a higher accuracy of production than boys. The difference in mean scores is especially apparent in age groups 3;2 to 3;11. A one-way independent samples ANOVA revealed a significant effect of gender in age groups 3;11 ($F(1, 35) = 9.2$, $p = 0.004$) and 4;11 ($F(1,48) = 4.154$, $p=0.047$), and a marginally significant effect in 5;8 age group ($F(1, 49) = 3.484$, $p = 0.068$). Significant gender differences are frequently reported in normative studies of articulation accuracy (Smit et al. 1990, Dodd et al. 2003, Moyle 2005), although there are normative studies where no such differences are found (e.g. Owaida 2015). The reported ages of gender differences vary from study to study. While some studies found significant effect of gender in older pre-school children, but not in younger groups (e.g. Moyle 2005 reports higher accuracy for girls at 5;0-5;11 and 6;0-6;11 group, and Dodd et al. 2003 observed gender differences in 5;6 -7;0 y.o. children), others found that the tendency of girls to outperform boys reaches statistical significance in several non-consecutive age groups (e.g. Smit et al. 1990 reports significant differences between boys and girls at ages 4;0, 4;6 and 6;0 – similarly to what we find here). Explanations that have been suggested for the reported gender differences in speech development include a greater likelihood for boys to have language disorders (Weindrich et al. 1998, Lewis 1990), differences in the maturation rates of brain and speech organs, and differences in socialization (see Dodd et al. 2003 for an overview).

Table 2 provides mean accuracy scores (in percent) and standard deviation for boys and girls in each age group. As you can see, the variability in the accuracy scores is very large in our sample, especially in the younger age groups, where SD reaches up to 21.5. At the same time, there is an obvious tendency for SD to decrease with age, from 16.7 to 2.1 for boys and from 21.5 to 5.1 for girls. Large SD values with the tendency to decrease over age are often reported in cross-sectional articulation accuracy studies (Smit et al. 1990, Dodd et al. 2003; cf. Owaida 2015). This is not surprising, as we expect the differences between children to gradually reduce as their sound inventories are expanding (note, however, that the decrease in SD in our sample is not monotonic). Pearson´s product-moment correlation test revealed a significant inverse correlation between SD and age group (t = -5.11, r = -0.85, p = 0.0004) and SD and accuracy (t = -5.47, r = -0.86, p = 0.0003).

(4) Table 2: *Mean proportion of correct responses and SD by age and gender*

	3;2	**3;5**	**3;8**	**3;11**	**4;2**	**4;5**	**4;8**	**4;11**	**5;2**	**5;5**	**5;8**	**5;11**
B	56.7 (16.7)	71.7 (19.6)	78.6 (15.1)	77.4 (13.6)	90.7 (7.9)	81.0 (17.1)	91.1 (13.3)	89.7 (18.4)	95.0 (6.6)	93.1 (6.4)	92.8 (11.6)	98.9 (2.1)
G	69.4 (21.5)	78.3 (17.7)	88.2 (12.9)	90.0 (11.4)	87.5 (13.5)	83.7 (20.0)	87.2 (17.0)	97.2 (4.3)	96.0 (7.7)	93.6 (7.6)	97.6 (3.5)	97.6 (5.1)
	64.0 (20.0)	74.7 (18.7)	83.2 (14.7)	85.2 (13.5)	88.9 (11.4)	82.3 (18.3)	89.1 (15.2)	93.7 (13.3)	95.4 (7.1)	93.4 (7.0)	94.8 (9.4)	98.0 (4.4)

Large SD values in (4) point at the considerable dispersion of individual scores around the age group mean. Variability is one of the hallmarks of typical language development (see Hoff 2009, Menn et al. 2013 for an overview). Significant differences between children of the same age in the rate and/or course of acquisition have been reported for vocabulary (Bates et al. 1995), grammar (Hoff 2009, Stromswold 2001 for an overview) and phonology (Ferguson 1979, Stromswold 2001). Individual differences in non-disordered language acquisition have been attributed to the complex interaction between genetic (i.e. hereditary) and environmental factors. Potential effect of genetic factors on linguistic ability have been investigated in a number of studies comparing the performance of siblings in mono- and dizygotic (i.e. identical and fraternal) twin pairs on a range of linguistic measures. Since identical twins share 100% of their genetic material, while fraternal twins only share about 50% (Stromswold 2001), we would expect identical twins to be more similar to each other in their language abilities if such abilities are genetically conditioned. On the other hand, if identical twins are no more similar in their performance than fraternal twins, the role of genetic factors can be considered insignificant. Stromswold (2001) conducted a meta-analysis of more than 100 studies investigating the role of genetic factors in determining language abilities. With respect to phonology, it has been found that the effect of genetic factors on non-disordered articulation is moderate but significant, accounting for about 25% of variation in performance on articulation tests (Stromswold 2001:675). As for environmental factors, in several studies a positive correlation has been found between articulation skills and socioeconomic status (see Gordon-Brannan & Weiss 2007 for an overview), which has been related to higher SES families creating a more stimulating linguistic environment. Another environmental factor that has been shown to contribute to the development of articulation skills is sibling status, with children without siblings, firstborn children and children with greater age differences between siblings showing better performance on articulation accuracy measures (Gordon-Brannan & Weiss 2007 and references therein).

3.2. Acquisition of singleton consonants

In this Section we will discuss the results based on the proportion of acceptable productions of singleton targets. For the full summary of results by target, age group and gender, please refer to Appendix 1.

Figure 3 illustrates the mean proportion of acceptable production of singleton targets (initial, medial and final position combined) by age and gender. Already in the youngest group tested, the mean accuracy on singletons reaches 70% for boys and 80% for girls, while the threshold of 90% accuracy is reached by girls at the age of 3;8, and by boys at the age of 4;2. Again, a tendency for girls to outperform boys is evident in most age groups, although at 4;2, 4;8 and 5;5 this tendency appears to be reversed. However, the difference between genders reaches statistical significance only at 3;11 ($F(1, 34) = 10.32$, $p = 0.0028$).

(5) Figure 3: Mean proportion of correct singletons by age and gender

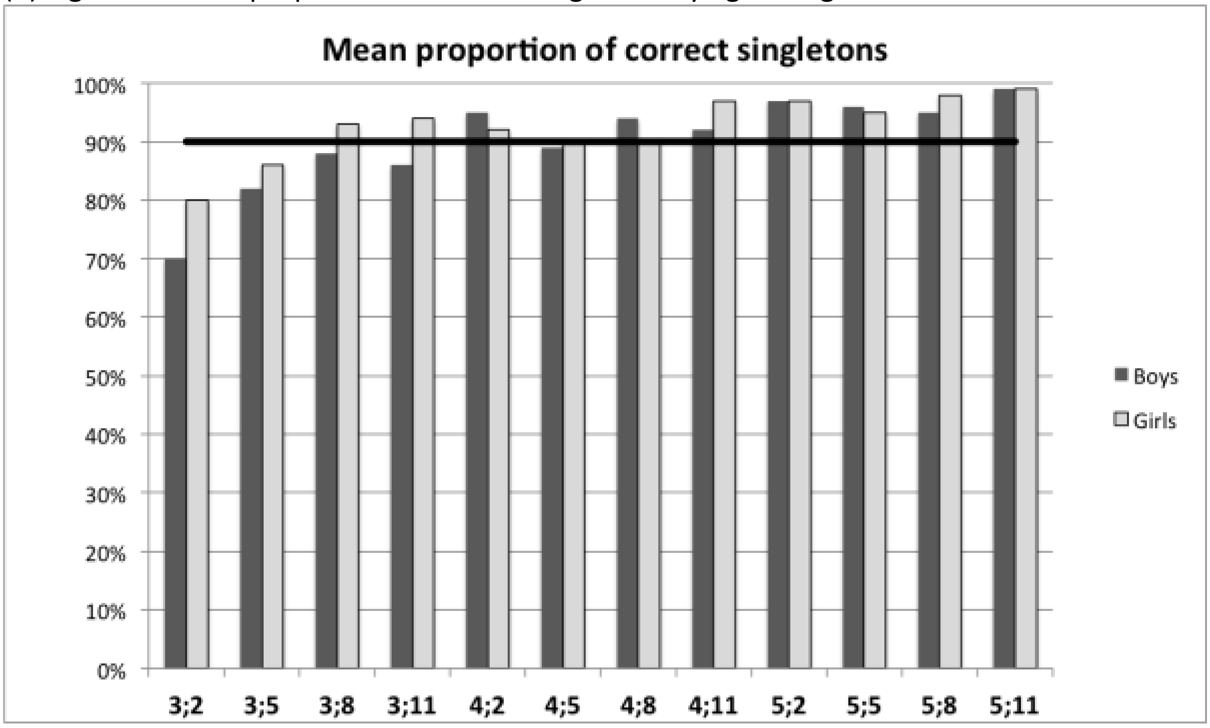


Table 3 in (6) provides the ages where a 75% and 90% acquisition threshold was reached for consonantal singletons. Following Amayreh & Dyson (1998), we define 75% threshold ("age of acquisition") as the age group where at least 75% of children produce the sound correctly in all three positions (or in all positions tested, if less than three); 90% threshold ("age of mastery") is reached when at least 90% of children produce the sound correctly in all positions. For the sounds that were at or above the set threshold in the youngest age group, "≤ 3;2" is indicated, while for the sounds that never reached the given threshold in our sample ">5;11" appears. The number in round brackets indicates the age when a given sound stabilized at 75% or 90% level, i.e. the age after which no reversals below a given threshold were observed in older groups. For instance, [r] first reached 75% level in the 4;8 age group for boys, but only stabilized at this level at 5;8 (the developmental curve for [r] (positions combined) is illustrated in Figure 4). As already mentioned, such reversals are frequently reported in articulation studies (Prather et al. 1975, Smit et al. 1990, Goldman & Fristoe 2000, Moyle 2005, Owaida 2015), and there is no consensus as to why they occur. Smit et al. (1990) proposes sampling error as a possible cause, and also discusses the possibility of examiner bias. Moyle (2005) and Dodd et al. (2003) also name inconsistency in production – i.e. within-child fluctuation between a correct and an incorrect form – as a potential reason for the pervasive reversal patterns. Finally, it is possible that the observed reversals reflect a true characteristic of the population – that is, it is indeed the case that individual children regress in their articulation after they have achieved a correct production of some sound (Smit et al. 1990). As a matter of fact, a U-shaped learning pattern – i.e. a developmental change characterized by a decrease in production accuracy relative to the adult target (Stemberger et al. 1999) – has been reported for individual children in a number of longitudinal studies (see, *inter alia*, Smith 1973, 2010, Fikkert & Levelt 2008, Stemberger et al. 1999, Becker & Tessier 2010 and references therein). However, while any of the explanations proposed for reversals (or some combination thereof) may potentially account for the observed patterns, more research is clearly needed before any definitive conclusions can be drawn.

(6) Table 3: Ages of 75% and 90% acquisition of singleton consonants

	75%		90%	
	M	F	M	F
b	3;5	3;5	3;11	4;8
d	3;5	≤3;2	3;8	≤3;2 (3;8)
g	3;5	3;5	3;5	3;8 (4;11)
p	≤3;2	≤3;2	≤3;2	≤3;2
t	≤3;2	≤3;2	≤3;2	≤3;2
k	≤3;2	≤3;2	≤3;2 (3;11)	3;5 (4;11)
l	3;8 (4;8)	≤3;2	4;2 (5;2)	4;8
m	≤3;2	≤3;2	≤3;2	≤3;2
n	≤3;2	≤3;2	3;11	3;5
ɟ (i, m)	4;5	≤3;2 (4;8)	≥ 5;11	4;11 (≥5;11)
c (i, m)	4;5 (5;2)	≤3;2 (4;11)	5;2 (>5;11)	≥5;11
ʎ	4;2	3;5	5;2	4;11 (≥5;11)
ɲ (m)	3;5 (4;2)	3;5	3;8 (4;11)	3;8 (4;5)
r	4;8 (5;8)	3;11 (4;11)	≥5;11	4;11 (5;8)
s	≤3;2	≤3;2	3;5 (3;11)	3;8 (4;11)
z	3;5	≤3;2	3;11 (4;8)	3;8 (4;8)
ʃ	3;8 (4;8)	3;8 (4;8)	4;2 (5;8)	4;11
ʒ	4;2 (4;8)	3;8 (4;8)	5;2 (≥5;11)	5;2 (5;8)
t͡s	3;5	≤3;2	3;11(4;11)	3;11(5;2)
d͡z	3;11	3;5	4;11	3;11 (4;11)
t͡ʃ (i, m)	3;8	≤3;2 (3;8)	5;2 (≥5;11)	3;11 (4;11)
v (i, m)	3;11	3;5	4;8	3;8 (4;11)
f (m)	3;8 (4;2)	3;8 (4;5)	4;8 (5;2)	4;11
h (i)	3;8 (4;8)	3;8	4;2 (5;5)	4;8
j (i, m)	3;5	≤3;2	3;5	≤3;2

(7) Figure 4: *Acquisition of [r] by age group*

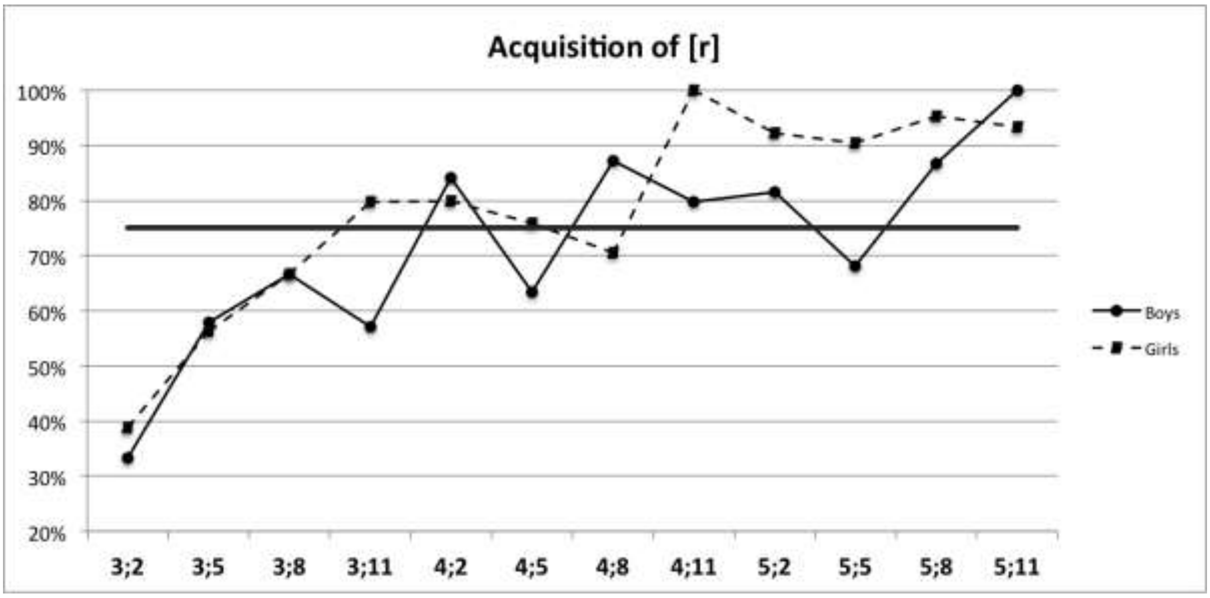


Table 3 shows that individual consonants vary considerably with respect to the age when they are mastered, which suggests that some consonants are in a sense “easier” than others. The rate and order of acquisition of individual sounds is usually attributed to their relative markedness, with the unmarked sounds appearing first in the developing inventories (Gnanadesikan 2004, Levelt & van de Vijver 2004). The notion of markedness is closely linked to typological distribution, such that the member of a contrasting pair that is more cross-linguistically widespread is said to be unmarked for the contrasting feature. Autosegmental theories of phonology (e.g. Clements & Hume 1995, Halle, Vaux & Wolfe 2000, Morén 2003) also establish the link between markedness and structural complexity, such that the marked member of the opposing pair is usually represented as having more complex structure. Since the notion of markedness was introduced by Trubetzkoy (1939/1969), markedness relations have been proposed for a number of phonological oppositions. It has been observed, for instance, that voiceless obstruents are more common than voiced ones, and that labial place is less marked than alveolar and velar (Maddieson 1984).

Figure 5 shows the total number of correct responses obtained from our sample for each word-initial singleton (max = 492). If we assume that the total score reflects the complexity of a given sound (or its “ease of acquisition”), Figure 5 allows us to draw certain conclusions about the relative markedness of individual sounds and sound classes. However, it should be kept in mind that markedness patterns derivable from these scores can still be reversed in individual children.

With respect to the place of articulation, the mutual ranking of plosive pairs [p, b], [t, d], [k, g] reveals *labial > alveolar > velar* hierarchy, which has been previously reported based on typological studies (Maddieson 1984). With respect to voicing, in all pairs contrasting in voicing (with the exception of [k, g]), the voiceless variant scores either the same (for [p, b] that are at ceiling) or higher than the voiced one, and this observation is true for plosives, fricatives and affricates alike. In anterior/posterior pairs ([s, ʃ], [z, ʒ], [t͡s, t͡ʃ], [l, ʎ]) the alveolar segment always scores higher than its postalveolar/palatal counterpart. In obstruents of the same place ([t, s, t͡s], [d, z, d͡z]), plosives score higher than fricatives, which in turn score higher than affricates (for [ʃ, t͡ʃ] this relationship is reversed). Finally, the accuracy score of initial sonorants [m, n, l, r] inversely correlates with their sonority rank, which might reflect their relative markedness in the onset position (Sievers 1881, Jespersen 1904, Selkirk 1984, Clements 1990).

(8) Figure 5: Total number of acceptable responses per each initial singleton

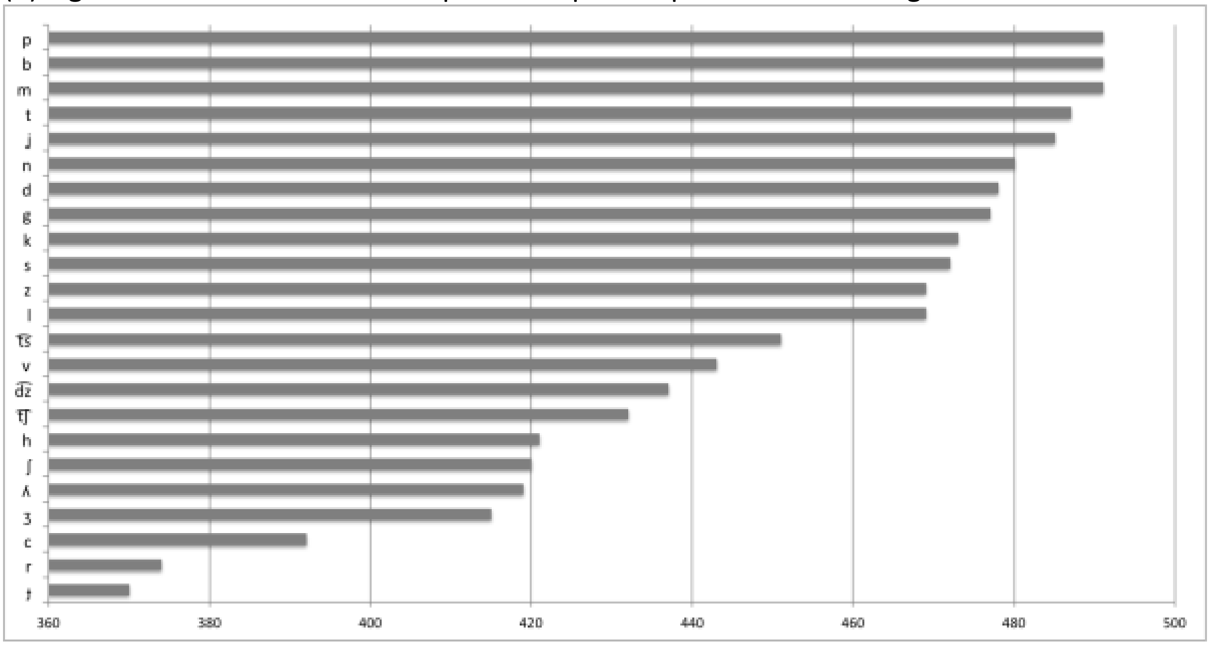


Table 4 illustrates the growth of consonant inventories of boys and girls over time. Unsurprisingly, a number of common features can be observed for both genders. Thus, both boys and girls achieve mastery of plosives [p, t, d], nasals [m, n] and the fricative [ʝ] before the age of 4;0. For both genders, [c, ɟ] do not reach stability at 90% level in our sample, and [r] and [ʒ] are acquired late. Palatal nasal [ɲ], voiced fricatives [z, v] and a voiced affricate [d͡z] are mastered before the age of five by both boys and girls. However, there are also some striking differences between boys and girls with respect to the rate of acquisition of individual sounds. Most surprising, perhaps, is the fact that girls do not master plosives [b, k, g] until after the age of four, while boys have them early. The plots illustrating the development of [g] in the three prosodic positions (10), reveals that girls achieved mastery of initial, medial and final [g] already in the youngest group, but later had a significant drop in the accuracy rate at the age of 4;8. Boys, on the other hand (10b), never regressed below the 90%-threshold after having achieved it at 3;5. Similarly, [s] is among the early sounds for boys, but only reaches 90% level in girls´ inventories by the age of five. At the same time, girls acquire fricatives [f, h, ʃ] before boys do, and achieve mastery of [r] and [ʒ] before the age of 6;0, while boys don´t. Curiously, the order of acquisition of individual sounds differs between the genders, too: for instance, boys acquire [t͡s] before [t͡ʃ], while for girls it is the other way round.

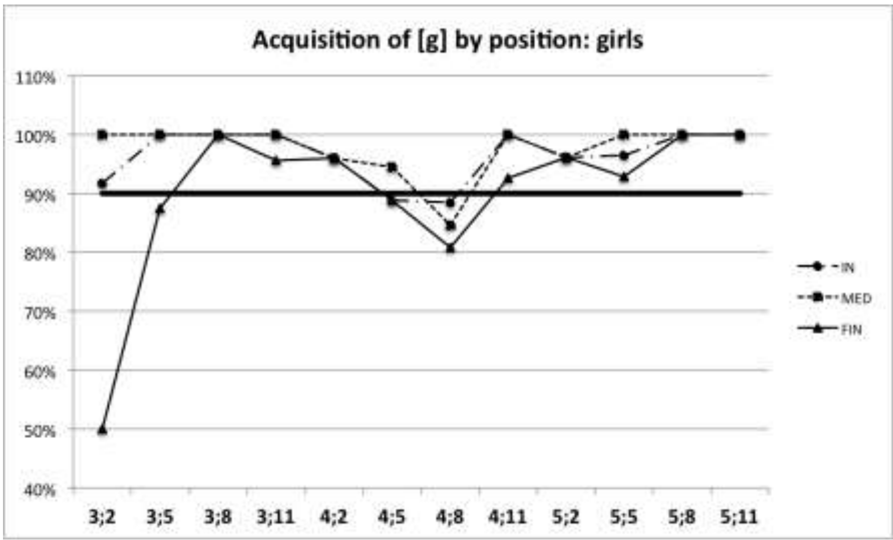
(9) Table 4

Age		Plosive	Nasal	Trill	Lateral	Fricative	Affricate
< 4;0	B	p, t, k b, d, g	m, n			ʝ, s	

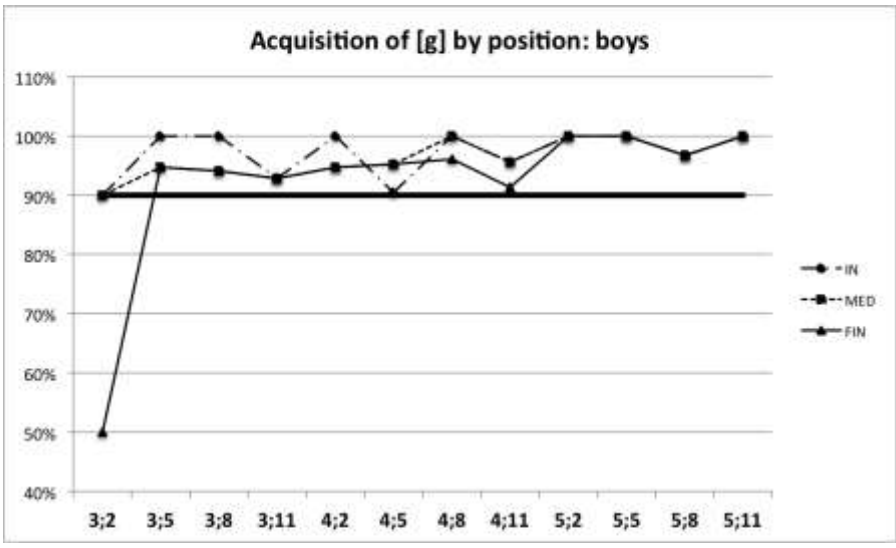
	G	p, t, d	m, n			ʝ	
< 5;0	B		ɲ			v, z	t͡s, d͡z
	G	k b, g	ɲ		l	s, z, ʃ, f, v, h	t͡ʃ, d͡z
< 6;0	B				l, ʎ	f, h, ʃ	
	G			r		ʒ	t͡s
> 6;0	B	c, ɟ		r		ʒ	t͡ʃ
	G	c, ɟ			ʎ		

(10)

a. Figure 6



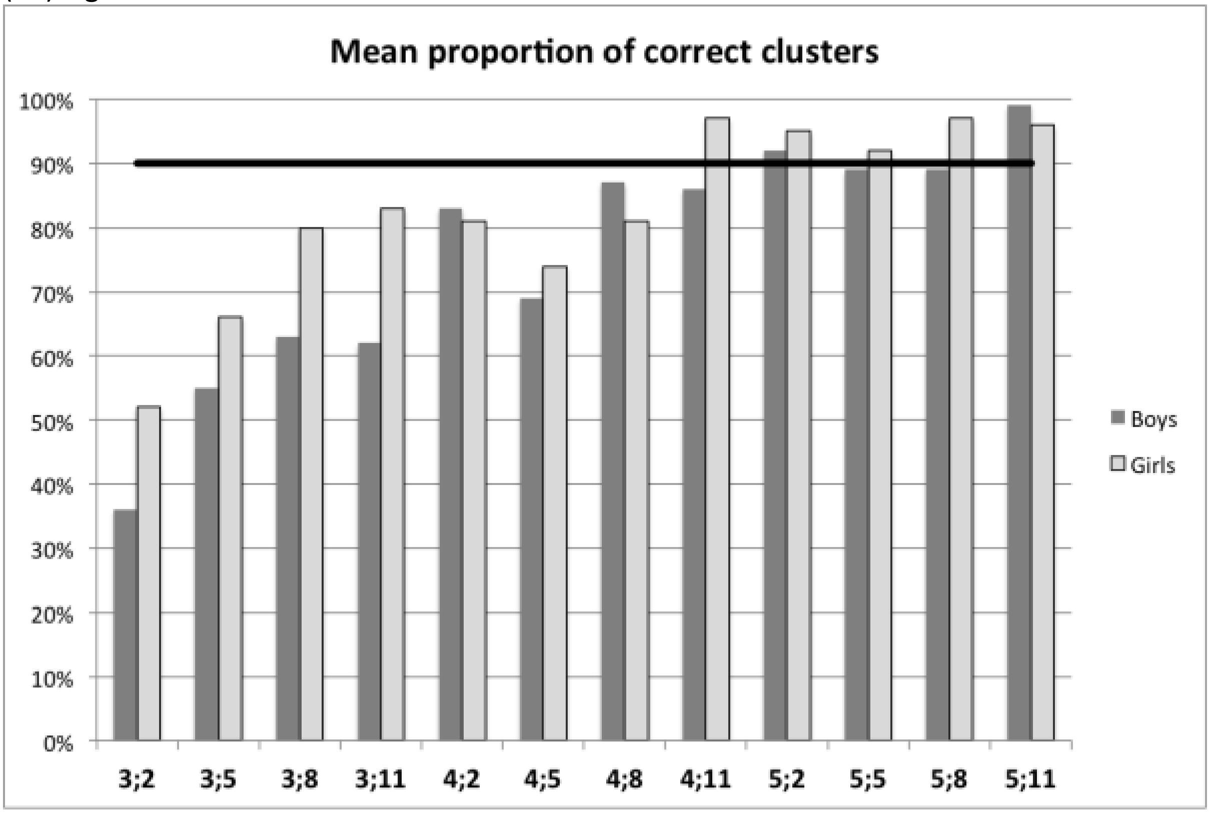
b. Figure 7



3.3. Consonant clusters

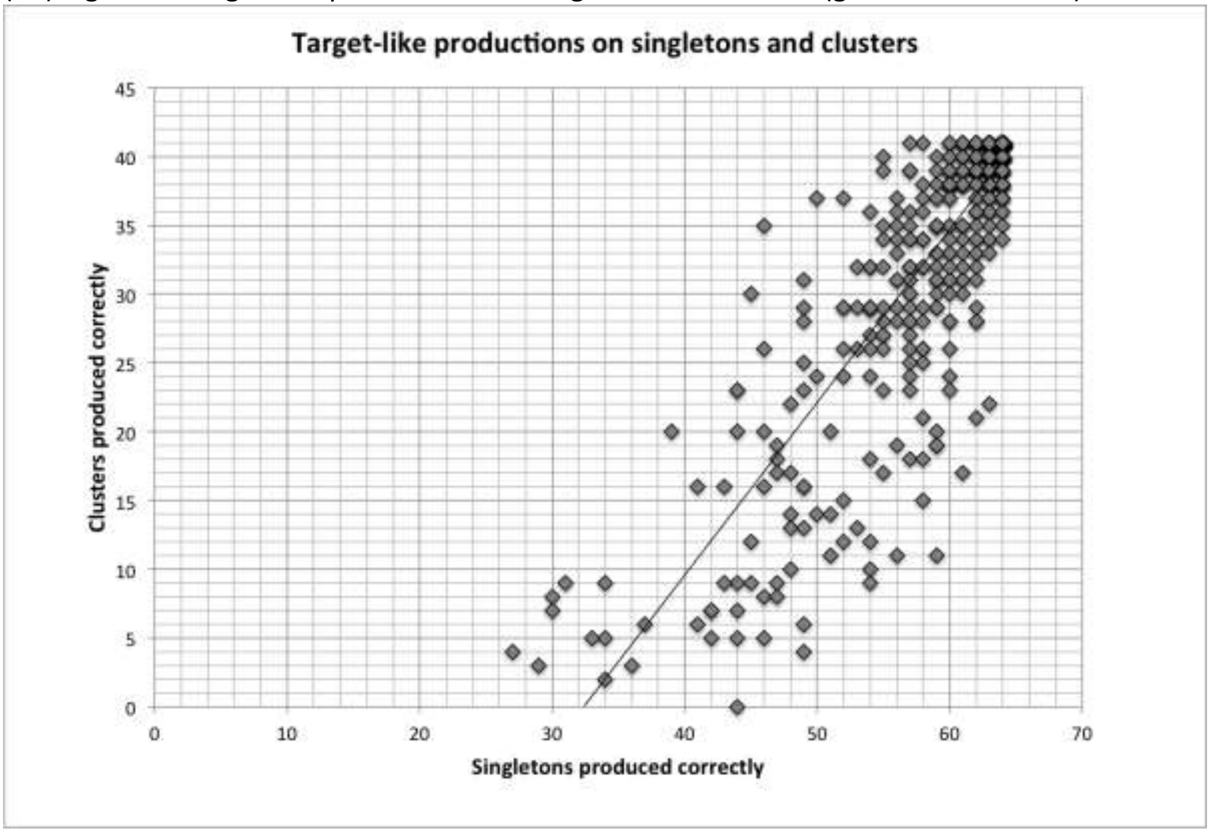
In this Section, we explore the results obtained for consonant clusters (for the full summary of the results by target, age and gender, please refer to Appendix 2). Figure 8 illustrates the mean proportion of correct responses on cluster targets (initial and medial position combined) for both genders. Just as above, there is a certain tendency for girls to score higher than boys (which, however, is reversed at 4;2, 4;8 and 5;11). The difference between boys and girls reaches significance at 3;8 ($F(1, 30) = 4.195$, $p = 0.049$), 3;11 ($F(1, 34) = 11.83$, $p = 0.0015$) and 4;11 ($F(1, 47) = 3.818$, $p = 0.056$).

(11) Figure 8



In Figure 9, the number of acceptable productions of singleton targets (max = 64) is plotted against the number of acceptable productions of clusters (max = 41) for every child. As expected, the plot reveals that the expansion of singleton inventory means the growth in the number of acceptable clusters ($t = 36.57$, $r = 0.85$, $p < 0.0001$). At the same time, the plot also shows a large degree of variation in the number of acquired clusters for children who scored in the range of 40 to 60 on singleton targets. In addition, some children who achieved the maximum score on singletons still struggle with cluster production. These results confirm that the acquisition of clusters involves more than the mastery of their components. On the articulatory side, it necessitates, for example, the correct coordination of consonant gestures in the cluster (Davidson 2003). At a more abstract level, it presupposes the acquisition of complex subsyllabic constituents (e.g. branching onsets or appendix-onset sequences).

(12) Figure 9: Target-like productions on singletons vs. clusters (genders combined)



The role of these factors becomes even more clear if we consider Figure 10, which shows the proportion of children who achieved full accuracy on word-initial singletons [s, p, t, k] and the proportion of children who produced all three initial clusters [sp-, st-, sk-] correctly. As Figure 10 illustrates, the difference between the groups remains considerable up to the age of 4;5, which indicates that only a fraction of those who can produce [s, p, t, k] correctly in isolation can also combine them in clusters.

(13) Figure 10

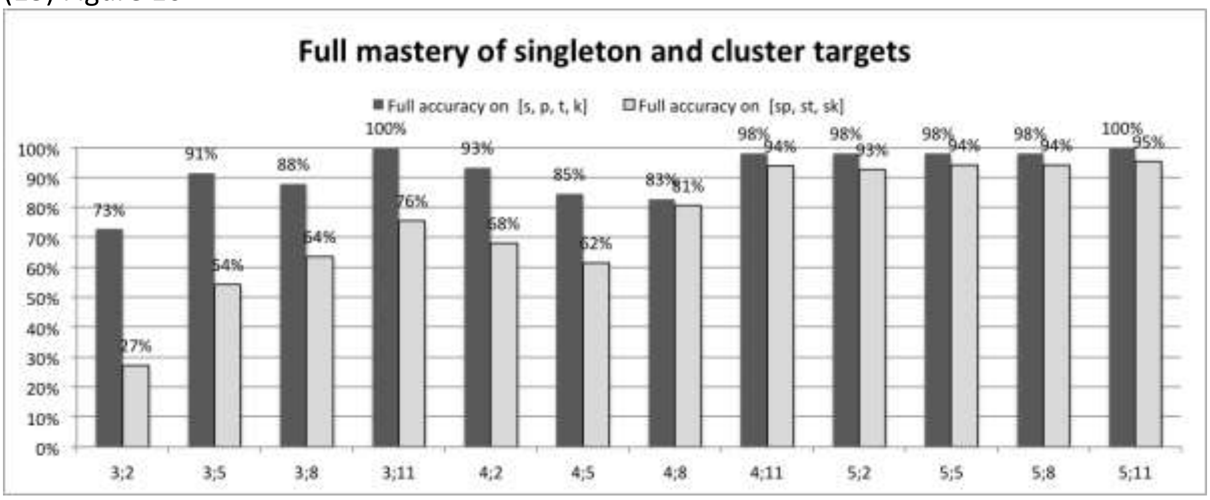


Figure 11 lists initial clusters ranked by the total number of correct responses. Again, the total number of acceptable productions elicited for each cluster may be taken to reflect its relative complexity. Interestingly, the six clusters with the highest cumulative accuracy scores are all sibilant-initial sequences (a relatively low accuracy score of [sk-] is probably due to the late-developing velar place). The tendency of sC clusters to be among the first clusters to appear in the developing inventories have been noted before (Barlow 1997:135 for English, Yavaş et al. 2008 for Germanic), and may be attributed to the special syllabic status of these sequences (Barlow 1997, 2001, Jongstra 2003, Goad & Rose 2004). It has long been observed that sC clusters pattern differently from word-initial sequences of other types – for instance, they consistently escape sonority-based generalizations (s + stop sequences are frequently the only type of falling-sonority onsets in a language) and combinatorial restrictions (homorganic s + sonorant clusters are usually licit, while other types of homorganic clusters might be banned). Based on these typological peculiarities, it has been proposed that sC clusters are not true branching onsets, but rather represent appendix-onset sequences (see Goad 2011 for an overview). Barlow (2001) proposed a typology of cluster development, where either true complex onsets or sC sequences can be the first ones to appear in the child´s inventory. The results in (14) suggest that in our sample sC sequences appear first, and are also the first ones to stabilize at 75% and 90% level (see (15)). While these results reflect the general tendency, it is still possible for it to be reversed in individual children. Rūķe-Draviņa (1990) reports the results of a longitudinal diary study following the language development of three Latvian-speaking children. While one of the children had [sp-] as the first word-initial cluster at the age of 3;0, the other child did not have sC clusters until the age of 4;3, while stop + sonorant clusters have been present already at the age of 3;6.

The next level of complexity is represented by the five clusters that have a lateral as a C_2, [kl, gl, sl, bl, bʎ]. The most difficult clusters are [tr-, dr- and dv-]. Low accuracy rates on rhotic-final clusters is not surprising in the light of the results for singletons that show that [r] is acquired late. Relative complexity of [dv-], which is one of the two licit stop-fricative onsets in the language (the other one being [tv-]), can be attributed to a small sonority distance between its elements.

(14) Figure 11: total number of correct responses by initial cluster

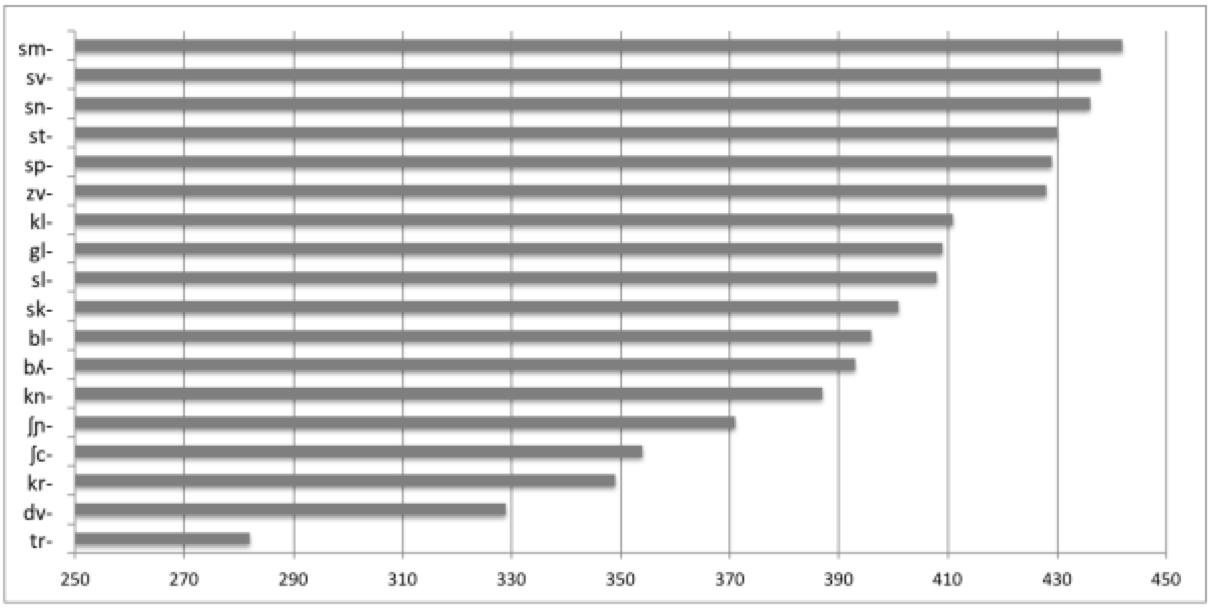


Table 5 lists the age of acquisition (i.e. the age where acceptable production has been achieved by 75% of the children) and age of mastery (i.e. the age when 90% of the children could produce the cluster correctly) for all word-initial clusters included in the test. As you can see, the development of clusters is also characterized by frequent reversals, where children in the older age groups regress below the threshold achieved in the younger group. The earliest initial cluster to stabilize at 90% is [sk-], which is consistently produced correctly by at least 90% of boys from age 4;8 onwards. The hardest sequence to acquire is [ʃc-], which never reaches stability at 90% in our sample.

(15) Table 5: Ages of acquisition of word-initial clusters:

	75%		90%	
	M	F	M	F
bl-	4;2 (4;8)	3;8 (4;5)	5;8	4;11
gl-	4;2 (4;8)	3;8 (4;8)	4;8 (5;2)	4;11
kl-	4;2 (4;8)	3;5 (4;8)	5;5	4;11
bʎ-	4;2 (4;8)	≤3;2 (4;8)	5;5 (5;11)	4;11 (5;5)
kn-	4;2 (4;8)	3;8 (4;8)	5;2 (5;8)	4;11 (5;8)
kr-	4;11 (5;8)	3;11 (4;11)	5;11	4;11 (5;5)
tr-	5;2 (5;8)	4;11 (>5;11)	5;11	5;8 (> 5;11)
sl-	4;2 (4;8)	3;5	5;2 (5;8)	4;11 (5;8)
sm-	3;11	3;5	4;2 (5;2)	3;8 (4;8)
sn-	3;11	3;5	4;8 (5;2)	3;8 (4;8)
dv-	5;2 (5;11)	4;11 (5;8)	5;11	5;2 (5;11)
sv-	3;8 (4;2)	3;8 (4;8)	4;2 (5;2)	3;11 (4;8)
zv-	4;2 (4;8)	3;8 (4;8)	4;2 (5;2)	3;8 (4;8)
ʃɲ-	4;2 (4;8)	4;2 (4;8)	4;2 (5;11)	4;11 (5;8)
sp-	4;2 (4;8)	3;5 (4;8)	4;8 (5;2)	3;8 (4;8)
sk-	4;8	3;11 (4;11)	4;8	4;11
st-	3;11 (4;8)	3;5 (4;8)	4;8 (5;2)	3;8 (4;8)
ʃc-	4;2 (5;11)	4;11	>5;11	4;11 (>5;11)

The inventories in (16) indicate the ages when word-initial clusters stabilized at 75% accuracy or above for boys and girls. As evident from (16), children of both genders first achieve 75% accuracy on s + sonorant sequences, although for girls it happens earlier than for boys. The latest clusters for both genders are [tr, kr, ʃc, dv]. In addition, girls do not acquire [sk] until 4;11 (which is probably related to the late emergence of velar plosives noted earlier). Both inventories in (16) reveal an apparent "cluster spur" occurring at the age of 4;8 for both genders. At that age, most stop + sonorant and s + obstruent clusters stabilize at 75% accuracy.

(16)

a. Initial clusters stabilized at 75% level or above by age group: boys

stop + fricative			dv
stop + nasal	sm, sn	kn	

stop + lateral			bl, gl, kl bʎ		
stop + rhotic				kr, tr	
s + stop			sp, sk, st		
s/z + fricative		sv	zv		
s + nasal					
s + lateral			sl		
ʃ + stop					ʃc
ʃ + nasal			ʃɲ		
	3;11	**4;2**	**4;8**	**5;8**	**5;11**

b. Initial clusters stabilized at 75% level or above by age group: girls

stop + fricative					dv	
stop + nasal	sm, sn		kn			
stop + lateral		bl	gl, kl bʎ			
stop + rhotic				kr		tr
s + stop			sp, st	sk		
s/z + fricative			sv, zv			
s + nasal						
s + lateral	sl					
ʃ + stop				ʃc		
ʃ + nasal			ʃɲ			
	3;5	**4;5**	**4;8**	**4;11**	**5;8**	**>5;11**

4. Summary and conclusions

In this article, we have summarized the results of a large-scale population study investigating the development of articulation accuracy in monolingual Latvian-speaking preschool children aged between 3;2 and 5;11. Being the first study of this kind focusing on the Latvian language, it represents a resource with a range of practical and research applications. It can, for instance, serve as a basis for cross-linguistic comparison in typological studies, and as a source for those interested in Latvian phonotactics and prosody. In pedagogical practice, it can be useful in creating study materials aimed at encouraging the development of articulation skills in young children.

However, while this study provides a good starting point for further inquiry into the development of articulation accuracy in Latvian-speaking children, its findings should be interpreted with caution when applied in clinical practice. Pervasive reversal patterns noted above both for the individual sounds and overall accuracy rates – while very commonly observed in similar large-scale articulation studies – might obscure the actual tendencies in the population. While it has been proposed – and is certainly possible – that regressions indeed occur as a normal developmental trend, the observed reversals might also be attributable to sampling errors and examiner bias, and thus might not adequately reflect the acquisition progression in the population at large. In order to shed some light on the true nature of these reversals, it would be desirable to conduct a longitudinal articulation study involving a representative gender-balanced sample of children, which would exclude – at the very least – the possibility of a sampling error.

Another factor that has been noted above – and that should definitely be taken into the account when applying these findings, e.g. for screening purposes - is a large degree of individual variation that is extremely typical in young children with respect to their language abilities. It is important to keep in mind that considerable within-group differences are characteristic of typically-developing children, and therefore it is necessary to establish a cutting point for classifying a certain pattern as a delay (e.g. two standard deviations below the mean criterion that is frequently applied). Again, it is desirable that the effect of factors like sampling error is eliminated before such criteria can be established.

Acknowledgements

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Appendix 1

() Proportion of correct responses for singleton targets by age group and gender: boys

	3;2	3;5	3;8	3;11	4;2	4;5	4;8	4;11	5;2	5;5	5;8	5;11
Phoneme	M	M	M	M	M	M	M	M	M	M	M	M
b-	100	95	100	100	100	100	100	100	100	100	100	100
-b-	100	95	100	100	100	100	100	100	100	100	100	100
-b	60	84	94	100	100	95	96	91	97	96	97	100
d-	90	89	100	93	100	95	96	96	97	100	97	100
-d-	90	100	100	100	100	100	100	100	100	100	100	100
-d	70	89	100	100	100	100	100	96	100	100	97	100
g-	90	100	100	93	100	90	100	96	100	100	97	100
-g-	90	95	94	93	95	95	100	96	100	100	97	100
-g	50	95	94	93	95	95	96	91	100	100	97	100
p-	100	100	100	100	100	100	100	100	100	100	100	100
-p-	100	100	100	100	100	100	100	100	100	100	100	100
-p	100	95	100	100	100	100	96	100	100	100	100	100
t-	90	100	94	100	100	100	100	96	100	100	100	100
-t-	100	100	100	100	100	100	100	100	100	100	100	100
-t	100	100	100	100	100	100	100	100	100	100	100	100
k-	90	100	88	100	95	100	92	100	100	100	97	100
-k-	100	100	94	100	100	95	100	100	100	100	100	100
-k	90	95	94	100	95	95	96	91	100	100	93	100
l-	50	100	100	86	100	95	88	91	100	96	100	100
-l-	70	79	88	79	100	90	92	96	100	92	93	100
-l	40	68	88	64	95	75	92	87	97	92	93	100
m-	100	100	100	100	100	100	100	100	100	100	100	100
-m-	100	100	100	100	100	100	100	100	100	100	100	100
-m	100	95	100	100	95	100	96	100	100	96	100	100
n-	80	89	100	100	95	95	96	100	100	96	100	100
-n-	90	100	100	100	100	95	100	96	100	100	100	100
-n	90	95	88	100	100	100	100	100	100	100	100	100

ɟ-	60	58	65	43	53	81	77	87	86	79	80	86
-ɟ-	70	63	65	79	95	81	81	83	97	79	80	86
c-	40	47	82	57	89	76	69	74	93	88	83	86
-c-	40	42	76	50	74	76	65	74	93	83	77	86
ʎ-	30	63	76	71	95	76	88	87	97	100	90	100
-ʎ-	40	84	76	64	89	81	96	87	97	100	97	100
-ʎ	70	95	71	57	100	81	100	91	97	100	100	100
-ɲ-	70	79	94	71	89	90	88	91	97	100	97	100
r-	20	63	63	57	89	62	88	74	83	71	83	100
-r-	30	53	65	50	74	62	81	83	76	67	87	100
-r	50	58	76	64	89	67	92	83	86	67	90	100
s-	80	95	94	100	100	90	96	100	100	96	97	100
-s-	100	95	91	93	97	95	94	96	100	98	98	100
-s	100	95	88	93	95	95	96	96	100	100	97	100
z-	90	84	94	100	100	90	92	96	100	100	93	100
-z-	100	100	100	100	100	95	96	91	100	100	97	100
-z	50	95	88	100	100	86	92	96	100	100	93	100
ʃ-	40	42	76	86	100	76	96	87	97	96	90	100
-ʃ-	30	63	76	79	95	86	92	87	93	100	97	100
-ʃ	40	53	88	79	95	67	88	83	97	88	93	100
ʒ-	50	63	71	64	100	71	92	83	90	96	87	100
-ʒ-	30	63	71	86	84	71	96	91	90	96	83	86
-ʒ	30	63	71	64	100	71	88	83	90	100	87	100
t͡s-	60	84	82	93	100	90	92	91	100	100	97	100
-t͡s-	80	79	88	93	95	90	88	91	100	100	93	100
-t͡s	70	89	94	100	94	100	96	96	100	100	93	100
d͡z-	60	74	65	86	89	80	92	91	100	100	97	100
-d͡z-	80	63	100	100	100	95	88	91	100	100	100	100
-d͡z	70	74	94	100	100	95	96	91	97	100	97	100
t͡ʃ-	40	63	82	86	89	86	92	87	90	100	83	100
-t͡ʃ-	60	63	82	79	84	86	88	87	90	100	90	100
v-	60	74	69	79	89	90	100	96	97	96	97	100
-v-	100	89	94	93	100	95	96	100	100	100	100	100
-f-	20	53	76	50	89	81	92	87	97	100	93	100
h-	40	63	82	79	95	71	92	87	86	96	90	100
ʝ-	70	95	100	100	100	100	96	96	100	100	100	100
-ʝ-	90	100	100	100	100	100	100	100	100	100	100	100

()Proportion of correct responses for singleton targets by age group and gender: girls

	3;2	3;5	3;8	3;11	4;2	4;5	4;8	4;11	5;2	5;5	5;8	5;11
Phoneme	F	F	F	F	F	F	F	F	F	F	F	F
b-	100	100	100	100	100	100	100	100	100	100	100	100
-b-	100	100	100	100	100	100	100	100	100	100	100	100
-b	73	93	88	83	92	94	96	93	100	100	100	100
d-	100	88	100	100	100	94	96	100	96	100	100	100

-d-	92	94	100	100	96	100	96	100	100	100	100	100
-d	92	100	100	96	96	100	92	100	100	100	100	100
g-	92	100	100	100	96	89	88	100	96	96	100	100
-g-	100	100	100	100	96	94	85	100	96	100	100	100
-g	50	88	100	96	96	89	81	93	96	93	100	100
p-	92	100	100	100	100	100	100	100	100	100	100	100
-p-	92	100	100	100	100	100	100	100	100	100	100	100
-p	100	100	100	100	100	100	100	100	100	100	100	100
t-	100	94	100	100	100	100	96	100	100	100	100	100
-t-	100	100	100	100	100	100	100	100	100	100	100	100
-t	100	100	100	100	100	100	96	100	100	100	100	100
k-	83	100	100	100	96	89	77	100	96	100	100	100
-k-	100	100	100	100	92	94	88	100	96	100	100	100
-k	100	100	100	100	96	89	88	96	96	96	100	100
l-	83	88	94	96	100	89	96	100	100	100	100	100
-l-	75	100	88	91	100	94	92	93	96	100	100	100
-l	75	75	88	91	84	89	96	93	100	100	100	100
m-	100	100	100	100	100	100	100	100	100	100	95	100
-m-	100	100	100	100	100	100	96	100	100	100	100	100
-m	92	100	100	100	100	100	100	100	100	100	100	100
n-	100	94	100	100	92	94	100	100	100	100	100	100
-n-	92	100	100	100	100	100	100	100	100	100	100	100
-n	83	100	100	100	96	94	96	100	100	100	100	100
ɟ-	75	69	88	65	60	72	77	93	77	75	86	93
-ɟ-	92	81	88	87	72	83	81	93	85	93	90	100
c-	83	81	81	83	68	83	85	85	81	86	86	100
-c-	75	56	75	87	72	83	73	89	77	82	81	100
ʎ-	50	81	88	87	88	78	88	96	88	89	90	93
-ʎ-	92	81	100	96	88	78	88	100	100	93	86	93
-ʎ	83	94	100	96	92	89	88	100	88	93	95	100
-ɲ-	67	75	94	91	88	94	92	100	96	100	100	100
r-	33	50	63	78	72	72	69	100	92	89	95	93
-r-	42	50	63	83	84	78	69	100	92	93	95	93
-r	42	69	75	78	84	78	73	100	92	89	95	93
s-	75	94	100	100	92	89	88	100	100	100	100	100
-s-	83	91	100	100	96	86	92	100	100	98	100	100
-s	82	88	100	100	96	88	92	100	100	96	100	100
z-	75	88	100	96	92	94	96	100	96	100	100	100
-z-	100	94	94	100	92	89	96	100	100	100	100	100
-z	92	94	100	100	92	72	92	100	100	93	100	100
ʃ-	58	56	75	87	92	72	85	93	96	93	100	100
-ʃ-	67	69	81	91	88	78	92	96	96	96	100	100
-ʃ	75	69	88	78	84	83	85	96	96	93	100	93
ʒ-	58	56	88	83	92	72	85	93	96	89	100	100
-ʒ-	58	56	88	91	88	78	81	93	92	82	95	87
-ʒ	58	40	75	83	84	83	88	85	96	89	90	93

t͡s-	75	81	88	91	92	83	92	89	100	93	100	100
-t͡s-	83	100	94	100	96	89	92	100	100	93	100	100
-t͡s	75	100	100	100	100	100	92	100	100	96	100	100
d͡z-	58	81	88	100	92	83	85	93	100	85	100	100
-d͡z-	73	88	94	100	96	89	88	96	100	93	100	100
-d͡z	67	94	100	96	88	94	88	100	100	89	100	100
t͡ʃ-	83	81	94	96	88	83	85	100	96	86	100	93
-t͡ʃ-	75	56	81	91	80	89	92	93	96	86	95	87
v-	58	81	100	96	88	89	88	93	100	93	100	93
-v-	92	94	94	96	96	100	96	96	96	100	95	100
-f-	50	69	88	87	72	89	85	96	96	96	100	100
h-	58	69	75	82	88	89	96	93	96	93	100	100
ʝ-	100	100	100	100	100	94	100	100	100	100	100	100
-ʝ-	100	100	100	100	100	100	100	100	100	100	100	100

Appendix 2

() Proportion of correct responses for cluster targets by age group: boys

	3;2	3;5	3;8	3;11	4;2	4;5	4;8	4;11	5;2	5;5	5;8	5;11
Cluster	M	M	M	M	M	M	M	M	M	M	M	M
bl-	10	58	69	71	89	60	77	83	90	88	93	100
gl-	20	58	53	64	89	67	92	83	97	96	93	100
-gl-	40	53	53	64	89	71	92	87	97	88	93	100
kl-	20	63	65	64	84	71	88	87	90	92	93	100
-kl-	30	42	53	50	84	65	88	87	93	96	90	100
bʎ-	10	58	59	50	84	62	81	87	90	96	77	100
-bʎ-	70	74	53	64	89	76	81	87	90	96	83	100
kn-	20	58	41	43	79	71	85	78	100	88	93	100
-kn-	50	74	82	71	95	90	96	87	100	100	97	100
kr-	10	37	59	36	74	57	73	83	72	71	87	100
tr-	10	11	24	14	58	33	62	70	79	67	80	100
-tr-	20	42	53	36	53	52	77	78	79	71	83	100
sl-	30	47	71	64	84	67	88	87	100	88	90	100
sm-	40	63	71	86	100	76	92	87	100	100	97	100
sn-	30	58	71	79	89	81	92	87	100	100	97	100
dv-	20	21	47	43	53	52	69	70	90	83	73	100
sv-	60	63	76	71	95	85	92	87	100	96	93	100
zv-	20	53	65	71	100	74	100	87	100	100	97	100
ʃɲ-	10	32	41	50	100	53	88	87	90	92	87	100
sp-	20	53	65	71	84	71	96	87	100	100	93	100
sk-	10	58	59	71	68	62	96	91	93	100	90	100
-sk-	60	68	71	79	95	81	96	96	100	100	93	100
st-	30	58	71	79	89	71	92	87	97	100	97	100
-st-	80	74	76	86	89	86	96	87	100	100	93	100
ʃc-	30	26	35	50	84	52	85	83	86	83	70	86
-ʃc-	10	26	47	50	95	50	88	78	83	83	70	86
-tn-	40	63	82	79	79	86	96	91	100	92	97	100
-lt-	40	58	47	57	53	57	69	78	76	75	77	100

-lk-	40	63	59	50	63	67	69	91	90	75	83	100
-mb-	100	100	100	100	100	90	92	96	100	100	97	100
-mp-	90	79	94	93	100	95	92	96	100	100	100	100
-nt-	90	89	94	100	100	100	100	91	100	100	100	100
-ŋg-	100	79	94	100	100	95	100	96	100	96	93	100
-rd-	10	47	53	43	68	57	81	78	90	71	87	100
-rp-	10	32	47	36	74	57	81	87	72	71	87	100
-rk-	10	16	41	29	74	52	81	83	86	71	83	100
-ls-	60	68	76	64	89	86	85	87	93	92	97	86
-lv-	20	53	65	64	68	67	85	83	83	71	90	100
-rv-	0	47	53	14	84	52	85	87	79	71	87	100
-rn-	10	37	53	43	74	48	81	74	79	75	87	100
-ps-	90	89	94	93	100	95	92	96	100	100	97	100

() Proportion of correct responses for cluster targets by age group: girls

	3;2	3;5	3;8	3;11	4;2	4;5	4;8	4;11	5;2	5;5	5;8	5;11
Cluster	F	F	F	F	F	F	F	F	F	F	F	F
bl-	50	69	81	74	72	78	81	96	100	96	95	93
gl-	50	69	81	87	84	72	77	96	96	96	100	100
-gl-	75	75	81	87	88	67	85	96	96	96	95	100
kl-	58	81	88	83	80	67	81	96	96	96	100	100
-kl-	50	75	75	70	76	61	81	93	100	96	100	93
bʎ-	75	56	88	87	80	67	81	96	88	96	95	93
-bʎ-	75	88	88	83	92	78	92	96	92	93	95	93
kn-	33	63	81	78	79	67	81	96	100	85	100	93
-kn-	75	75	94	96	88	78	88	100	96	100	100	100
kr-	25	44	69	78	64	61	58	100	88	93	95	100
tr-	25	44	38	35	48	44	50	81	88	71	95	73
-tr-	25	56	63	57	72	67	65	96	92	89	95	87
sl-	42	81	81	83	88	78	88	93	96	89	90	100
sm-	58	75	94	96	92	78	96	100	100	100	100	100
sn-	50	75	94	91	92	78	96	100	100	100	100	100
dv-	50	56	69	70	56	61	54	89	92	71	81	93
sv-	58	69	88	91	96	72	96	100	100	96	100	100
zv-	42	63	94	87	92	72	96	100	96	100	100	100
ʃɲ-	33	38	69	74	80	56	77	96	96	89	95	93
sp-	58	81	94	96	88	72	92	100	100	96	100	100
sk-	50	63	69	87	80	67	73	100	96	93	100	100
-sk-	75	75	94	96	96	72	85	100	96	96	100	100
st-	50	75	94	96	92	67	92	100	100	96	100	93
-st-	75	75	94	100	92	83	92	100	100	96	100	100
ʃc-	33	44	69	74	68	72	73	100	85	79	100	87
-ʃc-	42	38	69	78	72	72	73	96	85	81	100	87
-tn-	58	69	100	96	100	94	92	100	96	93	100	100
-lt-	25	44	69	70	64	61	69	85	88	68	90	100
-lk-	50	75	69	87	80	67	85	93	92	89	86	100
-mb-	100	88	100	100	100	94	96	100	96	100	100	100
-mp-	83	94	100	100	100	100	100	100	100	100	100	100
-nt-	83	94	100	100	100	89	96	100	100	100	100	100

-ŋg-	92	75	100	100	92	89	88	100	100	100	100	100
-rd-	33	56	63	74	72	78	69	100	92	82	90	100
-rp-	17	50	56	74	68	78	69	96	88	89	95	93
-rk-	42	50	56	65	68	72	69	96	88	89	95	93
-ls-	67	75	94	91	80	89	88	100	96	96	100	100
-lv-	33	44	75	87	60	67	77	89	88	93	95	100
-rv-	33	56	56	70	76	78	73	96	88	86	95	93
-rn-	25	50	63	70	72	78	62	96	92	85	95	93
-ps-	75	88	100	100	88	89	96	100	100	100	100	100