Phonological Development in Children with DLD: An Exploratory Study of [R]

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PHONOLOGICAL DEVELOPMENT OF CHILDREN WITH A DEVELOPMENTAL LANGUAGE DISORDER

AN EXPLORATORY STUDY OF /R/

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Abstract

In this exploratory study, the productions of the phoneme /ʀ/ were examined in the speech samples of 25 children. All children (aged 2;11 - 6;3) have a (presumed) Developmental Language Disorder and were attending either a toddler Intervention Group or an Auris Language school. From each child a language sample was elicited twice in a play situation and during a picture naming task, by their speech therapist, with an interval of 3 months. The productions of target /ʀ/ within these speech samples were studied and analyzed in terms of correctness, substitutions and deletions. Productions revealed a wide variety of renditions of target /ʀ/, the most significant being /ʀ/ -> [l], [ʋ],and [j]. It was difficult to determine progress in the productions of /ʀ/ between the two recordings, which indicates the need for a longer interval between recordings, or more recordings. A deviating development of /ʀ/ could be observed in the data of this specific group of children.

1.   Introduction

This thesis is developed as a result of an internship at Royal Auris Group. This organization offers care, education and treatment to people who are deaf/hard of hearing or have a language development disorder (DLD). The data analyzed for this study comes from an ongoing PhD research of Scheffer (in progress). DLD is a neurodevelopmental disorder that affects the ability to acquire and use language.

The results of a picture naming task from former research by Scheffer et al. (under review), showed that production of the consonant [ʀ] seems to be extremely difficult for children with DLD. In the resulting data of this study, a score of all produced consonants (independent of accuracy) shows a lack of [ʀ] in syllable initial position, and in final positions it occurs only at the age of 4;5. In the results of the correct production, only one child (out 82) produces [r]. What is not yet clear, is what the realization of this phoneme is in words. Does it occur at all in spontaneous speech, where there is a possibility to avoid it? Is there a difference in distribution of correct productions between picture naming tasks and spontaneous speech? Which phonological simplification processes play a role during acquisition in children with DLD, compared to typical development (TD)? More specific: Which substitutions can be observed, and what can be the source of these substitutions? Is there a difference in complex

onsets, compared to singleton onsets? In order to contribute to predictability in the phonology of language impaired children, this study investigates the productions of [ʀ] in the speech samples of 25 children with (presumed) DLD, and compares the results of a picture naming task and spontaneous speech, at two different moments. The results can be an indication for future treatment.

Currently, at Auris a study into the phonological development of children with (presumed) DLD, examines whether using an independent measurement of the actual productions that children make, without looking at correctness, provides sufficient information about development over time (Scheffer et al., under review).

In the remainder of this section, an overview will be provided of the typical phonological development, as well as what characterizes DLD. Phonological simplification processes and the difference in occurrence of those between TD children and children with DLD will be discussed further, as well as the difference between the samples of a Picture Naming Task (PNT) and Spontaneous Speech (SS). Finally the characteristics of the phoneme /ʀ/ specific for Dutch are provided.

1.1   Phonological development in typical developing children

The process of language acquisition already starts before birth, at the end of the third trimester. A fetus is able to hear sounds from outside, and a baby is able to distinguish between speech and other sounds at birth (Vouloumanos & Werker, 2007). Around 12 month of age, the first attempts to produce adultlike words occur (Gerrits et al. 2017). If communicative intention is inadequate, that is, if the child is not showing the motivation to actively communicate with his or her environment, this may be an indication for DLD (Gerrits et al. 2017).

Van Haaften et al. (2020) conducted a large scale, cross-sectional study on the phonetic and phonological development of 1500 typically developing children acquiring Dutch as their first language between 2;0 and 6;11. This provided a reliable overview of the developing sound inventory of these children, which is shown in Table 1. Note that the consonants reported here were considered "acquired" when 75 % of children produced them correctly in 75 % of the attempts.

Table 1. *Phonetic inventory (Van Haaften et al. 2020)*

Age group	n	Consonants										Vowels			
		Syllable-initial					Syllable final								
		Plosives	Fricatives	Nasals	Liquids	Glides	Plosives	Fricatives	Nasals	Liquids	Glides	Short	Long	Reduced	Diphthongs
2;0–2;3	72	/b, t/		/m, n/				/f, s/	/m/	/l/		/ɪ, ɛ, ɔ, ʉ, ɑ/	/y, u, o, a/		/ʉy, ɛɪ/
2;4–2;7	101		/s/			/j/	/p/				/w/		/i, ø/		
2;8–2;11	101	/p, d, k/	/f, ʃ, h/			/w/	/t, k/	/ʃ/	/n/					/ə/	/ɑu/
3;0–3;3	102		/ʒ, x/										/e/		
3;4–3;7	107				/l/			/x/							
3;8–3;11	101									/r/					
4;0–4;3	99								/ŋ/						
4;4–4;7	111		/v/		/r/										
4;8–4;11	112														
5;0–5;3	117														
5;4–5;7	128		/z/												
5;8–5;11	116														
6;0–6;5	117														
6;6–6;11	119														

Other studies (Beers, 1995) also report that the features 'sonorant', 'labial' and 'coronal' in syllable initial position are distinguished first, resulting in the acquisition of the sounds /p/, /t/, /m/, /n/ and /j/. The next acquired phoneme is /k/, which signifies the acquisition of the feature 'dorsal'. Mastering the third level, 'continuance' results in being able to realize /s/, /x/ and /h/, where the fourth, correctly producing /b/, /f/ and /w/, means being able to recognize the features 'round' and 'front'. Last mastered are /l/ and /r/, which shows the features 'lateral', 'rhotic' and 'nasal' are acquired.

What becomes clear in the previous section is that the Dutch rhotic is one of the most difficult sounds to acquire, even in typical development.

So far, typically developing children have shown to follow a specific pattern in the acquisition of single onset consonants (see Table 1, Van Haaften et al., 2020). The production

of complex onsets however, is even more difficult. Van Haaften et al. (2020) reported an age of 4;7 for the correct production of all consonant clusters, except in the syllables like CCVCC, where cluster productions did not appear to be correct before the age of 6;11 years. In the current study, all targets onsets of /ʀ/ will be taken into account, both in singleton and complex onsets.

All children acquiring language make use of processes of simplification. That is, adult target consonants are reduced or substituted by another consonant due to restrictions of the articulatory system of the child (Beers, 1995). Cluster reduction (CCV -> CV) is the most common process in typical phonological development (Van Haaften et al. 2020, Beers, 1992). Furthermore, fronting (e.g. /k/ -> [t]), stopping (e.g. /s/ -> [t]), and voicing / devoicing (e.g. /p/ -> [b] or vice versa) are reported as usual processes in typical development up until the age of 4;3 (Van Haaften et al., 2020). Gliding, the process whereby both /r/ and /l/ are substituted for the glides /j/ and /ʋ/, is reported as very common by Beers (1995), but was not found in the samples of Van Haaften et al. (2020). This might be due to the difference in data collection: Beers (1995) used spontaneous speech samples, whereas Van Haaften (2020) derived their data from a picture naming task. In the current study, both types of data are analyzed, but only the realizations of target /ʀ/ are investigated. In English, /ʀ/ is mostly realized by /w/, because of their common feature 'round' (Beers, 1995). In Dutch, this is not expected, as /r/ has different realizations and /w/ is not part of the Dutch phonological inventory. Instead, the Dutch equivalent for /w/ is labio-dental /ʋ/. Based on the literature concerning both typical and disordered language development (Van Haaften et al. 2020, Beers, 1992), substitutions for word initial /ʀ/ by [j] and [ʋ] therefore are expected, as well as deletions in complex onsets (cluster reduction).

1.2   Developmental Language Disorder

Developmental Language Disorder is a relatively unknown condition, although approximately 7 % of all children is affected by it (Leonard, 2014). The term came up as an alternative for Specific Language Impairment (Leonard, 2014), which failed to describe the condition in an appropriate way. The diagnosis is not a straightforward one. There is actually no standard test that can demonstrate DLD. Providing a diagnosis means ruling out other possible causes of a deficit in language development, such as a hearing impairment, low non-verbal intelligence, language deprivation or a specific neurological condition (Gerrits et al., 2017, Leonard, 2014). It is a congenital condition, and it requires language to be the most significant problem. Although most studies to date have focused on children, DLD is a persistent condition that also impacts the daily life, education, social interactions, economic status, and societal participation of adults (Gerrits et al., 2017). Not much is known about the origin of the condition, except that it is - most likely - genetic in nature. (Leonard 2014).

        The difficulties that language impaired persons may face are diverse. Roughly speaking, a division can be made between people experiencing problems only in speech production, and those having problems in both perception and production of speech. These difficulties can be observed in different language domains, such as phonology, morpho-syntax and pragmatics. The group of children with a language development disorder is therefore by no means homogeneous (Leonard, 2014).

        The literature on DLD does not report any influence of multilingualism (Gerrits et al 2017). When a child learns more than one language, it is important, however, to examine development in both (or all) languages the child is attempting to acquire. If their is a delay in only one language, DLD seems unlikely, but if the concerns hold for all languages, more research is appropriate. The prevalence for DLD in boys is marginally higher than in girls (8

% versus 6 %) (Gerrits et al. 2017).

Previous research has shown that children with a DLD specifically have problems learning aspects of language that require specific rules (Bishop, 2000). This does not hold just for grammar and syntactic structure, but also for the phonological system that needs to be acquired. In early stages of development, the child learns words and phrases as a whole, unaware of the common segments they are build of (Bishop, 2000). As the mental lexicon grows, the need for a more rule based system arises, to be able to use features in different environments. If the child is not able to develop this rule based system, it will not recognize sounds in new contexts, as surrounding sounds influence the acoustic signal (Bishop, 2000).

Children with (presumed) Developmental Language Disorder (DLD) show a different phonological development than that of typically developing children (Gerrits et al., 2017). Not only is there a delay, but phonological simplification processes are also more persistent, and processes that are rare in TD, occur more frequently in children with DLD (Beers, 1992).

Beers (1992) distinguishes 3 types of processes: Normal processes that are more persistent in children with DLD, unusual processes, that occurred only occasional, and the exceptional processes, which she calls idiosyncratic. Some of the unusual and idiosyncratic processes were found in the samples of children with DLD more frequently. Examples are H-zation (realizations of several target consonants as [h]), initial consonant deletion, lateralization and gliding. Substitutions for [h] are found for a variety of consonants in DLD, including target /r/ (Beers, 1992). The process of lateralization entails substitutions for [l] for target /ʀ/. This process does not just apply to substitutions for /ʀ/, but for any consonant (Beers, 1992). While lateralization is also present in typical development (Van Haaften et al., 2020), reports suggest that it occurs more often in DLD cases, according to literature (Beers, 1992). Beers (1992) reports 36 occurrences in 10 samples, which places this process in the middle of the ranking scale of frequency of occurrence, just a few places lower than initial

consonant deletion. The process of gliding, where both /l/ and /r/ are realized as /ʋ/, is rarely found in TD, but does occur in almost half of the samples of children with DLD (Beers, 1992).

In summary, in the speech samples analyzed in the current study, deletions of target /ʀ/ are expected to occur frequently in both singleton and complex onsets, along with realizations of /ʀ/ as [h], [ʋ] and [l].

1.3   Dutch phoneme /r/

In Dutch, a wide variety of realizations of the phoneme /ʀ/ is found, both in terms of place- and manner of articulation (Sebregts, 2014). Production of the syllable initial target /ʀ/ is profoundly different from its word final equivalent. The word final /ʀ/ is almost completely vocalized, and hardly recognizable as consonantal (Sebregts, 2014). For this reason I will only focus on realizations of target onset /ʀ/. Both coronal and dorsal realizations are found in the Dutch speech sound system (Van Bezooijen et al., 2002). In Standard Dutch, the dorsal realization of /ʀ/, however, is reported to be more common (64.4 %) than its coronal equivalent (35.5 %) (Van Bezooijen et al., 2002). A large scale study on the distribution of variants of /r/ reports regional and personal differences in the realizations of /r/ (Sebregts 2014) . For onset positions, a distinction is made between coronal and dorsal as places of articulation, and tap, trill, fricative, and approximant as manner of articulation. The data from the Sebregts (2014) study comes from urban communities around the cities of Amsterdam, Rotterdam, The Hague, Leiden, Utrecht and Nijmegen. In the regions of Amsterdam, an alveolar tap is the most common realization of /r/, and in the Rotterdam region a mix of alveolar and uvular trill is found. The other regions in the Netherlands all showed a preference for uvular trills (Sebregts, 2014). The schools and preschools the children in the current study attend, are all situated in regions where the uvular realizations are most common, except one.

For the analysis of /ʀ/ in the current study, I will therefore assume that the Dutch rhotic is, in principal uvular, target /ʀ/. One child visits a school in Haarlem, which falls under the Amsterdam region. The results of the productions of this child will be analyzed separately, to control for a possible different target /r/.

1.4   The current study

For the analysis of the realizations of target /ʀ/, as well as its deletions and substitutions, a feature chart of Dutch consonants, based on Booij (1995) and Sebregts (2014) will be used (see Table 2).

Table 2. Feature chart of Dutch consonants (Booij 1995)

	LABIAL						CORONAL							DORSAL				
	ʋ	m	v	f	b	p	l	n	z	s	d	t	r	R	ŋ	χ	h	k
SON	+	+	-	-	-	-	+	+	-	-	-	-	+	+	+	-	-	-
CONT	+	-	+	+	-	-	-	-	+	+	-	-	+	+	-	+	+	-
NAS	-	+	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-
VOI	+	+	+	-	+	-	+	+	+	-	+	-	+	+	+	-	+	-
APPR	+	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	+	-
LAT	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-

In most studies (e.g. Booij, 1995, Scheffer et al. under review) /r/ is only considered coronal, however, as mentioned before, in this study it is regarded as both coronal and dorsal, because of its appearance in most Dutch regions. Furthermore, /j/ is interpreted as the consonantal equivalent of the vowel /i/, because of it's phonological characteristics (Levelt 1989, Booij 1995).

        Phonemes can be distinguished not only by their features, but also by their place and manner of articulation (Van der Torre, 2003, Sebregts, 2014). The Dutch rhotic /ʀ/ differs in place of articulation from /r/, as mentioned before. The following overview (see table 3) gives

a detailed outline for places and manner of articulation for all Dutch consonants (Booij 1995, Rietveld & Van Heuven 2016, Van der Torre 2003, Sebregts 2014). In order to contribute to the understanding of substitutions, this overview is used to explain the origin.

Table 3: Place- and manner of articulation of Dutch consonants

Place of articulation	Manner of articulation				
	Obstruents		Sonorants		
				Approximants	
	Plosives	Fricatives	Nasals	Liquids	Glides
Bilabial	/p/, /b/		/m/		
Labiodental		/f/, /v/			/w/, ([ʋ])
Alveolar	/t/, /d/	/s/, /z/	/n/	/l/, /r/ ([r])	
Post-alveolar		[ʃ], [ʒ]			
Palatal					/j/
Velar	/k/, /g/	/x/, /ɣ/	/ŋ/		
Uvular					/r/, ([R])
Glotal	/ʔ/	/h/			

1.5   Data collection: Picture Naming Task versus Spontaneous Speech

Schwartz and Leonard (1981) investigated whether children (age 1;1 - 1;3) actively avoided words with phonological forms that were difficult for them. They concluded that it was a matter of failing to select the appropriate form rather than intentionally avoiding, with the latter being an intentional operation. The participating children were presented with novel words for objects and actions. Some of these words had, and some had did not have a phonological form that was part of the child's phonological system. They found that the words of the first category were imitated, could be elicited and were used in spontaneous speech more than those of the second category. Thus, in this early stage of development, children were less proficient in selecting forms that were not yet represented in their phonology, which resulted in – apparent - avoidance. Spontaneous speech is therefore a more

reliable source of the phonological knowledge of a child. Picture naming tasks, on the other hand, consist of a balanced list of words that contain all age appropriate phonological forms the child should be able to produce. Such tasks therefore provide more information about phonemic and phonological development in general, and about the specific deficits and delays in children with a language disorder (Masterson, Bernardt & Hofheinz, 2005). For the current study, both types of samples are used.

2.   Method

2.1   Participants

The data that is analyzed is collected for an ongoing study at the Koninklijke Auris Groep (Scheffer, in progress). This study involved a selected group of 37 children from Auris Language Schools and Toddler Intervention groups, focusing on individuals diagnosed with or showing signs of Developmental Language Disorder (DLD). Enrollment in the study did not involve any exclusion criteria except the differential diagnosis for (presumed) DLD. All participants had normal hearing levels, non-verbal intelligence scores of at least 85, and no recognized neurobiological conditions (Gerrits et al.,2017).

From 32 children a second measurement, which is recorded within 3-4 month after the first is analyzed and used for the current study. Five children dropped out after one recording, and are therefore excluded. From all children who participated in two or more recordings, 7 were excluded due to a small sample size (< 90 words). From the remaining 25 children (ten girls, fifteen boys, with ten being bilingual) the two recordings are phonetically transcribed and used for this study. The mean age of the children is 4;7 (2;11 - 6;0) at the first of two recordings, and 4;10 (3;2 - 6;3) at the second (see Table 4). In order to examine the influence

of age on their speech, participants were divided into four age groups.

Table 4. Participant information

Recording 1	age group	number of children	age range	number of girls	number of boys	number of multilingual children
	1	7	2;10-3;9	2	5	2
	2	6	3;10-4;9	4	2	1
	3	9	4;10-5;9	4	5	4
	4	3	5;10-6;9		3	3
Recording 2	age group	number of children	age range	number of girls	number of boys	number of multilingual children
	1	6	2;10-3;9	2	4	1
	2	4	3;10-4;9	2	2	2
	3	11	4;10-5;9	6	5	4
	4	4	5;10-6;9		4	3

2.2   Procedure

A picture naming task (PNT) was administered to all children, which was recorded to examine their phonological inventory (see Appendix A). For the PNT, the *NAO* 3 *Verwervingsvolgorde* (`Dutch Articulation Assessment – Order of Acquisition', LOGO-Art, 2012) and Metaphon screening (Leijdekker-Brinkman, 2002) were used. These tests are not normed. To compare scores of the children in this study, the Computer Articulation Instrument (CAI) (Maassen et al. , 2019), was used as reference. Each PNT contained a balanced word list, where all sounds that the child should be able to produce are represented at least tree times in all positions.

From all children a Spontaneous Speech (SS) sample is recorded in a play situation with their speech therapist. The children in the recordings played with Playmobil, a doll house, or anything that can elicit spontaneous speech. In order to be able to observe

development, three consecutive recordings were made, with intervals of 3 months, from which the first two were used for this study, unless these recordings did not provide enough words (minimum of 90) to analyze. Recordings were usually made with an I-pad or a smartphone. From each speech sample 90-92 words were elicited and analyzed, which corresponds to the number of words from the picture naming task. As mentioned before, the children were recorded during a play situation with their speech therapist, in order to obtain spontaneous speech. In addition, a story telling task was recorded, which was only analyzed in case the SS task did not provide the required amount of words. In this task, the child was asked to retell a story, on the basis of pictures, after the speech therapist read them the story first.

The parents of these children gave informed consent for participation and recording. All results are pseudonymized.

The samples from the Picture Naming Tasks (PNT), as well as half of the Spontaneous Speech (SS) samples were already phonetically transcribed by a speech therapist. The other half of the spontaneous speech samples were transcribed on behalf of the current study. All samples, of both the PNT and SS, were phonologically transcribed according to the regulations of Fonologische Analyse van het Nederlands (FAN) (phonological analysis of Dutch, Beers 1995). Consonants were analyzed using the Klank Articulatie Tool (KAT) (Sound Articulation Tool), which was designed by Koninklijke Auris. This tool provides an excel file to collect the sample, which can be uploaded and analyzed automatically. Based on the words a child has produced, this tool provides an overview of the sounds in the child's inventory. All of the transcribed samples were analyzed and compared. A percentage of consonants correct (PCC) was calculated. For this study, the distribution of the realizations of target /ʀ/ was investigated in the aforementioned speech samples. As mentioned before, /ʀ/ was only analyzed in onset position, both singleton and complex (see Table 5).

Table 5. Model for collection of realizations of /r, ʀ/.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	single	complex	single	complex	single	complex	single	complex
Correct								
Substitution								
Deletion								

Based on the models discussed so far (Table 2 & 3), an analysis was performed of the type and possible source of substitutions children show. Each phoneme can be distinguished from others on the basis of features, specific for only that phoneme (Booij, 1995, Van der Torre, 2003, Sebregts 2014). Two phonemes always contrast in at least one feature. Substitutions can be explained in terms of neutralizations of two contrasting features. The feature chart in paragraph 1.4 shows the specific features for the different phonemes, which makes clear that the targets /r/ and /l/, for example, only differ on one feature. The main contrast between the alveolar tap /r/ and /l/ is [± continuant]. Although the dorsal target /ʀ/ and /l/ differ in [± continuant] too, the more important contrast is their place of articulation (Van der Torre, 2003). All substitutions are examined according to the contrasting features, in order to find systematic agreement in their appearances.

2.3   Results

In the samples from the PNT, 12 words per recording contained the target sound /ʀ/, so 24 for two recordings. In total, this results in 600 words containing target /ʀ/ (24 words x 25 children = 600). From these 600 productions of target /ʀ/, 194 were produced correctly, of which 78 (26 % of total amount of words) in the first recording, and 116 (39 % of total amount of words) in the second, which results in an increase of almost 49 %. From the remaining 406, 261 productions were substituted by a variety of consonants, of which 140 in the first recording, and 121 in the second, a decrease of almost 14 %. In the process of

deletion a decrease was observed between recording one and two, from 56 (19 %) to 41 (14 %). The process of a combination of reduction and substitution occurred 20 times in the first recording, and 15 times in the second (decrease of 25 %). This process holds, of course, only for complex onsets, for example, target /χʀ/ becomes [h] (for an overview, see appendix D).

Finally, the other processes involved distortions and insertions. Distortions are those targets that are still recognizable as /ʀ/, but pronunciation is not completely correct according to the adult model. These distortions were observed four times in the PNTs all together. Insertion means that another consonant is added to the target word, besides target /ʀ/. Insertions were observed twice in the PNTs. Distortions and insertions are combined in appendix B under 'other' . Together they were responsible for ± 2 % of the target /ʀ/ in the sample.

The majority of the substitutions were from /ʀ/ -> [l], with an almost equal distribution over the two recordings (93 in the first recording and 92 in the second). These substitutions occurred at all age groups, but only in the youngest group (2;11 - 3;9) all children except one showed at least six of these substitutions. In both bilingual and monolingual children the /ʀ/ -> [l] substitution was present.

Other consonants that appeared as realizations of /ʀ/ relatively frequent were [ʊ], [j] and [h] while [d], [n], [m], [χ] and [f] occurred only occasionally through all groups of children (see appendix C).

Spontaneous speech samples displayed considerably less words containing target /ʀ/. A mean of seven per child per recording is observed, which amounts to 342 in total (170 in the first recording, and 171 in the second). On average, five instances of the target sound per task per child less were produced compared to the picture naming task, an amount that was almost 42 % smaller. From all target /ʀ/ realizations , a hundred (29 %) were produced correctly, 44 in the first recording, and 56 in the second, demonstrating an increase of 27 %.

Another striking difference between the two types of samples is that in SS, the percentage of deletions was much higher: 16.17 % in PNTs, compared to 22.51 % in SS. The same pattern according to the type of substitutions was observed in PNT and SS samples. The number of substitutions from target /ʀ/ to [l] was the most common with 125 (93 in PNT, 32 in SS) in the first recording, and 114 (92 in PNT, 22 in SS) in the second. Other substitutions, such as /ʀ/ -> [j], /ʀ/ -> [ʋ] and /ʀ/ -> [h] occurred less frequently (see appendix C for a complete overview). Under 'other' the number of distortions, missing words, insertions and insertions combined with substitutions is summarized (Table 6). For a complete overview of all data per child, see appendix B, C, D, and paragraph 2.3.1.

Table 6*. Results*

	Picture Naming Task	% from total	Spontaneous Speech	% from total
Targets of /ʀ/ in total for 25 children	600		342	
Number of correct productions	185	30.83	100	29.24
Total number of substitutions	270	45	104	30.41
Deletions	97	16.17	77	22.51
Cluster Reductions + substitutions	35	5.83	17	4.97
Other	13	2.17	44	12.87

Below in paragraph 2.3.1, I will first present a brief overview of the results for each individual child. A distinction will be made between singleton onsets and complex onsets, PNT samples versus SS samples, and the two recordings.

What follows in paragraph 2.4 is an analysis per group of children that display the same level of phonological development and / or the same pattern in phonological simplification processes.

2.3.1 Results per individual child

Child 01 (age: 3;2 - 3;5)

Child 01 shows a very consistent pattern of substitutions of /ʀ/ -> [l]. Only one word is correct, and deletions occur in the words 'brood' (bread), 'andere' (different) and 'kleren' (clothes). In the word 'rups' (caterpillar), an insertion and a substitution is seen, resulting in 'blus'. In words with complex onsets, the complete onset, including target /ʀ/ is mostly deleted and substituted for consonants [l], [h] and [ʋ].

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct		1						
Substitution [l]	3	3	10			1		1
Deletion	1				1		2	
insertion + substit.		1						
Reduction + substi.		3		2				1
Vocalisation					1			

Child 02 (Age: 4;3 - 4;6)

The majority of the productions of Child 02 are correct for the picture naming task. Substitutions occur in the words 'regen' (rain), which becomes 'legen', 'rups' (caterpillar), becomes 'jups' and in the second recording 'bril' (glasses) turns up as 'blil'. In the spontaneous speech samples, however, less words with target /ʀ/ are produced. In the first recording, four words are produced, which are all correct. In the second, an increase of the amount of words is observed, however, less are correct. In the incorrect words, target /ʀ/ is deleted.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	2	8	4	6	2	2	1	1
Substitution [l]	1			1				
Substitution [j]	1							
Deletion							1	2

Child 03 (Age: 3;1 - 3;4)

Correct realizations of target /ʀ/ are seen in complex onsets only for this child. The majority of realizations show an /ʀ/ -> [l] substitution, with some exceptions for /ʀ/ -> [j], in the same word twice ('giraf'(giraffe) -> 's(l)i-jaf'). Deletions occur mainly in complex onsets. Child 03 shows a consistent pattern of substitutions with a couple of exceptions. What is surprising is the word giraf (giraffe), which is pronounced as sli-jaf.

What else stands out are the words 'troep' (mess) and 'trap' (stairs) that appear correct, where the /ʀ/ in 'trein' (train) is still realized as /l/.

Another striking result is the substitution and deletion in 'groen' (green) and 'gras' (grass). Where the /ʀ/ in 'groen' is deleted, resulting in 'goen', [χun], it is substituted in 'gras', with an additional substitution for the /χ/, which makes [slɑs].

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct				1				1
Substitution [l]	3	7	3	6			3	
Substitution [j]	1		1					
Deletion		1		1		2	1	

Child 04 (Age: 5;2 - 5;7)

Child 04 shows primarily correct productions. The only exceptions are a realization as [ʋ] in the PNT in the word 'rups' (caterpillar), and a realization as [l] in the word 'waarom' (why) in spontaneous speech. Only one deletion takes place.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	4	8	3	8	2		2	3
Substitution [l]					1			
Substitution [ʋ]			1					
Deletion							1	

Child 05 (Age: 5;10 - 6;2)

Child 5 too produces a substantial portion of the speech sample correctly, both for PNTs and SS, although a variety of substitutions is observed as well. In the picture naming task, only substitutions for [ʋ] and [h] are found. In spontaneous speech, however, [l], [j], [ʋ], [h] and even [m] are present. In the second recording, the amount of realizations of /ʀ/ rises, although some distortions are observed. Deletion occurs in complex onsets only.

| | PNT | | | | SS | | | |
| | 1e recording | | 2e recording | | 1e recording | | 2e recording | |
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	3	5	4	6	3		4	
Substitution [l]					1			
Substitution [ʋ]		2		1			1	
Substitution [h]	1				1			
Substitution [m]					1			
Deletion		1		1		3		
Distortion							2	2

Child 6 (Age: 5;1 - 5;4)

Child 06 does not make any mistakes in realizations of /ʀ/ in PNTs. In SS samples, 2 realizations as [l] are observed, and 2 deletions in complex onsets.

| | PNT | | | | SS | | | |
| | 1e recording | | 2e recording | | 1e recording | | 2e recording | |
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	4	8	4	8	3	3	5	4
Substitution [l]						2		
Deletion						2		

Child 07 (Age: 4;9 - 5;0)

The same holds for child 07. Most productions are correct. Only 1 substitution is observed, and 3 deletions.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	4	8	4	8	2	3	3	3
Substitution [ʊ]		1						
Deletion	1							2

Child 08 (Age: 5;3 - 5;7)

No correct productions in the picture naming task for Child 08, but a variety of substitutions is observed. In the first recording, all singleton onsets are substituted, and most complex onsets are reduced to a singleton, whereby /ʀ/ is deleted. In spontaneous speech, the first recording shows one correct realization of /ʀ/, in a complex onset. The second recording shows three correct realizations, all singleton onsets. The complex onsets in words like 'kruiwagen' (wheel barrow) and 'driewieler' (trike) are reduced and realized as [t]. Singleton onsets are realized as [l], [j] and [d], in SS samples.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct						1	3	
Substitution [l]			3	2	2			
Substitution [j]					3			
Substitution [d]	1						1	
Substitution [n]	3		1					
Deletion		6		5	1			
Reduction + subst.		2		1				2

Child 09 (Age: 3;1 - 3;4)

Complex onsets are mostly reduced to singleton onsets by Child 09, or reduced and substituted by a variety of consonants. Singleton onsets are also substituted, and mainly realized as [h]. Some deletions in singleton onsets are observed in spontaneous speech, but not in picture naming tasks.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct								
Substitution [l]			1					
Substitution [j]	1						1	
Substitution [ʊ]							2	
Substitution [h]	3		3		2		1	
Deletion		7		7	2	1	1	1
Reduction + subst.		1		1		2		
Distortion					1			

Child 10 (Age: 3;5 - 3;9)

Child 10 shows a variety of substitutions, with the majority being /ʀ/ -> [l]. A small amount of correct realizations are observed, mainly in complex onsets. The combination of reduction and substitution for [t] shows up in words like 'kruiwagen' (wheel barrow) and 'gras' (grass), resulting in 'tuinage' and 'tas'.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	1			2		1		1
Substitution [l]	3	5	2	3	2	1	2	1
Substitution [h]					1			
Substitution [n]			2					
Deletion						2		
Reduction + Subst.		3		3		2		
Distortion								4

Child 11 (Age: 5;0 - 5;3)

This child is the only one who visits a school in the Amsterdam region, where an alveolar tap is the most common realization of /ʀ/.

In the samples from the PNT of Child 11, no correct productions are present. Most targets /r/ are substituted, for [l], [j] and [ʊ]. In the second recording more realizations of /ʀ/ are

observed, however, not pronounced correctly. In the spontaneous speech samples only one word contains target /ʀ/, which is produced correctly. Complex onsets are substituted, reduced, or pronounced slightly different. The word 'camera' (camera), contains a position error. The word is pronounced 'ka-mer-a', instead of 'ka-me-ra'.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct					1			
Substitution [l]	1	1		1				
Substitution [j]	1	3	2					1
Substitution [ʋ]	2	1	2	2				
Deletion		1						1
Reduction + subst.		1						1
Insertion + subst.		1						
Distortion				5				1
Postition error							1	

Child 12 (Age: 3;4 - 3;7)

An increase in correct productions between recordings one and two is observed in the speech samples for Child 12, as well as a decrease in substitutions in singleton onsets in the picture naming tasks. Reduction and substitution in complex onsets take place in words like 'brood' (bread) and 'bril' (glasses), resulting in 'loot' and 'lil'.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct		2	3	5			3	
Substitution [l]	3	3		3				
Substitution [h]			1					
Substitution [d]					1			
Substitution [f]	1							
Deletion					1			2
Reduction + subst.		3				1		1

Child 13 (Age: 3;10 - 4;1)

The samples from the picture naming task of Child 13 show a discrepancy between correct productions in singleton and complex onsets. Where complex onsets display an increase in correct productions, singleton onsets show the opposite. Although spontaneous speech provides less words that contained target /ʀ/, almost all are correct.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	3	4	1	6	4	2		3
Substitution [l]		4	2	1		1		
Substitution [ʋ]	1							
Substitution [d]			1					
Deletion				1				1

Child 14 (Age: 5;2 - 5;7)

The speech samples from Child 14 contain a small amount, but wide variety of substitutions. Target /ʀ/ appears as [l], [j], [ʋ], [h] and even [χ], in singleton onsets. In complex onsets, however, more deletions are found.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct		1	1	3		2		
Substitution [l]	1				1			
Substitution [j]	1							
Substitution [ʋ]								
Substitution [χ]	1		2					
Substitution lh]					1			
Deletion		7		3	1	3		3
Reduction + subst.				2				
Insertion + subst.			1					
Distortion							1	1

Child 15 (Age: 5;5 - 5;8)

Child 15 shows a consistent pattern of substitutions from target /ʀ/ to [l]. In PNT's it is the only realization of target /ʀ/. A smaller sample containing target /ʀ/ is found in spontaneous speech, but in the second recording, some correct realizations are present.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct							1	2
Substitution [l]	4	8	4	8	1	2	1	1
Substitution [ʊ]					1			
Deletion								

Child 16 (Age: 4;7 - 4;11)

For Child 16, the majority of targets /ʀ/ in picture naming tasks is substituted by [ʊ]. In spontaneous speech more realizations as [l] are found.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct				1				
Substitution [l]	1		1	3	3	2	1	
Substitution [j]		1						
Substitution [ʊ]	2	3	3	2				
Substitution [h]	1				1			
Deletion		4		2		4		4
Reduction + subst.					1			
Distortion						1		

Child 17 (Age: 5;3 - 5;5)

In the samples of Child 17, most targets /ʀ/ are deleted. Only singleton onsets are substituted, some by [l], some by [h], but the majority by [j]. Some complex onsets are reduced and

substituted, mainly by [s]. In one word, singleton onset /ʀ/ was realized as [lj], resulting in

'ljups' for 'rups' (caterpillar).

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct							1	
Substitution [l]							1	
Substitution [j]	4				2		3	
Substitution [h]			3					
Deletion		6		8		8	1	4
Reduction + subst.		2				3		
Insertion + subst.			1					
Distortion								1

Child 18 (Age: 5;11 - 6;3)

Child 18 shows a large amount of correct productions of target /ʀ/, however, also a lot of

productions with a distortion. Correct productions occur mainly in the picture naming tasks,

and distortions more in spontaneous speech. Deletions in complex onsets are found mainly in

the picture naming task.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	4	3	2	6	1	1	2	2
Substitution [ʊ]			1					
Substitution [p]			1					
Deletion		5		2	1	1	1	
Distortion					3	5	1	6

Child 19 (Age: 6;0 - 6;2)

Child 19 shows a consistent pattern of realizations as [l], which improve from recording one

to two for singleton onsets, but not for complex onsets. Some deletions and distortions are

observed as well. In the word 'trein', a schwa is inserted, and /ʀ/ is realized as [l], resulting in 'təlein'.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct		1	2	1	1	3	2	
Substitution [l]	4	5	1	7	1	5		1
Substitution [ʋ]						1		2
Substitution [d]			1					
Deletion		1				1		
Insertion + subst.		1						
Distortion							1	3

Child 20 (Age: 5;8 - 5;11)

Child 20 substitutes target /ʀ/ for a variety of consonants, and even a schwa. The pattern in these substitutions, however, is consistent. Both realizations of the word 'giraf' (giraffe), for example, are the same, with substitution /ʀ/ -> [j]. The same word occurs twice in spontaneous speech as well, with the same substitution. The realization as [ə] is found in the word 'trein' (train), resulting in 'təein'.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct				1				
Substitution [l]				1				
Substitution [j]	2	1	2	1	4		1	
Substitution [ʋ]					1	2	1	2
Substitution [h]	2		2				1	
Substitution [d]					1			
Substitution [ə]				1				
Deletion		6		3		1	1	
Reduction + subst.		1		1				
Distortion						1	1	2

Child 21 (Age: 4;3 - 4;7)

In the results of the picture naming tasks, most targets /ʀ/ are realized as /l/. No correct productions are found. The spontaneous speech samples, although much smaller in number, did contain correct productions. In addition, a number of substitutions is observed, although less consistently for the same consonant as in the picture naming tasks.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct					1	1		1
Substitution [l]	3	3	4	5	1	1	1	
Substitution [j]							1	
Substitution [ʊ]		1					1	
Substitution [h]					1			
Substitution [s]	1							
Deletion		4		3		1		1

Child 22 (Age: 4;9 - 5;1)

This child substitutes target /ʀ/ for a variety of consonants. What stands out, however in the speech of Child 22, is the large number of a combination of reduction and substitution. The complex onset /χʀ/ is realized as [h], and /kʀ/ becomes [t] in the words 'groen' (green), 'gras' (grass) and 'krant' (newspaper), consistently in both recordings. The word 'trap' (stairs) becomes 'pap', with the complex target /tʀ/ realized as singleton onset [p]. The word 'giraf' (giraffe) is not said by the child at all. In the first recording of spontaneous speech, only one word with target /ʀ/ is produced, and there target /ʀ/ is deleted. In the second recording, some correct productions are found, besides substitutions and reductions.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct			2				3	
Substitution [l]			1					
Substitution [j]							1	
Substitution [h]	2							
Substitution [n]	1							
Substitution [m]			1					
Deletion		3		3		1	1	1
Reduction + subst.		4		5				1
Reduction + distort.								1
Missing word	1	1						

Child 23 (Age: 3;6 - 3;10)

The samples of Child 23 show a consistent pattern of substitutions by [l]. The results of the picture naming tasks all had one exception. In the word 'giraf' (giraffe) the target /ʀ/ is realized as [kl], resulting in 'klaf'. The words 'trap' (stairs) in the first recording, and 'gras' (grass) in the second are both correct. The first recording of spontaneous speech shows the same pattern of correct productions and realizations as [l]. The second recording contains less words with target /ʀ/, and no correct productions are found.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct		1		1		2		
Substitution [l]	3	7	4	7	3	2	1	2
Deletion						1		
Insertion + subst.	1							1

Child 24 (Age: 2;11 - 3;2)

In the samples of Child 24, some progress is found in recording two of the picture naming task. The first recording only shows realizations as [l] and a single deletion. The second recording contains some correct productions. The samples of spontaneous speech only show

an increase in number of words with target /ʀ/. The majority of targets is deleted or substituted.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct			2	1			1	
Substitution [l]	4	7	2	5		1	2	2
Substitution [j]					1			
Substitution [d]					1			
Deletion		1		2			1	2
Reduction + subst.								1

Child 25 (Age: 5;4 - 5;7)

In the results of the picture naming task of Child 25, an increase of correct productions is found between recording one and two, which means a decrease in realizations as [l]. In the samples of spontaneous speech, this effect is not present. Only one substitution is found, and a slight decrease in correct productions. Where target /ʀ/ is produced, it is not pronounced correctly.

	PNT				SS			
	1e recording		2e recording		1e recording		2e recording	
	singl	compl	singl	compl	singl	compl	singl	compl
Correct	2	2	4	6	2	3	2	2
Substitution [l]	2	5		2			1	
Deletion		1				1		
Distortion					1	1	1	1

2.4   Analysis

In the following section, the results are analyzed per type of phonological simplification process. The most common processes are described and explained using the characteristics and natural classes of phonemes. The results in the previous paragraph showed that

substitution in general, in both complex and singleton onsets, is the most common process. Within this class, substitutions for [l] outnumber substitutions for all other consonants substantially (more than 50 %). Deletions and correct productions are not part of the analysis, but will be mentioned briefly for completeness of the participant overview.

In the analysis of substitutions, the results of PNT and SS, as well as the results of recordings one and two are merged, in order to maximize the information about the type of substitutions children display.

2.4.1   Substitution /ʀ/ -> [l]

Children 01, 03, 10, 15, 19, 21, 23 en 24 all display a consistent pattern of substitution from /ʀ/ -> [l]. This substitution can be explained as a result of a mistake in place of articulation (Van der Torre, 2003). The targets /ʀ/ and /l/ share the features [+SONORANT, + APPROXIMANT, + LIQUID]. However, within this natural class the children have not yet acquired the difference between coronal and dorsal, leading to [l] productions for both target /l/ and target /ʀ/. This neutralization is a common phenomenon in child language, both in typical development and language disordered development, called lateralization (Beers, 1992, Van Haaften, 2020) . In typical development, the contrast is usually acquired at the age of 4;4 to 4;7 years (Van Haaften, 2020). In children with (presumed) DLD, this phonological simplification process is more persistent, and is still found in children of 4;10 - 5;9 and 5;10 - 6;3 (age groups 3 and 4).

2.4.3   Substitution /ʀ/ -> [j]

Children who are making this substitution, are not consistent in the type of mistakes they make, meaning [j] is only one of the many consonants they use to realize target /ʀ/. Child 17

and Child 20 exhibit these substitutions most frequently.

/j/ is seen as the consonantal equivalent of the vowel /i/ (Levelt, 1989, Booij, 1995). Phonemes /r/, /ʀ/, and /j/ are all approximants, /r/ and /ʀ/ both are liquids, and /j/ is a glide. Although its characteristics are more vowel-like, place of articulation for /j/ is described as palatal in the literature (Booij, 1999, Rietveld & Van Heuven, 2016, Van der Torre, 2003). Calling it a neutralization of a specific contrast is therefore not completely correct. Vowel acquisition is usually completed earlier than consonants, both in TD and DLD (Van Haaften 2020, Beers 1995). According to degrees of complexity (Beers 1992), /j/ is in the first degree, and /ʀ/ is in the last (fifth) degree. Children realizing /ʀ/ as [j] must have completed the first degree of complexity, but not the last. This means that they at least acquired the contrasts labial, coronal and sonorant. All vowels are [+ CONTINUANT], which holds therefore for /j/ as well, and both /ʀ/ and /j/ are dorsal. The only contrast between the two sounds, therefore, is liquid versus glide. and this contrast is what children, who make these substitution, neutralize.

2.4.4   Substitutions /ʀ/ ->[ʋ]

Children 5, 11, and 16 are the ones who most frequently realize /ʀ/ as [ʋ], but their substitutions vary, resulting in inconsistency.

Substitution of /ʀ/ -> [ʋ], called labial lenition (Beers, 1992), is rarely found in typically developing children, and when it is, it is mostly applied to other labial sounds, like /p/. Substitutions /r/ -> [w] are very common in English (Beers, 1992). Although the orthographic sign for this phoneme is the same, the Dutch /ʋ/ is labiodental, rather than bilabial, and English [r] is categorized as more round and vowel-like. The English phonemes seem to have a considerable amount of similarities. Despite their many more differences, the Dutch counterparts do show some similarities as well. Both /ʀ/ and /ʋ/ are approximants, and share the features [+ SONORANT, + CONTINUANT]. Within the category of approximants,

they differ at two points: Where /ʀ/ is a liquid, /ʋ/ is a glide, and the first is articulated uvular, and the latter labiodental. Substitutions, therefore, cannot be the result of neutralization of a single contrast only. From the data, it became clear that this substitution occurred at the word 'kruiwagen' (wheel barrow), the most, where the complex onset was either reduced or substituted for [ʋ], resulting in 'ʋœy-ʋa-χə' or 'kʋœy-ʋa-χə' respectively. Although not part of this study, a investigation of the surrounding sounds revealed that the target in this tri-syllabic word might have been influenced by the following sounds, as they show the feature 'round', which is shared with /ʋ/ (Levelt, 1994).

2.4.5   Substitutions for a variety of other consonants

In the data of children 08, 09, 12, 13, 16, 20 and 22 a wide variety of consonants occur as realizations of /ʀ/. Not only is there a difference in the consonants that appear in the realizations of the target, all these consonants are different per child as well. For that reason the data will be analyzed for those children separately.

 The substitutions of child 08 demonstrate the same pattern as forementioned children according to/ʀ/ -> [l] substitutions. In his data, however realizations as [j] are common as well, and he is less consistent in his substitutions, in particular in the first session of recording. In the word 'giraf' (giraffe), as well as in 'regen' (rain) and 'rups' (caterpillar), /ʀ/ is realized as [n], which seems completely random, just like [d] in the word 'ring' (ring). According to the degrees of complexity as described by Beers (1995), the contrast [± NASAL] is acquired in the same stage as the contrast rhotic. If this child has not mastered this degree of complexity, it neutralizes this contrast.

 Child 09, shows, besides the previously mentioned realizations as [l], [j] and [ʋ], H-zation, the process that replaces a consonant, usually /ʀ/, by [h]. This is not uncommon in typically developing children, as well as in children with DLD (Beers, 1992). Child 9 applies

it to words with a range of following consonants, except /o/, /u/ and /i/. One plausible

explanation for this is that children are not specifically pronouncing [h], but on exhalation, a

kind of aspiration comes along with the pronunciation of the vowel. No clearance is found for

the difference in occurring of this process with various vowels.

Realizations as [ʋ] are all followed by a front vowel, which is explained through the theory

of consonant harmony (Levelt 1999). In the word 'groen' (green), not only /ʀ/ was realized as

[l], also /χ/ was realized as [k]. This clear case of stopping, in combination with lateralization

(Beers 1992), is an 'idiosyncratic' process, according to Beers (1992). The process of

devoicing in combination with gliding in 'brood' (bread), pronounced as 'pjot', in the first

recording is also observed in typical development, making it less unusual, however, more

persistent. Devoicing also happens in 'bril' (glasses), ending up as 'pɪl'. In this case, the more

common process of cluster reduction follows. A discrepancy is observed in the words 'gras'

(grass) and 'broek' (trousers), which surface as 'kjɑs' and 'bjuk' respectively. Unlike /b/ in

'brood', /b/ in 'broek' does not undergo the process of devoicing, while stopping (/χ/ -> [k])

does apply to other words.

The twin boys 12 and 13 were surprisingly accurate in their realizations of /ʀ/, despite their

young age. The data of child 13 show a different age range than that of his brother. Due to a

small sample size (< 90 words) in recordings one and two, for child 13 recordings three and

four were used, which were taken at a later date. The substitutions observed in these boys

showed several similarities, such as realizations as [l] before vowels /e/, /u/, /ɑ/ and

diphthong /ɛi/. These children had some, apparently random, other substitutions, such as [f] in

the word 'giraf' (giraffe) and [d] in the word 'dieren' (animals), which resulted in 'tifaf' and

'diede', respectively. This might, however, be a case of regressive assimilation, the process

whereby a consonant preceding the target influences the realization of the target.

Child 16 shows mainly realizations as [ʋ], [l], as mentioned before, and occasionally with [j] and [h]. There is a difference between recording one and two. In the first recording, the /ʀ/ in 'ring' becomes [l], and in the second recording it is replaced by [ʋ], which is unexpected, because usually the contrast between /l/ and /ʀ/ is mastered later than the contrast between /ʋ/ and /ʀ/. In 'rups' (caterpillar), /ʀ/ is substituted for [h] in the first recording, and [l] in the second, which is of more logical nature for the same reason. Gliding, as the process of substitution with [ʋ] is called (Beers, 1992) seems to be more of a habitual pattern for this boy, however, so he might have just made some mistakes by replacing /ʀ/ by other consonants.

Child 20 uses an expanded variety of consonants, and even a schwa to substitute /ʀ/. Besides the aforementioned [j], an [h], [ʋ] and [d] are found, and in the word 'trein' (train), the [ə] turns up. Insertion of a schwa is a common process in Dutch (Sebregts, 2014), although only if there is still a rhotic present, not instead of /ʀ/. The adult target word for this child could have been 'tə-ʀɛin', and then the very common process of deletion took place. Realizations as [j], [h] and [ʋ] are common, as has been shown in the analysis for other children. A realization as [d], however, is rare. It only occurs once in the samples of this child, and would have been clear if the adult target for this child is /r/, instead of /ʀ/, because of the similarities in place and manner of articulation. The alveolar tap and alveolar voiced stop are more similar than the uvular trill and alveolar voiced stop.

Child 22 mainly displays difficulties with complex onsets, where the complete onset is realized as [p], [t], [h] and [k]. It is unclear if these substitutions are the result from a misperception of target /ʀ/, the other consonant in the onset cluster, or the complete cluster. The substitution /b/ -> [p], is more obvious than /ʀ/ -> [p], however. The first is an example of devoicing, the latter is more difficult to explain. The same holds for /k/ -> [t] versus /ʀ/ ->

[t], where the first is an example of backing. Substitution /ʀ/ -> [h], forms a consistent pattern for this child, in both singleton and complex onsets.

2.4.2   Substitutions Child 11

Child 11 is the only child that attends a school in the Amsterdam region, where alveolar tap is the most common realization of target /ʀ/ (Sebregts, 2014). This child might, but does not have to, have a different perception of the target, compared to the other children in this study. It is unsure if the target this child perceives is in fact /r/ , instead of /ʀ/, but for this study, I assume it is. In the speech samples of this child, realizations as [ʊ], [j], [l] and [p] occur. This is not particularly different from other children, however, cannot be explained in the exact same way. Place of articulation for /r/ and /l/ should be the same, namely coronal. In this specific case, the main difference between the two phonemes is [± CONTINUANT]. The explanation therefore for this substitution is, the child neutralizes this contrast. As for the realizations as [j], there is more than one contrast this child needs to acquire. First, /j/ has the same specifications as the vowel /i/, and is therefore a [+FRONT, + HIGH], but it is not coronal, like /r/. Place of articulation therefore, is difficult for this child. Furthermore, manner of articulation differs, just like with children who acquire the dorsal /ʀ/. All are approximants, however, /r/ and /ʀ/ both are liquids, and /j/ is a glide.

Child 11 demonstrates a modest amount of progress between the results of recording one and two. In the words 'brood' (bread), 'bril' (glasses), 'gras' (grass), 'krant' (newspaper), [ʀ] (or [r]) is realized, however with a minor difference in pronunciation. Remarkable, further, is the lack of words containing /ʀ/ in the first sample of spontaneous speech. This might be avoidant behavior.

2.4.3 Deletion

In the samples of children 14, 17 and 18, the majority of targets /ʀ/ are deleted, specifically in complex onsets.

In the results of the first recording of the picture naming task of Child 14, all complex onsets are deleted, as well as one singleton onset. In the word 'rups' (caterpillar) the /ʀ/ is substituted by [χ], which is an uncommon process (Beers, 1992). The same process appears in the second recording in the words 'rups' and 'ring' (ring). In the word 'krant' (newspaper) the complex onset is reduced to a singleton, and appears as [χ], resulting in 'gat' (/n/ also deleted). The phonemes /ʀ/ and /χ/ are both dorsal sounds, which means that the child neutralizes the contrasts [± SON].

Child 17 consistently reduces complex onsets, which is a common simplification process in both typical and disordered language development (Beers 1992, Van Haaften 2020).

Child 18 displays a combination of correct productions and deletions of target /ʀ/. In the first recording, most targets are deleted, and in the second recording more correct productions are found.

2.4.1 Correct realizations of target /ʀ/

Children 02, 04, 05, 06 and 07 have mainly correct realizations of /ʀ/, and child 25 shows an increase of six in correct productions between recording one and two. Most of these children are in age group 3 and 4, which is not surprising, as this is the age of acquisition for /ʀ/ in typical development (Van Haaften, 2020). Recordings from the children 04, 05, 06 and 07 are all collected by the same speech therapist. Besides that, there are no other similarities. Two of the children are bilingual boys and the other two are monolingual girls.

3.   Discussion

In this study a systematic investigation of the productions of the phoneme /ʀ/ of children with (presumed) Developmental Language Disorder was conducted. In order to be able to address

the question to what extend this development deviates from that of typical developing children, speech samples of 25 children, at two different moments, in two different ways, were analyzed and compared to the existing literature on normal phonological development (Van Haaften et al. 2020) and impaired development (Beers, 1992). Specifically substitutions for other consonants were subject of the investigation.

First, a difference in the correct production was expected between the samples of a PNT and samples elicited through SS. Previous literature showed that children avoided phonemes that were experienced difficult in SS (Schwarz & Leonard, 1982). The data of the current study showed a significantly lower amount of words that contained targets /r, ʀ/ in SS compared to the PNT, which confirms the findings from the literature on TD children. Second, progress of correct productions was expected between recording one and two for at least age groups three and four, as this is the age of acquisition for the target in TD (Van Haaften, 2020). Although overall, some progress was found, this was not completely reliable. Some children produced less words containing the target, but all were correct. Others produced more words containing the target, nevertheless, most of them were incorrect. Some children even showed a decline in the amount of correct productions.

Examination of the type of substitutions appearing in the current study, revealed information about the difference in phonological development between TD children and those with DLD. From the literature (Beers, 1992, Van Haaften 2020) it became clear that the process of lateralization ([l]), was expected to be rare, as it is reported 'idiosyncratic' in DLD (Beers 1992). This is not confirmed by the results of the current study, as it appeared to be the most common substitution. Beers (1992) describes the process of gliding, where both /l/ and /ʀ/ are realized as [ʋ] as 'persistent normal', but in this study substitutions by [ʋ] for /ʀ/ are found less (/l/ was not part of this research as a target). H-zation was found in less than 4 % of the total targets, and 9 % of all substitutions were H-zation. This confirms the findings from

the literature (Beers, 1992). Substitutions for [j] were not reported in the literature, neither for TD, nor for DLD (Van Haaften, 2020, Beers 1992). In the current study they were found even more than substitutions for [h] (4,5 % of total targets, 11 % of substitutions).

Substitutions for all other consonants were not expected from the literature (Van Haaften, 2020, Beers, 1992). In the current study, substitutions for [d], [f], [g], [k], [m], [n], [p], [s] and [t] are found, although very rarely. In this sense, the development of children with Developmental Language Disorder deviates from that of typically developing children.

No influence of bilingualism was expected for prevalence of DLD (Gerrits et al., 2017). Prevalence among boys was expected to be marginally different than for girls (8 % versus 6 %) (Gerrits et al., 2017). The results for this study correspond to what is found in the literature (Gerrits et al., 2017).

According to the source of substitutions, the most common substitution /ʀ/ -> [l] is caused by neutralization of the contrasts dorsal and coronal. Place of articulation is the most important difference between /ʀ/ and /l/. This is therefore the contrast that needs to be acquired. For the realization as [j] for /ʀ/, the cause lies in the manner of articulation. Both targets are approximants, but /j/ is glide, and /ʀ/ is a liquid (see Table 3.). This contrast is what the child still has to learn. To find evidence for the /ʀ/ -> [ʋ] is not so straightforward. There is not one single contrast between phonemes /ʀ/ and /ʋ/. Not only do they differ in place of articulation (dorsal versus labial), they also differ in manner of articulation (liquid versus glide). One explanation is that children realizing /ʀ/ as [ʋ] simply neutralize two contrasts, which is supported by the data, because children who realize /ʀ/ as [ʋ], also demonstrate realizations as [l] and [j]. Within in the category of feature approximant, these children alternate between [ʀ], [l], [j] and [ʋ]. Another explanation is that realizations as [ʋ] are caused by influence of the surrounding, rounded vowels, which is also supported by the data.

3.1   Limitations

The findings as described above showed that the 25 children studied showed a different pattern than was previously expected based on the literature. To conclude that language development deviates for DLD, compared to TD, is beyond the scope of this Bachelor Thesis. It is an indication for further research, though. Further, It is unclear whether only the phonetic realizations are incorrect, or whether there is also a deficit in the mental representation of the target phonemes. This requires research into perception. Finally, two different measurement moments with an interval or 3 month did not reveal significant progress. Therefore samples from the two recordings are merged. From every child, four consecutive samples were elicited. To provide a solid conclusion concerning progress, investigation of the remaining samples could be an indication for further research.

3.2   Clinical Implications

For a speech therapist, specific information about which sounds are difficult for a child is very valuable. This research provides this information, per child. However, it also gives an indication of the properties of sounds that a child does not yet distinguish. Without directly addressing the target sound, a speech therapist can help teach the missing contrast. This may also be important for distinguishing other contrasts, and selecting appropriate treatment goals.

4.   Conclusion

In this study, the specific type of substitutions for the phoneme /ʀ/ that occur in the speech samples of children with DLD are compared to that of TD children. It became clear that the participants in this study displayed a different pattern of substitutions, compared to the findings in the existing literature (Van Haaften et al, 2020). The main differences are found in

the type and use of phonological simplification processes. Not only are the common processes more persistent (Beers, 1992), but the uncommon and idiosyncratic processes are found more and longer in children with DLD (Beers 1992).

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APPENDIX A.

WORDS FROM PICTURE NAMING TASK

Target word	Translation	IPA transcription
Poes	cat	pus
Maan	moon	man
Fiets	bicycle	fits
Vis	fish	vis
Wolk	cloud	ʊ
Jas	coat	jɑs
Koe	cow	ku
Aap	monkey	ap
Boom	tree	bom
Boef	crook	buf
Boek	book	buk
Zaag	saw	zax
Slang	snake	slɑŋ
Appel	apple	ɑ-pəl
Emmer	bucket	ɛ-məɹ
Ta-fel	table	ta-fəl
Kruiwagen	wheelbarrow	kʀœy-ʊa-xə
Blokken	blocks	blɔ-kə
Vo-gel	bird	vo-xəl
Zingen	singing	zi-ŋə
Bank	couch	bɑŋk
Bal	bal	bɑl
Gie-ter	watering can	χi-təɹ
Huis	house	hœys
Boot	boat	bot
Baby	baby	be-bi
Zwaaien	waving	zʊa-jə
Na-vel	belly button	na-vəl
Lamp	lamp	lɑmp
Neus	nose	nøs
Pan	pan	pɑn
Ba-naan	banana	ba-nan
Twee	two	tʊe

Tas	bag	tɑs
Deur	door	dʏr
Leeuw	lion	leʋʊ
Stoel	chair	stul
Au-to	car	ʌy-to
Ballon	balloon	bɑ-lɔn
mei-sje	girl	mɛis-jə
horloge	watch	hɔɹ-lo-ʒə
zeehond	seal	ze-hɔnt
kwast	brush	kʋɑst
sjaal	shawl	sjal
giraf	giraffe	ʒi-ʀɑf
klok	clock	klɔk
knoop	button	knop
cadeau	present	ka-do
plei-ster	band-aid	plɛis-təɹ
bloem	flower	blum
fles	bottle	flɛs
stift	marker	stɪft
vlag	flag	vlɑx
dwerg	dwarf	dʋɛɹx
glij-baan	slide	χlɛi-ban
vlecht	braid	vlɛxt
schep	shovel	sχɛp
ma-ma	mummy	mɑ-ma
snor	mustache	snɔɹ
fee	fairy	fe
jo-jo	yoyo	jo-jo
ring	ring	ʀiŋ
vliegtuig	airplane	vlix-tœyx
jurk	dress	jʏɹk
kikker	frog	kɪ-kəɹ
juf	teacher	jʏf
zee	sea	ze
vork	fork	vɔɹk
dak	roof	dɑk

regen	rain	ʀe-xən
duim	thumb	dœym
jongen	boy	jɔ-ŋə
brood	bread	brot
lolly	lollypop	lɔ-li
glas	glass	χlɑs
bad	bath	bɑt
varken	pig	vɑɻ-kə
bril	glasses	bʀɪl
rups	caterpillar	ʀʏps
woef	woof	ʋuf
krant	newspaper	kʀɑnt
sneeuwpop	snowman	sneyʋ-pɔp
trein	train	tʀɛin
nest	nest	nɛst
groen	green	χʀun
heks	witch	hɛks
trap	stairs	tʀɑp
spook	ghost	spok
spin	spider	spɪn
gras	grass	χʀɑs

APPENDIX B.

RESULTS PER CHILD

Recording 1

	bilingual	age	PNT cor	PNT sub	PNT del	PNT sub/red	PNT oth	SS cor	SS sub	SS del	SS sub/red	SS oth
child 01		3;2	1	6	1	3	1		1	1	1	
child 02	Farsi	4;3	10	2				4				
child 03		3;1		11	1					2		
child 04	Arabic	5;2	12					2	1			
child 05	Nepalese	5;10	8	3	1			3	4	3		
child 06		5;1	12					6	2	2		
child 07		4;9	12					5	1	1		
child 08	Afrikaans	5;3		4	6	2		1	5	1		
child 09		3;1		4	7	1			2	3	2	1
child 10	Arabic	3;5		9		3		1	5	2	2	
child 11	Burmese	5;0		9	1	1	1	1				
child 12		3;4	2	7		3			1	1	1	
child 13		3;10	7	5				6	1			
child 14		5;2	1	3	8			1	2	5		
child 15		5;5		12					4			
child 16		4;7		8	4				5	4	1	
child 17		5;3		4	6	2			2	8	3	
child 18	Polish	5;11	7		5			2		2		8
child 19	Unknown	6;0	1	9	1		1	4	7	1		1
child 20		5;8		5	6	1			8	1		1
child 21		4;3		8	4			2	3	1		
child 22		4;9		3	3	4	2			1		
child 23	Turkish	3;6	1	10			1	2	5	1		
child 24		2;11		11	1				3			
child 25	Dari	5;4	4	7	1			4		1		2
Total			78	140	56	20	6	44	62	41	10	13
							300					170

agegroup:
- 2;10-3;9
- 3;10-4;9
- 4;10-5;9
- 5;10-6;9

Recording 2

	bilingual	age	PNT cor	PNT sub	PNT del	PNT sub/red	PNT oth	SS cor	SS sub	SS del	SS sub/red	SS oth
child 01		3;5		10		2			1	2	1	
child 02	Farsi	4;6	11	1				2		3		
child 03		3;4	1	10	1			1	3	1		
child 04	Arabic	5;7	11	1				5		1		
child 05	Nepalese	6;2	10	1	1			4	1			4
child 06		5;4	12					9				
child 07		5;0	12					6		2		
child 08	Afrikaans	5;7		6	5	1		3	2	1	2	
child 09		3;4		4	7	1			4	2		
child 10	Arabic	3;9	2	7		3		1	3			4
child 11	Burmese	5;3		7			5		1	1	1	2
child 12		3;7	8	4				3		2	1	
child 13		4;1	7	4	1			3		1		
child 14		5;7	4	2	3	2	1			3		2
child 15		5;8		12				3	2			
child 16		4;11	1	9	2				1	4		1
child 17		5;5		3	8		1	1	4	5		1
child 18	Polish	6;3	8	2	2			4		1		7
child 19	Unknown	6;2	3	9				2	3			3
child 20		5;11	1	7	3	1			5	1		3
child 21		4;7		9	3			1	3	1		
child 22		5;1	2	2	3	5		3	1	2	1	1
child 23	Turkish	3;10	1	11					3			1
child 24		3;2	3	7	2			1	4	3	1	
child 25	Dari	5;7	10	2				4	1			2
Total			107	130	41	15	7	56	42	36	7	31
							300					172

agegroup:
- 2;10-3;9
- 3;10-4;9
- 4;10-5;9
- 5;10-6;9

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APPENDIX C

TYPE OF SUBSTITUTIONS PER CHILD

Recording 1

	bilingual	age	/ʀ/ -> [l]	/ʀ/ -> [j]	/ʀ/ -> [ʊ]	/ʀ/ -> [h]	oth	/ʀ/ -> [l]	/ʀ/ -> [j]	/ʀ/ -> [ʊ]	/ʀ/ -> [h]	oth
			PNT					SS				
child 01		3;2	6									1
child 02	Farsi	4;3	1	1								
child 03		3;1	10	1								
child 04	Arabic	5;2						1				
child 05	Nepalese	5;10			2	1		1	1		1	1
child 06		5;1						2				
child 07		4;9								1		
child 08	Afrikaans	5;3					4	2	3			
child 09		3;1		1		3					2	
child 10	Arabic	3;5	8		1			3	1		1	
child 11	Burmese	5;0	1	4	3							
child 12		3;4	6				1					1
child 13		3;10	4		1			1				
child 14		5;2	1	1			1	1			1	
child 15		5;5	12					3		1		
child 16		4;7	1	1	5	1		4			1	
child 17		5;3		4						2		
child 18	Polish	5;11										
child 19	Unknown	6;0	9					6		1		
child 20		5;8		3		2				4	3	1
child 21		4;3	6		1		1	2			1	
child 22		4;9				2	1					
child 23	Turkish	3;6	10					5				
child 24		2;11	11					1	1			1
child 25	Dari	5;4	7									
Total			93	16	13	9	8	32	12	6	7	5

Recording 2

	bilingual	age	/ʀ/ -> [l]	/ʀ/ -> [j]	/ʀ/ -> [ʊ]	/ʀ/ -> [h]	oth	/ʀ/ -> [l]	/ʀ/ -> [j]	/ʀ/ -> [ʊ]	/ʀ/ -> [h]	oth
			PNT					SS				
child 01		3;5	10					1				
child 02	Farsi	4;6	1									
child 03		3;4	9	1				3				
child 04	Arabic	5;7			1							
child 05	Nepalese	6;2			1					1		
child 06		5;4										
child 07		5;0										
child 08	Afrikaans	5;7	5				1	1				1
child 09		3;4	1			3			1	2	1	
child 10	Arabic	3;9	5				2	3				
child 11	Burmese	5;3	1	2	4					1		
child 12		3;7	3			1						
child 13		4;1	3				1					
child 14		5;7					2					
child 15		5;8	11	1				2				
child 16		4;11	4		5			1				
child 17		5;5				3		1	3			
child 18	Polish	6;3			1		1					
child 19	Unknown	6;2	8				1	1		2		
child 20		5;11	1	3		2	1		1	3	1	
child 21		4;7	9					1	1	1		
child 22		5;1	1				1		1			
child 23	Turkish	3;10	11					3				
child 24		3;2	7					4				
child 25	Dari	5;7	2					1				
Total			92	7	12	9	10	22	7	10	2	1

APPENDIX D

REDUCTIONS + SUBSTITUTIONS (COMPLEX ONSETS)

child	bilingual	age	l	w	h	s	t	p	j	k	g
			Recording 1 + 2 / PNT + SS								

child	bilingual	age	l	w	h	s	t	p	j	k	g
child 01		3;2	4	1	1						
child 02	Farsi	4;3									
child 03		3;1									
child 04	Arabic	5;2									
child 05	Nepalese	5;10									
child 06		5;1									
child 07		4;9									
child 08	Afrikaans	5;3				1	4				
child 09		3;1			1		1	2			
child 10	Arabic	3;5	1				2	1	1		
child 11	Burmese	5;0						1		1	
child 12		3;4	3			1		1			
child 13		3;10									
child 14		5;2		1							1
child 15		5;5									
child 16		4;7			1						
child 17		5;3			1	3		1			
child 18	Polish	5;11									
child 19	Unknown	6;0									
child 20		5;8					2				
child 21		4;3									
child 22		4;9			4		2	3	1	1	
child 23	Turkish	3;6									
child 24		2;11	1								
child 25	Dari	5;4									
Total			9	2	8	5	11	9	2	2	1