Abstract

The knowledge of typical phonological development is of clinical significance for the identification of children with speech sound disorders (SSD). Data available from other languages, even of the same language family, cannot be transferred for clinical purpose. At present there are no studies describing Norwegian-speaking children's typical phonetic and phonological development.

The purpose of the present study was to gain first insight into the phonetic and phonological development in 14 monolingual Norwegian-speaking children aged 2;6-2;11. The study is part of a large-scale cross-sectional study on Norwegian speaking children's phonological development conducted at Statped South-East. A newly designed picture naming task (*Diffkas*, Bjerkan & Frank, 2017) was used to investigate the phonetic inventories, use of tonal accent, type/token of phonological processes, and the number of infrequent variants produced. In addition, the children were asked to complete a stimulability task to assess production of all phones in isolation.

Results showed that the phonetic vowel inventory was complete in all children assessed, while this was not yet the case for the consonant inventory. No tone errors were found. Fourteen phonological processes were shown by more than 10% of the children, with a mean of 6 types per child. The analysis of infrequent variants indicated a large variance across children. Compared to results from languages of the same language family (Germanic /Northern Germanic), the Norwegian speaking children showed similar types of processes and missing phones. However, language specific processes were also found. In comparison to studies on German and Danish-speaking children, the Norwegian-speaking children in the present study seemed to be slower on most measures in their phonological development.

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Celine Alme

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1. Introduction

Normative data is of significant importance to speech-language therapists (SLTs) in the evaluation and intervention of children with speech sound disorders (SSD). Children with SSD constitutes a substantial portion of SLTs caseloads, with studies reporting SSD to be the largest referred group of children in speech therapy (Dodd, 2014; McLeod & Baker, 2004; Mullen & Schooling, 2010). In order to properly identify children with suspected SSD normative data on the child's ambient language is important because it serves as a baseline in differentiating typical from atypical development (Dodd, Holm, Zhu, & Crosbie, 2003). Further, normative data as a baseline is important in planning appropriate intervention for the children diagnosed with SSD. Choosing the appropriate intervention is vital because studies show that children with SSD are a heterogeneous group and partly at high risk for future academic, socioemotional and occupational difficulties (McCormack, McLeod, McAllister, & Harrison, 2009).
In addition, normative data can contribute in the theoretical discussion on language acquisition by challenging or supporting theories on developmental universals (Zhu & Dodd, 2006a). However, due to the scope of this thesis, this will not be discussed further.

Normative data has been collected on a number of languages from several language families over the past 20 years, including English (Dodd et al., 2003), German (Fox & Dodd, 1999), Danish (Clausen, 2016), Putonghua (Zhu, 2006b), and Turkish (Topbas & Yavas, 2006). However, at present no such data exists for Norwegian. Norwegian SLTs, therefore, rely on data collected for other languages. This is problematic because although data is available from closely related languages in the same language family studies show that there are language specific differences in children's acquisition of language (Clausen, 2016; Dodd et al., 2003). Language specific data on Norwegian is, therefore, essential to Norwegian SLTs in order to accurately identify Norwegian-speaking children with SSD.

Due to the lack of normative data on Norwegian phonology, the aim of the present study is to investigate the stage of phonological development in Norwegian-speaking children aged 2;6-2;11. A picture naming task will be used to investigate the children's phonetic inventory, use of tonal accent, type/token of phonological processes, and number of infrequent variants

produced. The results from the study will be compared cross-linguistically to other languages with available normative data in the same language family.
This age group was chosen because this is the age at which children's phonology has been shown to be systematic (Holm, Crosbie, & Dodd, 2007; Schäfer & Fox, 2006) and phonological processes can be investigated (Dodd, 2005).
Due to the scope of this thesis only a small number of children will be investigated; however, the data collected will be part of a larger normative study currently being conducted in Norway. Since no such data currently exists on Norwegian phonology, the present study will provide a first insight into Norwegian-speaking children's phonology at ages 2;6-2;11.

To provide a theoretical baseline for the present study, Chapter 2 will present research on phonological development, information about Norwegian phonology and the studies available on Norwegian children's phonology, normative data from recent cross-linguistic studies, as well as the clinical relevance of the study being undertaken. Due to the scope of this thesis only languages in the same language family as Norwegian will be presented. Research questions will be presented at the end of Chapter 2. The methods used in the present study are the same as those used in current cross-linguistic investigations of children's phonology and will be described in Chapter 3. The results will be presented in Chapter 4, and subsequently discussed and compared cross-linguistically in Chapter 5. Finally, Chapter 6 provides a brief summary of the main findings from the present study.

2. Theory

As a theoretical background for this thesis, this section will cover different areas of research. First, the process of speech acquisition in typically developing children will be described. Second, since this study will focus on Norwegian-speaking children the phonology of Norwegian as well as current knowledge of the phonological development in Norwegian-speaking children will be presented. Third, to allow for cross-linguistic comparison of the Norwegian data, knowledge of phonological development on other Germanic languages will be discussed. Last, clinical implications and research questions will be presented.

2.1 Speech sound acquisition

The process of speech sound acquisition involves the acquisition of both the receptive and expressive sound systems of the ambient language. The receptive aspect precedes the expressive aspect and will be presented in that order.

2.1.1 First year of life

Children are born with an innate ability to discriminate auditory stimuli, and studies show that infants as young as 4 weeks old are able to discriminate between speech sounds (Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993). Through exposure to the ambient language the child's perceptive abilities change. By 6-12 months the child starts to prefer speech sounds found in its environment, and the ability to discriminate phonetic contrast not found in the ambient language declines (Best & McRoberts, 2003; Nettelbladt, 2007; Werker & Pegg, 1992).

Early speech productions (babbling) are affected by the physiological development of the infant's speech mechanisms (Kent, 1992), and the physical abilities to articulate the sounds in the ambient language emerges in the first year of life (Frank, 2013; Oller, 1980).

Children's pre-lexical vocal development can be divided into stages (Oller, 1980; Stark, 1980). The goo stage (Oller, 1980) appears when the infant is around 3 months and is characterised by nasalized glottal vocalisations of vowels and consonants. In the expansion stage between 4 and 6 months the infant starts to explore a larger range of vocalisations, and by the end of this period the infant will produce consonants and vowels that resemble adult production. Canonical babbling emerges around 6 months and is seen as a milestone in speech

development because the infant has now developed more motor control of the jaw and begins to produce reduplicated consonant-vowel sequences, i.e /baba/, in adult-like speed of transition (Oller, 1980). In the early stages of sound acquisition speech perception and speech production are closely connected, and the child's vocal productions reflect the language in their surroundings (Locke, 1993; Nettelbladt, 2007; Vihman, 2014). The next stage begins around 10 months and is characterized by production of more variable strings of syllables, known as variegated babbling. The strings go from being reduplicated, as in /baba/, to contain a larger number of consonants and vowels, f.ex /bagega/. The consonant repertoire expands in this period, and the child also uses variation in stress, length and pitch within the strings of syllables (Frank, 2013; Nettelbladt, 2007; Oller, 1980; Vihman, 2014). Thus by the end of the first year the child has acquired the necessary motoric prerequisites by babbling, reflecting the melodic intonation patterns, phoneme frequencies and syllable structure in the child's ambient language at adult-like speed and competence (Dodd, Holm, Crosbie, & Hua, 2005). This is in contrast with Jakobson (1941/1968), who claimed that babbling was purposeless and that there was a discontinuity between babbling and children's first production of words.

2.1.2 The acquisition and phonology of the first 50 words

The first words typically emerge between 12 and 18 months, but there is a great deal of individual variation. For a study on Norwegian-speaking children's lexical development see Simonsen, Kristoffersen, Bleses, Wehberg, and Jørgensen (2014). Defining the first words can be problematic because the shift from non-reduplicated strings of syllables and first words is unclear. However, the first words can be said to have developed when the child attaches meaning to an utterance (Dodd et al., 2005; Nettelbladt, 2007; Vihman, 2014). In the transitional period between babbling and words many children use proto-words. These are stable sound sequences used to convey meaning, but these sequences do not resemble the adult form of the word. The early word production emerges shortly after the child uses proto-words, and early word production begins when the sound sequences of the child's words start to resemble the adult form (Vihman, 2014).

Children's first words are acquired based on a whole-word approach. This means that they pay little attention to the different segments of the words, rather they see words as whole units (Ferguson & Farwell, 1975; Macken, 1979; Nettelbladt, 2007; Waterson, 1971). By using this strategy the children learn one word at a time, and the development of the first 50 words is relatively slow (Dodd et al., 2005). Once the vocabulary expands there is a reorganization of

the children's phonology indicating a change in strategy from whole-word to a segmental phonology (Dodd & McIntosh, 2010; Ingram & Ingram, 2001). It is not certain exactly when this shift occurs: Ingram (1976) proposed a shift at approximately 50 words, whereas Sosa and Stoel-Gammon (2006) found evidence for a shift when the children's vocabulary had reached 150-200 words.

In this phase of vocabulary development (50-150/200 words) the children's production is inconsistent (Holm, Crosbie, & Dodd, 2005). Studies in German (Schäfer & Fox, 2006), English (Holm et al., 2007) and Danish (Jørgensen & Bøgh, 2017) show that children become consistent in their word production between the ages 2;0-2;5. These studies show that there is a large variability in when children overcome inconsistency within and across languages: Danish children showed consistency at age 2;0 (Jørgensen & Bøgh, 2017), whereas the English and German children showed consistency at latest 2;5 (Holm et al., 2007; Schäfer & Fox, 2006). When children have overcome the phase of inconsistency more and more consistent use of phonological processes (see below) can be observed, and children's phonology can be said to have become systematic. However, although children show systematic use of processes at this age, there are still some phonological variations within the children's production. Albrecht (2017) defines these phonological variations as infrequent variants. Studying the children's use of infrequent variants could be a measure of how systematic the children's language is at an early age (Albrecht, 2017; Fox-Boyer, 2016). Two recent studies investigated infrequent variants in young children. In the first study Fox-Boyer (2016) studied infrequent variants in German-speaking children aged 2;6-3;11. She found that the number of infrequent variants were highest in the youngest age group, age 2;6-2;11, and that occurrences decreased with age. The second study investigated infrequent variants in German-Turkish bilingual children aged 3;0-5;5 (Albrecht, 2017). Although this study also found that infrequent variants declined with age, this study was on bilingual children, thus results are not comparable to the results found in monolingual children.

The shift to segmental phonology can be seen in the word forms the children use at this stage (Dodd et al., 2005; Nettelbladt, 2007). The words the children produce start to resemble the adult shape, but are characterized by consistent phonological errors, termed phonological

processes (Ingram, 1974) or error patterns (Dodd et al., 2005)[1]. The use of phonological processes imply that children have begun to analyse words phonemically (Dodd et al., 2005).

Phonological processes are defined as "consistent differences between child and adult realizations" (Zhu, 2006a). These processes are used to describe children's erroneous realisations of adult target words. Further, phonological processes are divided into two categories: Structural processes, processes which affect the syllable structure of the word, and systemic processes which involves substituting one sound for another (Dodd, Holm, Zhu, Crosbie, & Broomfield, 2006; von Tezchner et al., 1993). Typical examples of structural processes are consonant cluster reduction, weak syllable deletion and assimilation. Examples of systemic processes are fronting, stopping, and /r/-substitutions (Bowen, 2011; Dodd et al., 2006; Simonsen, 1997).

2.1.3 Phonological development after the age of 2;6

Children with a typical phonological development will show a reduction in the use of phonological processes with age (Dodd et al., 2005; Nettelbladt, 2007), and the number of infrequent variants can also be expected to decline (Albrecht, 2017; Fox-Boyer, 2016). In terms of understanding children with phonological difficulties, it is useful to determine which processes can be found to be developmental and at which age they should be overcome. Studies of the age at which the various phonological processes are present have been conducted in numerous languages from numerous language families, for example English (Dodd et al., 2006), German (Fox, 2006), Danish (Clausen & Fox-Boyer, 2017), Icelandic (Másdóttir, 2008), Turkish (Topbas & Yavas, 2006) and Putonghua (Zhu, 2006b). These studies show that although many of the same processes are present in the different languages, the age at which they are considered age appropriate is language specific, and the age when the processes are overcome varies from language to language. At present, data on which processes Norwegian-speaking children show and at what age they show them is still not available.

[1] There exists a theoretical discussion on the use of these terms that will not be discussed due to the scope of this thesis. For this thesis the term phonological processes will be used.

2.2 The phonology of Norwegian

This study focuses on children acquiring Norwegian, therefore, the phonological features of Norwegian will be presented in the following section. Norwegian is the official language of Norway and is spoken by approximately 5.2 million people. Norwegian belongs to the North Germanic languages together with Danish, Swedish, Icelandic and Faroese. Norwegian has 2 official written norms: Bokmål and Nynorsk, but no official spoken norm (G. Kristoffersen, 2000). Although not the official spoken norm of Norwegian, Bokmål has a spoken realization used in the larger parts of eastern Norway, and this is often seen as the unofficial standard of spoken Norwegian (G. Kristoffersen, 2000). G. Kristoffersen (2000) refers to this as Urban East Norwegian (UEN), and this will be used as reference for this thesis.

2.2.1 The Norwegian consonant and vowel inventory

The consonant inventory consists of 21 consonants as seen in Table 1:

Table 1: The Norwegian consonant inventory (Bjerkan, 2005)*

	Bilabial	Labiodental	Dental	Alveolar	Post-alveolar	Retroflex	Palatal	Velar	Glottal
Plosive	p b			t d		ʈ ɖ		k g	
Nasal	m			n		ɳ		ŋ	
Tap or flap				ɾ					
Fricative		f		s	ʃ		ç		h
Approximant		ʋ					j		
Lateral approximant				l					

*G. Kristoffersen (2000) additionally mentions three further phonemes which are not presented here: /ʂ ɽ ɭ/. These phonemes are not included in *Diffkas* (see section 2.3.1) because they are regarded as allophones, and are therefore not included in the table above.

Norwegian only has voiceless fricatives. The restrictions on the distribution of Norwegian consonants are that the retroflex elements [ʈ ɖ ɳ] and the nasal element [ŋ] cannot occur in syllable-initial position, and [h] and [ç] cannot occur in syllable-final position. The voiceless plosives have two allophones: one aspirated and one unaspirated. The voiceless plosives [p t k] appear aspirated word-initially and at the beginning of stressed syllables (K. E. Kristoffersen, 2007).

It is worth mentioning that there currently is a merger between the fricatives /ʃ/ and /ç/. Although these phonemes are used to distinguish minimal pairs, there is a growing trend to produce both [ʃ] and [ç] as [ʃ] (Dommelen, 2003). This is found mostly in the younger generation, but is now also extending to the older generations (K. E. Kristoffersen, 2007).

The vowel inventory consists of 18 monophthongs: 9 short and 9 long vowels that function contrastively in stressed syllables: [i: ɪ y: y ʉ: ʉ u: u e: ɛ ø: ø o: ɔ æ: æ ɑ: a].
In addition, Norwegian has 5 diphthongs: [æɪ øy æʉ ɔj aj]. There is some disagreement in the literature on the transcription of the diphthongs. G. Kristoffersen (2000) transcribes the diphthongs [æj œj æw ɔj ɑj]. For this thesis, the transcription used in the *Diffkas* assessment will be used (see section 2.3.1).
The Norwegian vowel system has a feature that is rare cross-linguistically in that it has four contrastive high front vowels [i y ʉ ø], three of which are rounded [y ʉ ø] (G. Kristoffersen, 2000). The vowel [æ] is considered marginal because of its limited distribution, only occurring before [ɾ j w] (G. Kristoffersen, 2000). However, in the dialect spoken by some of the children in the present study /æ/ also occurs in other environments.

2.2.2 Syllable structure

The shortest possible syllable in Norwegian consists of a single V, for example *å* [ˈo:] (Eng. *to*). Other short structures are VC, for example *egg* [ˈɛg] (Eng. *egg*) and CV, for example *ta* [ˈtɑ:] (Eng. *take*). Norwegian allows up to three consonants in the onset of monosyllabic words, for example *strå* [ˈstɾo:] (Eng. *straw*), and up to five consonants in the coda, for example *skjelmskt* [ˈʃɛlmskt] (Eng. *roguishly*). The syllable structure can be summed up as $C_{0\text{-}3}VC_{0\text{-}5}$. Up to four consonants can occur intervocalically in polysyllabic words, for example *monstre* [ˈmɔnstrə] (Eng. monsters).
Norwegian allows for several consonant clusters. In prevocalic positions there are 28 clusters that follow the sonority principle (see below) with obstruent + sonorant, for example [bjø:ɳ] (Engl. *bear*) and [plɑstəɾ] (Engl. *band aid*), and a few marginal clusters with nasal + liquid, for example [njo:l] (the name Njål) and [mjø:d] (Engl. *mead*). However, Norwegian also has several consonant cluster with /s/CC that do not follow the sonority principle because these combinations allow for the more sonorous element to come before elements with less sonority. Examples of these clusters are *skrive* [skɾi:və] (Engl. *write)* and *språk* [spɾo:k] (Engl. *language*). To date there is no satisfactory explanation for this violation in Norwegian syllable

structure (G. Kristoffersen, 2000). There are several possible combinations for postvocalic consonant clusters with sonorant + obstuent, sonorant + sonorant and obstruent + obstruent. (G. Kristoffersen, 2015).

The Norwegian syllables must be heavy (bimoraic) when stressed, and they must follow the maximal onset principle. This requires that a stressed syllable minimally must consist of a long vowel, or a short vowel and at least one consonant, and that a syllable must have an onset if possible within the phonotactic constraints of the language. In words like *måtte* [^{2}mɔtə] (Engl. *had to*) and *hadde* [^{2}hɑdə] (Engl. *had*) these rules are obeyed by gemination of the consonant: [^{2}mɔt.tə] and [^{2}hɑd.də] (G. Kristoffersen, 2000).
Norwegian syllables are also governed by the sonority principle which states that the syllable nucleus must consist of the most sonorous element, and sonority must increase from the margin to the nucleus. The sonority hierarchy is as follows: Vowels > glides > liquids > nasals > obstruents (Kløve, 2008).

2.2.3 Tonal accent

Most Norwegian dialects have contrastive use of pitch using two distinct tones or melodies called accent 1 and accent 2. In the eastern Norwegian dialects, including UEN, accent 1 is made with a low tone on the stressed syllable, whereas accent 2 has an initial tone of the opposite value, realized as high-low-high. The two tones can be used to differentiate words with more than one syllable, for example *bønder* [^{1}bønəɾ] (Eng. farmers) and *bønner* [^{2}bønəɾ] (Eng. *beans or prayers*), and *tanken* [^{1}tɑŋkən] (Eng. *the tank*) and *tanken* [^{2}tɑŋkən] (Eng. *the thought*) (G. Kristoffersen, 2000).

2.2.4 Area specific features

The regional dialect in the area in which the children were assessed, Nord-Østerdal, has some minor phonological differences from urban East Norwegian (UEN). No systematic research has been found on this dialect; however, due to the current situation of dialect levelling in Norway, it is natural to use UEN as the reference for the children in the assessed group (Skjekkeland, 2016). The children were assessed by a native speaker of the dialect, and potential dialectal effects were taken into consideration during assessment and analysis. The main differences between UEN and the local dialect are the use of tonal accent, in which tone 2 is used instead of tone 1 e.g. /^{1}støʊəl/ is realised as /^{2}støʊəl/, the use of /æ/ instead of /ɛ/, /u/

instead of /o/, and /ʃ/ instead of /s/ in certain words. These changes do not affect the segmental phonology and will therefore not be discussed in this thesis.

2.3 Current knowledge on phonological development in Norwegian children

Research on Norwegian children's phonological development is sparse, and at present only 5 studies have been conducted. The first study was a longitudinal diary study by Vanvik (1971), in which he described his daughter's phonetic-phonemic development from 0 to 8 years of age. He found /r/-substitution until the age of 3, and that retroflexes and the fricative /ʃ/ were missing from the phonetic inventory until the age of 4. The last sound to be mastered was /ç/, which did not appear in the phonetic inventory until the age of 7. Phonological processes reported up to the age of 4 were metathesis and epenthesis (in early stages of development), consonant cluster reduction, assimilation and weak syllable deletion.

In 1983 a group of researchers conducted a cross-sectional study in which they investigated the phonology of 73 4-year old's from Eastern and Western Norway named *Trondheimsundersøkelsen* (Fintoft, Bollingmo, Feilberg, & Mjaavatn, 1983). By collecting data from connected speech samples, they looked at how the 4-year old's articulation differed from adult realizations of target words. They found that the children used /r/-substitution and made fricative errors (fronting) with /s ʃ ç/ as well as errors in the use of initial consonant clusters /sk/ and /st/. The study investigated the articulatory competence of the children assessed and did not go into detail about the children's use of phonological processes.

Simonsen (1990) conducted a longitudinal study on 3 Norwegian children from 2 to 4 years old. She used connected speech from play situations to investigate the children's consonant inventory, the use of consonant clusters and phonological processes. She found that consonants in word initial positions developed earlier than word medial consonants, and word final consonants developed last. Fricatives /ʃ ç/ and /r/ were the latest consonants to develop in any word position. However, Simonsen reported great individual variation in the development of the phonemic inventory in the 3 children studied, thus age of acquisition of the Norwegian phonemes is difficult to determine based on the data presented. Regarding consonant clusters, Simonsen found cluster reduction (deletion of a consonant in a cluster) and vowel insertion between two consonants in a cluster. Phonological processes reported present in the early stages of development were assimilation and final consonant deletion.

Weak syllable deletion, fronting of fricatives /ʃ ç/, backing of /l/, stopping, voicing/devoicing and /r/-substitution were common late processes.

Fortun (1997) studied the use of phonological processes in 13 children aged 2;8-3;0 in a cross-sectional study. Self-made picture material and structured observation was used to elicit the target words (Fortun, 1997). She found that all children assessed showed phonological processes, but that there was individual variation in how many processes the children showed. The processes reported in this study are assimilation, weak syllable deletion, fronting of fricatives /ʃ ç/, /r/-substitution, final consonant deletion and cluster reduction.

The latest cross-sectional study on Norwegian children's phonological development was conducted in 2006, and studied the use of s-clusters in 27 Norwegian children aged 21-36 months (E. K. Kristoffersen & Simonsen, 2006). Data for this study was collected by using a 45-item picture naming task (E. K. Kristoffersen & Simonsen, 2006). They found that S-clusters developed later than non-S-clusters, and that the pattern of deletion differed among the two types of clusters. In S-clusters children deleted consonant 1 (the sibilant), whereas consonant 2 was deleted in non-S-clusters.

In summary, the main findings of the available Norwegian studies were that labial and dental consonants develop before velars (Fintoft et al., 1983; Fortun, 1997; Simonsen, 1990, 1997; Vanvik, 1971), and that children up to 4 years of age show some instabilities in production of the voice-voiceless distinction of plosives (Fintoft et al., 1983; Simonsen, 1997). The r-sound develops late; however, differences were found in the different dialectal areas of Norway. *Trondheimsstudien* showed that children in the Eastern part of Norway, where an alveolar trill /r/ is used, had a higher percentage of substitutions than the children in the West, where a uvular trill /R/ is used. The r-substitutions used by the Norwegian children were /ð j l ɽ/ (Fintoft et al., 1983; Simonsen, 1990; Vanvik, 1971).
Regarding consonant clusters, it was found that most children produced all clusters by age 4, and that /s/ clusters were the latest to develop (Fintoft et al., 1983; E. K. Kristoffersen & Simonsen, 2006; Simonsen, 1990; Vanvik, 1971).
Common phonological processes reported were consonant cluster reduction, weak syllable deletion, assimilation, fronting of fricatives /ʃ ç/ and /r/-substitution (see table 2).

Table 2: Phonological processes found in Norwegian studies

Processes	**Vanvik**	**Simonsen**	**Fortun**
Assimilation	X	X	X
Weak syllable deletion	X	X	X
Fronting fricatives /ʃ ç/		X	X
Backing /l/ → /ɭ/		X	
Stopping		X	
Voicing/devoicing		X	
/r/-substitution	X	X	X
Final consonant deletion		X	X
Cluster reduction	X	X	X
Vowel insertion (clusters)		X	
Epenthesis	X		
Metathesis	X		

The studies conducted on Norwegian children's phonology shed some light on the phonological development and the types of phonological processes shown. However, due to limited sample sizes and differences in data collections (naming/spontaneous speech), generalizations about the typical phonological acquisition of Norwegian children must be made with caution. Further, although Fintoft et al. (1983) used a large sample of 4-year olds, methodological issues in the study can be raised in terms of elicitation methods and criteria used for phones included in the children's phonetic and phonemic inventories. Based on the studies conducted in Norwegian so far, the ages of phonetic and phonemic acquisition cannot be determined. In addition, that data available to date does not give sufficient information about phonological processes being typical for Norwegian-speaking children at what age. Thus, current knowledge is not sufficient in order to identify a child as typically developing. A prerequisite, however, for collecting representative data on a language is an assessment procedure fulfilling international criteria for construction validity (Eisenberg & Hitchcock, 2010; Kirk & Vigeland, 2014; National Council on Measurement in & American Psychological, 2014; Wolk & Meisler, 1998). Therefore, the following section will focus on available assessment material in Norwegian.

2.3.1 Tests available to assess Norwegian children's phonology

There is one test available for Norwegian SLTs to use in the assessment of phonology:

- Norsk Fonemtest (*Norwegian phoneme test*) (Tingleff, 2007)

This test was not used in the present study because it does not test all phonological features found in Norwegian and would therefore not give an accurate description of the assessed children's phonology. The test does not consider the tonal feature in Norwegian and does not take into account the syllable structure of Norwegian when assessing certain consonant clusters. The test includes words not commonly found in small children's vocabulary, and the drawings do not clearly represent the target word. The test is not standardised and there is no manual with instructions for how the test should be administered and scored.

In addition to the phonology test, there are a few tests that assess children's articulation:

- SVANTE-N: Assessment tool for articulation and nasality developed for children born with cleft palate (Lohmander et al., 2013)
- Artikulasjonsprøve for Registrering av Uttalefeil (*Test of articulation for registration of pronunciation errors)* (Johnsen, 1987)
- Norsk Logopedlags Språklydsprøve (*Norwegian association for SLTs speech sound assessment*) (Vidsjå, 1983)
- Artikulasjonsprøve B (*Articulation assessment*) (Backe, 1982)

Apart from SVANTE-N, which is normed for 4-year olds, none of these tests are standardised. The articulation tests are designed to assess children's articulatory competence and not phonological processes and are therefore not suitable for the present study.

2.3.2 *Diffkas*

Due to the lack of material to assess Norwegian children's phonology, *Diffkas*: Differaldiagnostisk Kartlegging av Språklydsvansker (Bjerkan & Frank, 2017) was developed. The first draft of *Diffkas* was developed in 2017 at Statped South-East by the department of Speech and Language disorders. Before this master's thesis project, *Diffkas* had only been piloted on a small group of children, thus this project contributed in piloting and developing the test. *Diffkas* is still a working project and has not yet been published. Permission to use the material for this study was granted by Statped South-East (see Appendix 1). *Diffkas* is constructed based on current international agreement of test construction in the assessment of child phonology (Eisenberg & Hitchcock, 2010; Kirk & Vigeland, 2014; National Council on Measurement in & American Psychological, 2014; Wolk & Meisler, 1998). It follows tests developed for German (PLAKSS-I, Fox, 2001;

PLAKSS-II, Fox-Boyer, 2014), English (DEAP, Dodd et al. 2002), and Danish (LogoFova, Clausen, 2014). Linguistic criteria considered in constructing the test were that all phonemes of Norwegian were assessed in all word positions at least 4 times, except for retroflexes /ʈ, ɖ, ɳ/ and palatal fricative /ç/ because they are infrequent and rarely found in small children's vocabulary. Further, it was ensured that all possible tone, stress and syllable structures were represented. Most Norwegian clusters were included, except marginal clusters that are infrequent in Norwegian children's vocabulary.

Diffkas contains 99 words selected from the Norwegian database "Ordforrådet" (Lind, 2015), a searchable database with 1650 Norwegian adjectives, nouns and verbs. The database contains information about word characteristics that can influence acquisition, storage and processing for individuals with speech- and language disabilities, as well as for individuals without such disabilities. The criteria used for the selection of the words in *Diffkas* were low age of acquisition, high frequency of occurrence in young children's vocabulary and high imageability. The vocabulary in *Diffkas* was piloted on very young children (aged 2;4-3;6) and found suitable for a picture naming task. A complete item list of the words included in *Diffkas* can be found in Appendix 2.

2.4 Cross-linguistic knowledge on phonological development

During the past 20 years a large number of studies on phonological development have been conducted in various languages. This is also the case for languages of the same language family as Norwegian: Danish (Clausen, 2016), Icelandic (Másdóttir, 2008), Swedish (Nettelbladt, 2007), German (Fox-Boyer, 2016; Fox & Dodd, 1999) and English (Dodd et al., 2003). A main focus in these studies was the types of phonological processes and the age of occurrence. Apart from the study on Swedish, comparable criteria is used in the investigation of the phonological development in the different languages studied. These same criteria will be used in the present study.

Cross-linguistic comparisons are important in understanding universal and language specific patterns of phonological development because they add to the theoretical concepts of phonological development. Further, cross-linguistic comparison shows how important it is to have normative data for specific languages because phonological development is language specific. Therefore, it cannot be assumed that data from one language can be used for another, even in the same language family. Although theoretical concepts will not be discussed in

detail due to the scope of this thesis, in order to investigate to which extent Norwegian-speaking children perform similarly or differently to other children of the same language family, normative data from languages in the same language family as Norwegian will be presented.

The latest normative study on phonological development was a cross-sectional study conducted by Clausen (2016), who investigated 443 Danish-speaking children aged 2;6-4:11. Másdóttir (2008) conducted a longitudinal study on 28 Icelandic-speaking children's phonological development at ages 2;4 and 3;4.
Data also exists on Swedish children's phonological development (Nettelbladt, 2007); however, no reports exist on how many children were investigated or at what age, and no standardised material was used for data collection. The phonological processes reported were seen in children up to the age of 4. The difference in methodology compared to the other studies mentioned in this section must be kept in mind when interpreting the data.
Fox-Boyer (2016) reported normative data on phonological development from a cross-sectional study on 689 monolingual German-speaking children aged 1;6-5;11. The study investigated the children's use of phonological processes. Further, data on 177 children's (aged 1;6-5;11) phonetic and phonemic development was presented (Fox & Dodd, 1999).
Dodd et al. (2003) conducted a large cross-sectional normative study on English-speaking children recording the phonological development of 684 children aged 3;0-6;0. In addition, normative data from a cross-sectional study of 62 English-speaking 2-year-olds was collected by McIntosh and Dodd (2008).

Results from the different studies showed a number of similarities but also differences. These can partly be explained by the differences within the phonological systems of these languages, even though they are of the same language family. In support of developmental universals, certain features were common in all the languages studied: the vowel inventories were completed earlier than the consonant inventories, and nasals and plosives were acquired before fricatives (Clausen, 2016; Dodd et al., 2003; Fox-Boyer, 2016; Másdóttir, 2008).

Phonological processes were investigated in the different languages. The studies showed a range of typical processes for each language and that the use of processes declined with age. Many of the phonological processes found were similar in the languages investigated; however, differences were also found. For the purpose of comparisons with the age group

assessed in this thesis (age 2;6-2;11), phonological processes shown by children aged 2;4 to 2;11 will be presented in table 3:

Table 3: Cross-linguistic comparison of phonological processes in Danish, Icelandic, Swedish, German and English[2] at age 2

Phonological processes	**Danish**	**Icelandic**	**Swedish***	**German**	**English**
Gliding			X		X
h-isation		X			
Deaffrication				X	X
Fronting velars	X	X	X	X	X
Fronting fricatives /ç ʃ/	X*[1]			X	X*[1]
Backing fricative /ʃ/				X	
Glottal replacement /ʁ/	(X)*[2]		X	(X)	
Cluster reduction	X	X	X	X	X
Cluster simplification		X			
Weak syllable deletion	X		X	X	X
Syllable deletion		X			
Stopping	(X)	X	X	(X)	X
Voicing/Devoicing		X	X	X	X
Initial consonant deletion		X			
Final consonant deletion		X	X	(X)	X
Consonant insertion		X			
Assimilation	X	X	X	X	X
Dentalisation		X			
Deaspiration	(X)	X			
Sibilisation		X			
Palatalisation		X			
Lateralisation		X			

*Swedish data on children aged 4

*[1]Danish phonetic inventory only has /ɕ/, English phonetic inventory only has /ʃ/

*[2](X) indicate processes found in children aged 2;0-2;5

As table 3 shows, fronting of velars, cluster reduction and assimilation is found in all the languages at ages 2;6-2;11. Other highly frequent processes are fronting of fricatives, voicing and final consonant deletion. Affricates are only found in English and German, and the process of deaffrication is language specific to those languages. Icelandic is the language with the most processes reported. The reason could be that the group of children reported were younger than in the other languages, assessed only at age 2;4 and not in an age band of 6 months. However, looking at the processes used by the same children at 3;4 show that most of

[2] (Clausen, 2016; Dodd et al., 2003; Fox-Boyer, 2016; Másdóttir, 2008; Nettelbladt, 2007)

the processes were still present (Másdóttir, 2008). Danish-speaking children show fewer processes than found in other languages. However, since the Danish-speaking children's phonological development seem to be more advanced than in other languages, a study investigating phonological processes at a younger age than 2;6 may reveal additional processes (Clausen, 2016). So far only a small longitudinal study (N=4) indicated that more processes are produced by children younger than 2;6 (Clausen, 2016). The studies reported in table 3 indicate that although many of the languages show the same processes, phonological development is language specific.

Norwegian is a tone accent language. The feature of tone is also found in Swedish and in dialects of Southern Denmark (G. Kristoffersen, 2000); however, it has not been investigated in the previously mentioned studies in Swedish (Nettelbladt, 2007) and Danish (Clausen, 2016). Although not in the same language family as Norwegian, and with more complex tonal features, Putonghua and Cantonese are worth mentioning for the cross-linguistic comparison of tone. Normative cross-sectional studies were conducted in Putonghua (Zhu & Dodd, 2000) with 129 monolingual Putonghua-speaking children aged 1;6-4;6, and in Cantonese (So, 2006) with 268 Cantonese-speaking children aged 2;0-5;11. Results from both studies showed an unproblematic early acquisition of tone, and the feature was acquired by 2;0 in Cantonese and 1;10 in Putonghua (So, 2006; Zhu & Dodd, 2000).

In summary, the phonological processes found within the different languages of the same language family indicate that it is not possible to apply normative data of one language onto another, and thus that specific features of types and age of occurrence can be expected to be found in Norwegian.

2.5 Clinical Implications

This is a master's thesis project in speech therapy, and it is important to note the clinical implications of the study being undertaken. The field of speech therapy is concerned with evidence-based research for the intervention of speech and language disordered children. Norwegian speech therapists rely on normative data from closely related languages when assessing whether children's phonological development can be considered typical or atypical. Although the languages are closely related, studies of universal patterns show that phonological development is language specific. In order to offer Norwegian speaking children evidence-based intervention, it is crucial that normative data exists for this population.

Further, collecting normative data on the age at which children are consistent in their word production will contribute to the possibility of offering early intervention. This is important because early intervention provides a better outcome for children with SSD (McIntosh & Dodd, 2008).

2.6 Research Questions

As stated above, the knowledge of typical development is of clinical significance for the identification of children with atypical phonological development. In order to attain knowledge of typical development, the study of normative data is crucial. Normative data is not only clinically significant, but also has theoretical implications. There are different views on language acquisition, and the first to propose a universal nativist theory was Jakobson (Jakobson, 1941/1968). Although recent studies show that there are certain similar tendencies in development across languages, there is also a great deal of language specific variation (Zhu & Dodd, 2006b). Thus, theories on phonological development must take into account the ambient language being learned and cannot be explained only by innate mechanisms. Normative data can aid in understanding the theoretical issues; however, due to the scope of this thesis this will not be discussed further.

The development of phonology has been studied in several languages, e.g. English (Dodd et al., 2003), German (Fox & Dodd, 1999), Putonghua (Zhu, 2006b), Danish (Clausen, 2016). Concerning the phonetic inventory, it can be expected - based on studies in other languages- that the children in the present study will have mastered more of the vowel inventory than the consonant inventory, but that they will also master a wide variety of consonants by the age of 2;11. The studies conducted by Zhu and Dodd (2000) and So (2006) showed that tone was an early acquired feature, thus it can be hypothesised that the children assessed will not make tone errors.

Based on earlier studies, it can be assumed that Norwegian-speaking children will show the most typical processes found in other languages in the same language family for the age group assessed. However, research from other languages also show that there are language specific processes, thus language specific processes for Norwegian can be expected. It can be hypothesised that language specific processes in Norwegian concerning the phonemes that are specific to Norwegian will be found. In addition to phonological processes, it can be expected that the children assessed will show some phonological variations which will be measured as infrequent variants.

The main aim of this thesis was to investigate the stage of phonological development in Norwegian speaking 2;6-2;11-year olds. Several research questions arose:

1. Which phones have the Norwegian-speaking children mastered in the age group 2;6-2;11? The phones produced in spontaneous speech (i.e. spontaneous naming in the picture-naming task) will be compared to phones produced in isolation in order to investigate whether differences between the two phone sets can be found.

2. Do the Norwegian-speaking children master the feature of tone by age 2;11?

3. What types of phonological processes do Norwegian speaking children age 2;6-2;11 show? What's the frequency of occurrence (token) per process type? What is the type/token ratio of processes per child and the mean value for the group?

4. What is the number of infrequent variants found in the children assessed?

5. To which extent do the results of this study resemble findings in earlier studies with regards to phones mastered, tones, phonological processes shown and infrequent variants?

3. Methods

This master's project is part of a larger cross-sectional study being carried out in Norway, and the method for this study has been collaborated on with a project group at Statped South-East. To allow for cross-linguistic comparison the design of this study is the same as in relevant studies on normative development (Clausen, 2016; Dodd et al., 2003; Fox-Boyer, 2016). Due to the scope of this thesis, only a small number of participants will be studied.

This study looks at typically developing Norwegian-speaking children's phonological competence at the age 2;6-2;11. This age has been chosen because this is the age at which children in other languages show consistency (Holm et al., 2007; Jørgensen & Bøgh, 2017; Schäfer & Fox, 2006). Children at this age can be expected to show a systematic speech production and make the study of phonological processes possible.

3.1 Participants

Fourteen typically developing monolingual Norwegian-speaking children, 9 males and 5 females, aged 2;6-2;11 participated in this cross-sectional study (See Table 4).

Table 4: Children participating in the study

Child	**Sex**	**Age**
B1	M	2;6
B2	M	2;7
B3	M	2;6
B4	M	2;8
B5	M	2;10
B6	M	2;10
B7	M	2;7
B8	M	2;7
B9	M	2;10
G1	F	2;10
G2	F	2;11
G3	F	2;9
G4	F	2;7
G5	F	2;9

The children were recruited from day-care centres in Nord-Østerdal, a region in the eastern part of Norway, by distributing information letters explaining the aim of the study,

background questionnaires for caregivers and consent forms (See Appendix 3). Teachers at the day-care centres gave these forms to the caregivers of the children who met the inclusion criteria. To meet the inclusion criteria the children had to be monolingual Norwegian speakers, have no known hearing disorder, no cognitive or physical impairments, and no previous intervention for speech or language problems. In addition, both caregivers and teachers at the day-care centre had to report the child to be typically developing, specifically concerning language development. Information gathered from the background questionnaire ensured that the child met the inclusion criteria.

3.2 Material

Two assessment tools were used to investigate the children's phonetic and phonological development. The first tool was a picture naming test, *Diffkas* (Bjerkan & Frank, 2017), which assesses all Norwegian phonemes and provides a baseline for the assessment of phonological processes (see section 2.3.1).

The second assessment tool was a stimulability task to assess the child's ability to imitate phones in isolation. During the task the assessor used a list of the Norwegian phonetic inventory, consonants and vowels alike, and asked the children to imitate the phones in isolation.

3.3 Procedure

All children were assessed by a graduate student in SLT (the author) who administered the tests in a quiet room in the child's day care centre. The children were seen individually, and the day care teachers were given the opportunity to attend the assessment if the child required it.

In the picture naming task, the assessor was seated next to the child with an Ipad clearly visible to both. The child was asked to name the pictures shown on the Ipad. If the child was unable to spontaneously name the picture, a cue was given in the form of sentence completion, for example: "After we wash our hands, we dry them on a …… (*towel*)." If the child still did not produce the target word, a choice between two words was given. If there was no production after the two cues, the child was asked to imitate the assessor. Target words elicited based on cues were marked on the scoring sheet.

After the picture naming task, the stimulability task was given, where the child was asked to imitate the phones produced by the assessor. If the child did not imitate spontaneously, the assessor repeated the item and gave visual cues by asking the child to look at the assessor's mouth.

All utterances were recorded using an Olympus digital voice recorder (VN-8500PC). The assessor completed a broad phonetic transcription based on the audio recording. 10% of the transcriptions were checked by one phonologist and one phonetician for inter-rater reliability. The agreement rate was 92.1%. The main difference was variations in the production of /s/ which was frequently produced in an addental or interdental manner. This was ignored since it does not affect child's intelligibility or phonological competence, which was the main emphasis of this thesis.

The tests took approximately 30 minutes per child to administer.

3.4 Analysis

The analysis of the data from this study focused on the phonetic inventory, tones, the phonological process shown by the children, as well as the number of infrequent variants produced. Dialectal differences compatible with the local dialect were not marked as incorrect.

The *phonetic inventory* was analysed in two separate ways. First, the phones in children's spontaneous speech (naming) was analysed. The data collected for each child was checked for production of all Norwegian phones. If a phone was produced twice within spontaneous speech, i.e. picture naming, independent of correct use in words, the phone was accepted and included in the child's phonetic inventory. In order to describe the phonetic inventory of the assessed age group, a phone was considered to be acquired if 75% of the children of that age group produced the phone. Phones produced by 90% of the children in the age group were considered to be mastered. These criteria are identical to those used by Clausen (2016), Fox and Dodd (1999) and Dodd et al. (2003) in order to support cross-linguistic comparison. Second, the children's phone production in imitation (stimulability test) was analysed. A phone was considered to be part of the child's phonetic inventory if the child was able to imitate the auditory stimulus spontaneously or with support. In order to describe the assessed group's phonetic inventory from the stimulability test, the same criteria as for spontaneous

speech were applied. A comparison of the two analyses of phonetic inventory was carried out on individual and on group level.

Each realisation of *tone* was compared to the Norwegian adult-like realisation of tone. For some words tones varied between the adult target in *Diffkas* and the dialect spoken in the area of the assessed children. Tone differences due to dialect were marked as correct.

A *phonological process* was defined as a particular pattern of phonological substitution or simplification produced by the child at least 4 times throughout the picture naming task, following recommendation by Kirk and Vigeland (2015). This was done to establish typical phonological processes for this age group. If a process was used by at least 10% of children in that age group, it was considered a developmental process (Clausen, 2016; Dodd et al., 2003; Fox-Boyer, 2016; Zhu, 2006b). The cut-off criterion of 4 occurrences was changed for processes affecting the retroflexes and the fricative /ç/, which were only represented in 6 and 3 test items respectively. For the retroflexes the cut-off criterion was 3, and for /ç/ the cut-off criterion was 2. A list of the phonological processes found across the children assessed and their frequency of occurrence will be reported. The type/token ratio of processes found per child and the group means were calculated (excluding phonetic variation of /s/ if present).

All phonological variations that did not reach the cut-off for the definition of a phonological process were added up to a score of *infrequent variants* per child. The mean and standard deviation of infrequent variants found in the group were calculated.

3.5 Ethical consideration

The study was approved by NSD, the Norwegian Data Protection Official for Research (see Appendix 4). Since this study used participants under the age of 15, parental consent for assessment and audio recording was obtained. The parental consent included detailed information about the aim of the study. In addition to consent, the caregivers completed a questionnaire to ensure that the children met the inclusion criteria of the study (Appendix 3). Caregivers gave consent for the information and data collected in this study to be handed over to Statped at completion of the master's thesis for it to be included in the national cross-sectional study on Norwegian-speaking children.

Although parental consent was given, the children were asked if they were willing to participate on the day of assessment. If the child did not want to participate, even only in parts of the study, this was respected. In the assessment of children, it is important that the children

feel safe and comfortable in the assessment situation. This was ensured by letting the children bring a familiar adult from the child care centre into the testing room if they required it. Upon completion of this thesis all parents will receive a letter thanking them for the contribution to this research project, including a group report on the results obtained. The parents who specifically requested individual reports will be given the opportunity to see their child's results. This is possible due to the small sample size in the present study.

4. Results

Results from the analysis of the *Diffkas* assessment concerning phonetic inventory, tone, phonological processes and infrequent variants are presented in this section. Results are presented in summary tables. Details of the individual children's results can be found in the Appendix.

4.1 Phonetic inventory

Vowels

The investigation of vowels showed that the children did not have any problems with vowel production, neither in spontaneous speech nor in imitation. The phonetic inventory of vowels can therefore be claimed to be complete by the age of 2;11. Five of the fourteen children produced /i/ instead of /y/ in the stimulability task; however, this was not considered an error because these two sounds produced in isolation are acoustically very similar (see Appendix 5). One child produced /æ/ instead of /e/, which can be explained by her use of dialect.

Consonants

The investigation of consonants showed that all children, except B1, were still missing consonant phones in their phonetic inventory. The mean number of missing consonants in spontaneous speech was 5, and the mean number in imitation was 6 out of 21 Norwegian consonants. However, the range varied from 0 to 10 (see table 5). When child B8 was asked to imitate isolated phones, he mostly added a vowel to the consonant, such as in alphabetic naming (see Appendix 5). However, if the consonant phone was produced correctly in the stimulability task, it was considered to be mastered.

Table 5: Types and token of missing phones per child in both spontaneous speech and stimulability task

Child	Sex	Age	N Miss SS	Type	N Miss Stim	Type
B1	M	2;6	0		2	/g, ʃ/
B2	M	2;7	5	/g ɳ ʃ ç r/	7	/ʈ ɖ k ɳ ŋ ç ɾ /
B3	M	2;6	1	/r/	3	/ɳ ç r/
B4	M	2;8	3	/ɖ ɳ r/	6	/ʈ ɖ ɳ ŋ ç r/
B5	M	2;10	3	/ɳ ʃ r/	6	/ʈ ɖ k s ç r/
B6	M	2;10	6	/ɖ k g ɳ ŋ ç/	5	/ʈ ɖ k ʃ ç /
B7	M	2;7	10	/ʈ ɖ k g ɳ ŋ ʃ ç r j/	9	/ʈ ɖ k g ɳ ŋ s ç r /
B8	M	2;7	4	/ʈ ɖ ɳ ʃ/	10	/d ʈ ɖ g ɳ ŋ ʃ ç r ʊ /
B9	M	2;10	7	/ʈ ɖ ɳ s ʃ ç r/	No data	
G1	F	2;10	6	/ʈ ɖ ɳ ʃ ç r/	6	/ʈ ɖ ɳ ʃ ç r/
G2	F	2;11	4	/ʈ ɳ ʃ r/	8	/ʈ ɖ ɳ ŋ f ç r j/
G3	F	2;9	4	/g ɳ ʃ r/	9	/ʈ ɖ k g ɳ ŋ ʃ ç r /
G4	F	2;7	4	/ʈ ɳ ŋ ʃ/	8	/t ʈ ɖ ɳ ŋ ʃ ç r/
G5	F	2;9	7	/ʈ ɖ g ɳ ŋ ç r/	7	/d ʈɖ ɳ ŋ ç r /
Mean:			4.57		6.62	

SS = spontaneous speech, Stim = stimulabitiy task

Table 6 demonstrates the phonetic inventory for consonants of the assessed age group under the two conditions 75% and 90% correct. The phones missing from the inventory are velar consonants, retroflex consonants, the two fricatives /ʃ ç/ and the alveolar tap /ɾ/.

Table 6: Phonetic inventory

	75% correct	90% correct
Spontaneous speech	p b t d m n f s h l ʊ j k	p b t d m n f s h l ʊ j
Stimulability	p b t d m n f s h l ʊ j	p b t d m n f h l ʊ j

Norwegian contains 21 consonants and the phonetic inventory of the children indicated that more than 50% of the phones were produced in imitation and used in spontaneous speech (see table 6). All bilabial and alveolar phones were acquired and mastered apart from /s/ where interdental production was used by 2 children in the stimulability task. Interdental production was marked as correct in the calculation of phones in spontaneous speech. The results were nearly identical in spontaneous speech and in the stimulability task, apart from the production

of /k/, which differed due to 1 child not producing the sound in isolation in the stimulability task.

4.2 Tones

Tones were analysed based on adult-like realisation of tones. Some minor differences were found in comparison with the target production on the *Diffkas* scoring sheet (see section 5.1.2 for examples). The differences were considered dialectally appropriate by a native speaker of the dialect and, therefore, scored as correct. None of the children had any difficulties with the realisation of tone.

4.3 Phonological Processes

The investigation of phonological processes revealed that all children showed phonological processes (see table 7). However, the children differed greatly in the amount of types of processes they showed, ranging from 1 to 11. The mean number of processes was 6. The number of process tokens varied from 19 to 112, with a mean of 60.

Table 7: Type /Token of phonological processes used per child

	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**G1**	**G2**	**G3**	**G4**	**G5**	**Mean**	**SD**
N Types	2	10	1	8	3	4	9	8	7	4	5	8	8	10	6	3
N Token	19	102	24	57	25	64	112	89	51	40	50	60	67	80	60	27.5

A process was considered developmental if 10% of children showed a process. For the assessed age group 14 processes were above the 10% cut-off (see table 8). The most common processes were consonant cluster reduction and fronting of retroflexes. Fronting of the velar /ŋ/, lateralisation of other elements, and insertion of /h/ before a vowel were processes that just came above the 10% cut-off, being shown only by two children each. For definition and examples of the processes see Appendix 6.

Table 8: Phonological processes found in the assessed group

Processes	N children	% children
Consonant cluster reduction	12	86
Fronting retroflex /ʈ ɖ ɳ/	10	71
Fronting velars /k g/	8	57
Lateralisation of /ɾ/	8	57
Assimilation	7	50
Fronting fricative /ʃ/	6	43
Fronting fricative /ç/	6	43
Stopping fricatives	6	43
Syllable final consonant deletion	5	36
Vowel change	4	29
Gliding /ɾ/	3	21
Fronting velar /ŋ/	2	14
Lateralisation of other elements	2	14
/h/ insertion before vowel	2	14
Gliding /l/	1	7
Frication of /ɾ/	1	7
/f/ or /v/ = /h/-onset	1	7
Approximant = /h/	1	7
Weak syllable deletion	1	7
Metathesis	1	7

Six phonological processes were found only in 1 child each, and they occurred just at the threshold for being defined as a process (4 occurrences) (see Appendix 7).

Additionally, the phonetic process of interdental realisation of /s/ was found in 29% (4/14 children).

4.5 Infrequent variants

The analysis of infrequent variants per child indicated a large variance, ranging from 6 to 29, the mean being 18, see table 9.

Table 9: Number of infrequent variants

Child	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**G1**	**G2**	**G3**	**G4**	**G5**	**Mean**	**SD**
N Infr Var	15	29	6	17	22	18	19	29	6	11	23	22	10	27	18.1	7.4

4.5 Summary of results per child

Looking at the result profiles for each assessed child, different levels of phonetic and phonological development can be observed (see table 10).

Table 10: Summary of participant's phonetic and phonological development*

	Processes		Infr Var	Miss Phones
Child	**N Type**	**N Token**	**N**	**N**
B1	2	19	15	0
B2	10	102	29	5
B3	1	24	6	1
B4	7	57	17	3
B5	3	25	22	3
B6	4	64	18	6
B7	9	112	19	10
B8	8	89	29	4
B9	7	51	6	7
G1	4	40	11	6
G2	5	50	23	4
G3	8	60	22	4
G4	8	68	10	4
G5	10	80	27	7

* Green = more than one SD above average, red = more than one SD below average

Two children were advanced in their phonological development compared to the other children, with numbers more than one standard deviation above average in at least 3 of 4 categories, indicated in green. Contrastively, two children were slower in their development averaging numbers lower than one standard deviation in 3 of 4 categories below average in the group assessed, indicated in red.

5. Discussion

The main purpose of this study was to investigate the phonology of Norwegian-speaking children aged 2;6-2;11. In order to do this a newly developed test for the assessment of Norwegian phonology was used, and analysis was carried out using criteria common in current cross-linguistic studies. The results of this study will be discussed considering current knowledge on the phonological abilities of children in this age group. Further, evaluation of methodology and limitations of the present study will be discussed, and suggestions for further research presented.

5.1 The phonetic and phonological development

5.1.1 Phonetic Inventory

The phonetic inventory was investigated in two ways, stimulability of phones and spontaneous use in picture naming. The present study shows that 57% of the Norwegian consonants and 100 % of the vowels were mastered by age 2;11 (at 90% criterion). The phones missing were /k g ŋ ʃ ç ɾ ʈ ɖ ɳ/. Thus, the phonetic inventory can be claimed not yet to be completed. Although no previous normative data for Norwegian-speaking children exist for the age group assessed, Fortun (1997) studied the phonology of Norwegian-speaking children aged 2;8-3;0. That study did not focus on the phonetic inventory of the children studied, but claimed that *most* sounds of the Norwegian phonetic inventory were mastered by 3;0. This contradicts the present findings. However, Fortun did not specify criteria for the analysis of phonetic inventory, thus direct comparisons cannot be made. Results from the present study are also not comparable with results from the Simonsen (1990) study, because data from only 2 children at the age group assessed were reported, and there was considerable individual variation in the 2 children's phonetic inventories based on phones mastered in word initial, word medial and word final position. Individual variation in phonetic inventory among the children was also found in the present study.

Previous studies on other languages showed that vowels are acquired earlier compared to consonants (see for example Danish (Clausen, 2016), German (Fox & Dodd, 1999) and Putonghua (Zhu, 2006b)). This agrees with finding from the present study, where the vowel inventory was complete by age 2;11.

In terms of cross-linguistic comparison of the consonant inventory, Norwegian-speaking children in this age group seem to have a slower development than children with other

Germanic language backgrounds, see table 11. The table indicates phones not mastered at 90% criterion. Note that data from Icelandic is not used for comparison because of the age at which the Icelandic-speaking children were assessed. The children in the Icelandic study were assessed at age 2;4 and 3;4 and their phonetic inventories varied greatly at the two assessed times.

Table 11: Cross-linguistic comparison of missing phones in Danish, German, English and Norwegian[3]

	Danish	German	English	Norwegian
Missing phones age 2;11at 90% criterion	ɐ	j ŋ ç ʃ	θ ð ʃ ʒ ʤ ʧ ɹ	k g ŋ ʃ ç ɾ ʈ ɖ ɳ

Although the consonant inventories in these languages are similar in terms of the number of phones, certain differences in features are found. English and German are the only languages with affricates, English the only language with fricatives /θ ð/, and Norwegian the only one with retroflexes. In accordance with universal theories of sound acquisition, features that are less common in languages are acquired later (Zajdo, 2013). All languages that include /ç/ and /ʃ/ in their inventory show a late mastery of this sound. /r/ is reported to be mastered late in other languages described e.g. age 6 in English (Dodd et al., 2003)**.** Taking this into consideration, the main difference seen in the Norwegian-speaking children's inventory at this age is the late mastering of the velar consonants. Although not yet mastered, the velar /k/ was acquired by 85 % of the children in the current sample. With a larger sample of children, it is possible that /k/ would have reached the 90% cut-off.

The differences in age of acquisition of phones across languages show that the developmental pattern of the phonetic inventory is language specific. The slower development in Norwegian-speaking children could be due to the types of consonants in the inventory i.e. retroflexes and to additional workload such as tones.

[3] (Clausen, 2016; Dodd et al., 2003; Fox & Dodd, 1999)

5.1.2 Tones

Some of the children assessed used dialectal variation on some of the tones, for example [^{2}bɑnɑn] instead of the UEN target [bɑ^{1}nɑ:n], or [^{2}tɛləfu:n] instead of [tɛlə^{1}fu:n]. These variations correspond to the adult realisation of the words in the local dialect, and were marked as correct. For the purpose of analysis, it was ensured that tonal variations did not affect the syllable structure in cases of weak syllable deletion. None of the children deviated from the adult realisation of tone and tones could be considered acquired by the age group assessed. The early acquisition of tone corresponds to results found in other languages with tone features (So, 2006; Zhu & Dodd, 2000).

5.1.3 Phonological processes

The Norwegian-speaking children in this study showed a large number of phonological processes. However, there was great individual variation in how many processes each child used, ranging from 1 to 11. This is in accordance with previous studies which show that there is considerable individual variation in children's phonological development (Dodd et al., 2003; Macken, 1979).

Fourteen processes were analysed to be developmental (see table 8), with occurrences in more than 10% of the children in the assessed group. The most frequently found processes were cluster reduction (86%) and fronting of retroflexes (71%). Three of the processes were shown by only 2 children. With such a small sample size (n=14), these processes may not be representable as developmental processes for Norwegian-speaking children. For a small study like this, the cut-off for developmental process could have been raised to 15%, as suggested by Albrecht (2017). Six processes were found only in one child each and thus fell under the cut off criterion. Gliding of /l/, metathesis and weak syllable deletion occurred rarely in the children who showed these processes, with occurrences just at cut-off level for a process (4 occurrences). Except for gliding, which is a developmental process in English, none of these processes are common in other languages studied. This may indicate that these processes are atypical for Norwegian-speaking children; however, this is not conclusive due to the limited sample size.

Some similarities were found when comparing the results from the present study with those of previous studies on Norwegian-speaking children's use of phonological processes. Both Fortun (1997) and Simonsen (1990) found consonant cluster reduction to be the most

common process, and both studies also reported fronting of fricatives and /r/-substitution. Fortun, in accordance with the present study, also found assimilation and final consonant deletion to be common processes. There are, however, many differences between the earlier studies and the one conducted for this thesis. Simonsen (1990), for example, found that the 3 children studied had problems with the voice/voiceless distinction, and that there was a high occurrence of vowel epenthesis in consonant clusters. Neither of these processes were found in Fortun's or the present study. Fortun (1997) reported that weak syllable deletion was the second most common process in the group of children assessed. This differs from the present study where only one of the fourteen children assessed showed this process. Further, although fronting of fricatives was found in Fortun's study, fronting of velars was not, which contradicts the findings in the present study where fronting of velars was found in 57% of the children assessed. Further, fronting of retroflexes occurred in 71% of the children in the present study, however, this process was not mentioned by either Simonsen or Fortun.

When looking at the differences between the Norwegian studies, it must be taken into consideration that Simonsen's study consisted of 3 children and that neither Simonsen's nor Fortun's studies used the same cut-off criteria for phonological processes as the present study. Fortun reported that she found assimilation to be a common process with 1-4 occurrences in each child's production. Occurrences below 4 would not have reached the cut-off for a process in the present study and would rather have been counted as infrequent variants. Whereas the present study analyses single words, both Simonsen and Fortun analysed both single words *and* connected speech, which may yield differing results. The lack of reports on retroflexes in the previous studies may be due to the selection of words for analysis.

Many of the similar processes found in the studies of Norwegian-speaking children, such as consonant cluster reduction, fronting, assimilation and final consonant deletion correspond to cross-linguistic studies as compared to processes found in other Germanic languages (see table 12). The table lists processes found at the same age group as the one assessed in the present study (2;6-2;11), except for Swedish where the processes listed are those shown by children up to the age of 4. The processes highlighted are those found in at least 4 out of 6 languages and indicate common processes across languages.

Table 12: Cross-linguistic comparison of phonological processes in Danish, Icelandic, Swedish, German, English and Norwegian[4] at age 2

Phonological processes	**Danish**	**Icelandic**	**Swedish***	**German**	**English**	**Norwegian**
Fronting velars	X	X	X	X	X	X
Fronting fricatives /ç ʃ/	X*[1]			X	X*[1]	X
Cluster reduction	X	X	X	X	X	X
Stopping	(X)*[2]	X	X	(X)	X	X
Final consonant deletion		X	X	(X)	X	X
Assimilation	X	X	X	X	X	X
Gliding			X		X	X
Lateralisation		X				X
Fronting retroflex						X
Vowel change						X
/h/-insertion before vowel						X
h-isation		X				
Backing fricative /ʃ/				X		
Glottal replacement /ʁ/	(X)		X	(X)		
Deaffrication				X	X	
Cluster simplification		X				
Weak syllable deletion	X		X	X	X	
Syllable deletion		X				
Voicing/Devoicing		X	X	X	X	
Initial consonant deletion		X				
Consonant insertion		X				
Dentalisation		X				
Deaspiration	(X)	X				
Sibilisation		X				
Palatalisation		X				

*Swedish data on children aged 4

*[1]Danish phonetic inventory only has /ɕ/, English phonetic inventory only has /ʃ/

*[2](X) indicate processes found in children younger than 2;6

Three processes seem to be specific to Norwegian: fronting of retroflex, vowel change and /h/-insertion before vowel. The process of fronting of retroflexes would be expected since children of this age group front both velars and fricatives, and Norwegian is the only language with retroflexes in the inventory of the Germanic languages. In order to compare fronting of retroflexes to another language with retroflexes, a study of Putonghua showed that the children fronted retroflexes until the age of 4;6. Thus it can be inferred that this process is common in languages with retroflexes.

[4] (Clausen, 2016; Dodd et al., 2003; Fox-Boyer, 2016; Másdóttir, 2008; Nettelbladt, 2007)

Vowel change was a process shown by 4 of the 14 children in the present study. Vowel change did not occur frequently, just at the cut-off for being a process (4 occurrences). Three of the four children who showed the process had an above average number of infrequent variants (see Appendix 8). Since the children are still very young, the vowel change showed by these children could be an indication of persistent instability in their phonological system.

/h/-insertion before a vowel just made the cut-off for a process, only being shown by two children. These two children inserted an /h/ before a vowel in 80% of the words beginning with a vowel. Nettelbladt (1983) reported one child who showed this process and called it dummy-consonant insertion. However, this process is not mentioned in any of the current literature on phonological processes, and it can be inferred that it is a language specific process for the Norwegian-speaking children assessed in the present study.

The results from the present study show that although many of the processes found in Norwegian-speaking children in the age group assessed compare cross-linguistically, there are processes that are language specific to Norwegian.

5.1.4 Infrequent variants

Since there are no studies on inconsistency in word production on Norwegian, it is unknown at which age Norwegian-speaking children become consistent in their word production. The present study shows that the children aged 2;6-2;11 show phonological processes and are systematic in their production. However, infrequent variants are present, which indicate some form of instability which might reflect inconsistency. Infrequent variants are not widely studied, and at present specific results have only been reported in two studies: Fox-Boyer (2016) reports results from German speaking children aged 2;6-3;11, and Albrecht (2017) reports results from bilingual German-Turkish-speaking children aged 3;0-5;5. The number of infrequent variants measured in the youngest age groups varied between the two previous studies, however, monolingual and bilingual children's results cannot be directly compared. The German-speaking monolingual children aged 2;6-2;11 reported by Fox-Boyer (2016) showed a mean of 22.8 infrequent variants across children, with a standard deviation of 15.95. Compared to the result of the present study, the Norwegian children showed a lower number of infrequent variants, with a mean of 18 and a standard deviation of 7.4.

In summary, the results of the present study indicated that development of the vowel inventory was complete by age 2;11, and that more than 50% of the consonant inventory was mastered by the age group assessed. All children showed phonological processes, the most common processes being cluster reduction and fronting of retroflexes. However, there was great variation in how many types and token processes each individual child showed. Infrequent variants were present in analysis of all children's productions, which indicates some instability in the children's phonological system. Children with a very high number of types and /or infrequent variants might show a high percentage of inconsistency in word realisation. These results are a first insight into the stage of phonological development of Norwegian-speaking children at this age group.

5.2 Clinical relevance of study

This study gives only a first insight into the Norwegian-speaking children's phonology at the age of 2;6-2;11. However, a study like this may be important in shedding light on what can be considered typical for this age group. Even though the individual variation among the children assessed was great, only a few of the children showed a very high number of processes, some of which were seen in only a small number of children. A larger sample of children is needed to investigate whether these processes are atypical for Norwegian-speaking children. Since the present study shows that none of the children assessed made tone errors, these types of errors could indicate atypical phonological development.

The present data can help SLTs in the detection of phonological disorders at a very early age, which is important for early detection and intervention for children with SSD.

The new test used in this study, *Diffkas*, proved to be appropriate for the age group assessed and gives Norwegian speech therapists a much-needed tool to investigate the phonology of very young Norwegian-speaking children.

5.3 Evaluation of methodology and limitations of the present study

Methodological issues need to be addressed when considering the results of the present study. In addition, since this study served in part as a pilot for the new assessment tool, the use of *Diffkas* will be elaborated on in the following section.

5.3.1 Participants

Sample size

This study is part of a larger-scale study collecting normative data on Norwegian-speaking children. Due to the small scope of this thesis, a method of convenience sampling was used (Gall, Borg, & Gall, 1996). The sample was drawn from an accessible population based on geographical closeness to the assessor to allow for practical access to the available children who fit the inclusion criteria. The initial attempt was to recruit 20 children; however due to the narrow age band and the limited time frame of the study, only 14 children were recruited. A study of 1 or 2 children would have allowed for a more detailed look at each child's phonology; however, studying more children made it possible to investigate tendencies in the phonology of the assessed group. Although general patterns could be found, the sample size was too small to explain certain observations. Some phonological processes were only found in one child, which could indicate atypical processes in Norwegian, though this cannot be confirmed with such a small sample size.

Due to the sampling method and the small number of participants, who were not socio-economically balanced, generalisations to the population cannot be made. However, a descriptive analysis of the data collected from the sample is still beneficial considering this is a first insight into the phonology of Norwegian-speaking 2-year-olds.

Gender

Due to difficulties recruiting participants, there is an uneven distribution of boys and girls. Previous similar studies (see for example Clausen and Fox-Boyer (2017), Fox (2006), Dodd et al. (2003)) show no gender differences in phonological development of the assessed age group, thus it can be expected that this would be the same for Norwegian-speaking children.

5.3.2 Material and Procedure

The material used for the present study appeared appropriate for the age group assessed. Since the study is a part of the piloting of the new test, *Diffkas*, some minor changes were suggested to the authors of the test. Although the vocabulary was appropriate for the young children, some of the words needed to be elicited more often than others through sentence completion or imitation. These were words that had a lower imageability, like *snow*, *rice*, and *hot chocolate*. Since the material used for the assessment was still in early stages of development,

photos were used instead of drawings, and the difficulty in naming these items could be due to the quality of the photos rather than the target words themselves. This has now been taken into consideration by the test developers and conveyed to the illustrator. *Snø* (Engl. *snow*) was changed to *snømann* (Engl. *snowman*) which has a higher imageability but still assesses the consonant cluster /sn/.

The order of some of the items has been changed, since many of the children in the assessed group were uncertain of the first 2 test items. The uncertainty made some of the children uncomfortable, thus suggestions were made to start the test with items that were considered easier for the young children.

In the stimulability task the children were asked to imitate all phones in isolation. The stimulability task was used to investigate whether the children were stimulable for phones that were not present in their phonetic inventory. However, the results showed that most children were missing more phones in the stimulability task than in spontaneous speech. This indicates that the children were able to articulate a particular phone, although they did not do so in the stimulability task. There are several possible reasons for these results: The children could be less motivated for the stimulability task because it required a different focus than naming pictures on an Ipad; the task could have been perceived as difficult because the auditory stimuli from the assessor was difficult to distinguish in isolation; only auditory and visual cues were given; the children had trouble understanding the task.

Different results in the stimulability task could have been obtained by using placement instruction and tactile cues, or by presenting the phone in a syllable giving the assessor an ability to stress the target phone with added length and loudness (Lof, 1996). The task could also have been made more appropriate for the age group assessed by adding picture symbols representing the phones.

Using a single-word naming task was an appropriate tool for assessment of all phones in all positions, and for making sure the children had the opportunity to produce words with different tones and syllable structure. The naming task ensured comparable data sets making it possible to look for general patterns in the group assessed. However, a naming task does not give a complete picture of the children's phonological abilities (Stoel-Gammon & Dunn, 1985). Although more time consuming, additional continuous speech samples could have been collected in addition to the picture naming task to further support the results found in the present study. This was not possible due to the time constraints in the current study.

5.3.3 Data Analysis

In comparison to previous studies on phonological development, broad phonetic transcription was used as a written record of the child's utterance in the present study. Furthermore, the transcriptions were used for analysis of phonetic and phonemic inventory and the use of phonological processes. Transcriptions posed a challenge in several ways. First, detecting slight differences of e.g. voicing or articulatory placement is difficult from the audio recording. Small children, such as those assessed in the present study, may be imprecise in their articulation, and perceiving the difference between sounds, especially plosives, was difficult. Initially, online transcription was planned to avoid such difficulties, however, the children assessed were so young and many lost focus when the assessor attempted to write during the assessment. Most of the transcriptions, therefore, had to be made based on the audio recordings. Transcriptions done after assessment could have been made more precise by using video recording, or in some cases using an acoustic analysis tool (like Praat).

Second, there is no straightforward solution for analysing transcribed data. In determining what phonological processes the children showed, it was important not only to look at the single segments, but at the transcribed sample as a whole. Take for example one child's production of /tɔt/ for the target /frɔsk/, where there is consonant cluster reduction both at the onset and the coda of the word. The child reduced all clusters and fronted velars consistently throughout the sample and this resulted in the final cluster /sk/ being realised as /t/. The cluster reduction of /fɾ/ at the onset of the word becoming /t/ could be assimilation to the /t/ in the coda, but it could also be stopping of the fricative /f/. In this case it was important to look at what the child did with fricatives in the rest of the sample. It appeared that the child showed some assimilation, but consistently stopped fricatives, thus /f/ → /t/ was analysed to be the process of stopping in addition to assimilation.

Some children produced variations of the adult target that did not fit the pattern of any process. Examples of this was /l/ → /b/ in /talæɾkən/, produced /tabæɾkən/ or /ʊ/ → /k/ in /ʊafəl/, produced /kafəl/. These types of variations were marked as 'oddies' and counted as infrequent variants (see appendix 8).

Dialectal variations were considered and checked with adult realisations of the target word. If the child's production matched the adult target it was marked as correct. In instances where the child deviated from the adult target, the child's dialect was taken into consideration when determining what phonological process was being shown. Analysis was made based on the adult target appropriate for the individual child's dialect.

5.3.4 Validity and reliability

The aim of the present study was to investigate children's phonology. Phonology is the study of sound structures in languages, and it is a widely used theoretical concept. To investigate the phonology in Norwegian-speaking children a newly developed assessment tool was used. The assessment tool, *Diffkas*, is based on similar standardised tests developed for the investigation of phonology in other languages (see section 3.2). *Diffkas* gives the assessed children the opportunity to produce all phones in all positions, and includes words with all possible tone, stress and syllable structures in Norwegian. This type of assessment tool thus investigates the children's Norwegian sound system, their phonology, and therefore *construct validity* is high (Kleven, Tveit, & Hjardemaal, 2011). However, the construct validity of the present study could have been strengthened by using other approaches in addition to *Diffkas*. Samples of phonology from children's continuous speech could have been used to generate a larger data set. Using continuous speech in research is a time-consuming measure, and due to the scope of this thesis it was not possible. Construct validity could also have been better ensured by using similar phonology assessment tools to see if two or more tests yielded the same results. This was not plausible because there are no other equivalent tests in Norwegian.

Due to the small sample size and the use of convenience sampling, the *external validity* is low in the present study. The results can only show tendencies in the sample investigated, and results cannot be generalised to the population of Norwegian-speaking children aged 2;6-2;11(Kleven et al., 2011). For results to be generalised to the population a random representative sample would have to be investigated. The scope of this thesis did not allow for such an investigation to be completed. However, the data collected in the present study will be included in a larger-scale study on Norwegian-speaking children's phonological development.

To minimise measurement errors both intra-rater and inter-rater reliability was measured. To account for *intra-rater reliability* the assessor transcribed and analysed approximately 50% of the data twice. *Inter-rater reliability* was measured by calculating the agreement rate between the assessor, a phonologist and a phonetician in 10% of the transcriptions. The agreement rate between raters was measured to be 92.1%, with the main difference being the transcription of interdental /s/. The agreement rate suggests high reliability (Sattler & Hoge, 2006).
The reliability in the present study could have been strengthened by conducting a re-test: assessing the children with the same tool within two weeks to check if the results compared. Similar or identical results of a re-test would indicate a small number of measurement errors. Conducting a re-test was not feasible due to the time limitation for the present study.

5.4 Suggestions for further research

In summary, future studies should investigate a larger sample of children in other areas of Norway to provide normative data that can be generalised to the population. A future study of a larger age range will be able to provide information on the age at which the phonetic inventory is completed, and at what age phonological processes are age-appropriate. Further, to learn about Norwegian-speaking children's inconsistency in word production, an inconsistency test should be developed. Additionally, *Diffkas* must be normed for the Norwegian-speaking population, and its diagnostic validity must be proven.

The data collected for the present study provided more information than is presented due to the scope of this thesis. Further studies could analyse the phonemic inventory in comparison to the phonetic inventory as well as cluster acquisition in the children assessed.

Re-testing the same children assessed for the present study again after 6 months could provide valuable information on the phonological development of these children. Based on earlier studies in other languages, it could be expected that the children will show a lower number of phonological processes, fewer infrequent variants and more phones mastered in their phonetic inventory.

6. Conclusion

The aim of the present study was to investigate the phonology of Norwegian-speaking children aged 2;6-2;11. In order to do so *Diffkas*, a newly developed picture naming test, was used in addition to a stimulability task. The picture naming test proved to be appropriate for the age group assessed. The results showed that the vowel inventory was complete, and that 57% of the phones in the consonant inventory were mastered at the age of 2;11. Fourteen phonological processes were found in more than 10% of the children assessed, with a mean number of six. However, there was great individual variability in the type/token of processes shown. No tonal errors were found; thus acquisition of the tone feature can be said to be complete by 2;11. Infrequent variants were found in all children which indicate some instability in their phonological system.

Several of the processes shown by the Norwegian-speaking children are processes common in other Germanic languages, such as cluster reduction, fronting of velars, fronting of fricatives /ʃ ç/ and final consonant deletion. However, language specific processes were also found. This

supports the notion that normative data of the ambient language is vital for the differentiation of typical and atypical development in the identification of children with SSD.

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APPENDIX 1: Agreement between Statped and NTNU

Databehandleravtale etter personopplysningsloven

Databehandleravtale

I henhold til personopplysningslovens § 13, jf. § 15 og personopplysningsforskriftens kapittel 2.

mellom

Statped, ved FoU-direktør Lise Kristoffersen

..Lise...Kristoffersen

behandlingsansvarlig

og

NTNU, ved Institutt for språk og litteratur

.....Bjørklund.....

databehandler

1. Avtalens hensikt

Avtalens hensikt er å regulere rettigheter og plikter etter Lov av 14. april 2000 nr. 31om behandling av personopplysninger (personopplysningsloven) og forskrift av 15. desember 2000 nr. 1265 (personopplysningsforskriften). Avtalen skal sikre at personopplysninger om de registrerte ikke brukes urettmessig eller kommer uberettigede i hende.

Avtalen regulerer databehandlers bruk av personopplysninger på vegne av den behandlingsansvarlige, herunder innsamling, registrering, sammenstilling, lagring, utlevering eller kombinasjoner av disse.

2. Formål

FoU-prosjektet håndterer data i tråd med NSDs vilkår for behandling av personidentifiserbar informasjon og søknad om godkjenning av prosjektet til NSD. Dataene er navn og fødselsdato på barn som testes med en billedbenevningstest, samt anonymiserte lydopptak av testingen. For masterstudent Celine Alme, medforsker i prosjektet, gjelder de vilkårene som her omtales. På dette grunnlaget skisseres følgende ansvar- og eierforhold i FoU-prosjektet. Prosjektleder Anne M. Frank og medforskere gis rett til å bruke forskningsdata Celine Alme innhenter i forbindelse med masterprosjektet sitt. Retten omfatter bruk for publisering i nasjonale og internasjonale fagkonferanser, journaler og bokutgivelser. Statped gis tilgang til pre-print for gjennomlesning før publisering.

Statped, ved prosjektleder Anne M. Frank og medforskere, har rett på tilgang og bruk av disse dataene (fødselsdato og lydopptak).

Statped gis rett til å sammenfatte og spre informasjon om prosjektet og publikasjoner fra prosjektet, samt å formidle funn og resultater på Statpeds web-sider. Anne M. Frank og medforskere har rett til innsyn for gjennomlesning, kommentarer/ justeringer før publisering.

Statped innehar rett til opptrykk av publikasjoner og masteravhandlinger for bruk i egen organisasjon

3. Databehandlers plikter

Databehandler skal følge de rutiner og instrukser for behandlingen som behandlingsansvarlig til enhver tid har bestemt skal gjelde.

Databehandler plikter å gi behandlingsansvarlig tilgang til sin sikkerhetsdokumentasjon, og bistå, slik at behandlingsansvarlig kan ivareta sitt eget ansvar etter lov og forskrift.

Behandlingsansvarlig har, med mindre annet er avtale eller følger av lov, rett til tilgang til og innsyn i personopplysningene som behandles og systemene som benyttes til dette formål. Databehandler plikter å gi nødvendig bistand til dette.

Databehandler har taushetsplikt om dokumentasjon og personopplysninger som vedkommende får tilgang til iht. denne avtalen. Denne bestemmelsen gjelder også etter avtalens opphør.

5. Sikkerhet

Databehandler skal oppfylle de krav til sikkerhetstiltak som stilles etter personopplysningsloven og personopplysningsforskriften, herunder særlig personopplysningslovens §§ 13 – 15 med forskrifter. Databehandler skal dokumentere rutiner og andre tiltak for å oppfylle disse kravene. Dokumentasjonen skal være tilgjengelig på behandlingsansvarliges forespørsel.

Avviksmelding etter personopplysningsforskriftens § 2-6 skal skje ved at databehandler melder avviket til behandlingsansvarlig. Behandlingsansvarlig har ansvaret for at avviksmelding sendes Datatilsynet.

7. Avtalens varighet

Avtalen gjelder så lenge databehandler behandler personopplysninger på vegne av behandlingsansvarlig.

Ved brudd på denne avtale eller personopplysningsloven kan behandlingsansvarlig pålegge databehandler å stoppe den videre behandlingen av opplysningene med øyeblikkelig virkning

Avtalen kan sies opp av begge parter med en gjensidig frist på 3 mnd, jf. punkt 8 i denne avtalen.

8. Ved opphør

Ved opphør av denne avtalen plikter databehandler å tilbakelevere alle personopplysninger som er mottatt på vegne av den behandlingsansvarlige og som omfattes av denne avtalen.

Det skal avtales at databehandler skal slette eller forsvarlig destruere alle dokumenter, data, lydopptak mv, som inneholder opplysninger som omfattes av avtalen. Dette gjelder også for eventuelle sikkerhetskopier. Databehandler skal skriftlig dokumentere at sletting og eller destruksjon er foretatt i henhold til avtalen innen rimelig tid etter avtalens opphør.

10. Lovvalg

Avtalen er underlagt norsk rett. Dette gjelder også etter opphør av avtalen.

Denne avtale er i 2 – to eksemplarer, hvorav partene har hvert sitt.

Sted og dato

Oslo 13/12 - 2017.

Behandlingsansvarlig	Databehandler
.....	.....
(underskrift)	(underskrift)

APPENDIX 2: Word List from *Diffkas*

Test item	Standard Pronunciation
T-skjorte	¹teːʃuʈə
arm	¹ɑrm
druer	²drʉːər
ski	¹ʃiː
banan	bɑ¹nɑːn
lampe	²lɑmpə
bjørn	¹bjøːɳ
finger	¹fɪŋər
hest	¹hɛst
kopp	¹kɔp
genser	¹gɛnsər
håndkle	²hɔŋklə
appelsin	ɑpəl¹siːn
hår	¹hoːr
jakke	²jɑkə
ekorn	²ɛkuːɳ
kakao	kɑ¹kɑːu
marihøne	²mɑːrɪˌhøːnə
rød	¹røː
lue	²lʉːə
fjell	¹fjɛl
kanin	kɑ¹niːn
ballong	bɑ¹lɔŋ
klokke	²klɔkə
glass	¹glɑs
Lego	¹leːgu
måne	² moːnə
drikke	² drɪkə
nese	² neːsə
løve	² løːʊə
mus	¹mʉːs
okse	²uksə
nøkkel	²nøkəl

Test item	Standard Pronunciation
ost	¹ust
frosk	¹frɔsk
lys	¹lyːs
bok	¹buːk
gaffel	¹gɑfəl
klovn	¹klɔʊn
kjole	²çuːlə
jente	² jɛntə
vaffel	¹ʊɑfəl
plaster	¹plɑstər
hjerte	² jæʈə
kniv	¹kniːʊ
baby	¹beːbɪ/¹bæɪbɪ
gardin	gɑ¹ɖiːn
kaffe	¹kɑfə
kylling	²çylɪŋ
trampoline	trɑmpu²liːnə
skjerf	¹ʃærf
tog	¹toːg
tre	¹treː
paraply	pɑrɑ¹plyː
kjeks	¹çɛks
potet	pu¹teːt
stjerne	² stjæːɳə
pære	² pæːrə
dusj	¹dʉʃ
saft	¹sɑft
piano	pɪ¹ɑːnu
briller	² brɪlər
pølse	² pølsə
saks	¹sɑks
dør	¹døːr
seng	¹sɛŋ

Test item	Standard Pronunciation
blomst	¹blɔmst
Sau	¹sæʉ/¹sæʊ
Sjiraff	ʃɪ¹rɑf
Rev	¹reːʊ
Sklie	² skliːə
Ris	¹rɪːs
Snø	¹snøː
elefant	ɛlə¹fɑnt
Vei	¹ʊæɪ
sjokolade	ʃukuˈlɑːdə
Spade	²spɑːdə
krokodille	krukuˈdɪlə
Strand	¹strɑn
Egg	¹ɛg
Støvel	²støʊəl
motorsykkel	¹mutuˌʃykəl
Sko	¹skuː
tallerken	tɑ¹lærkən
Fly	¹flyː
telefon	tɛlə¹fuːn
traktor	¹trɑktur
Fisk	¹fɪsk
Valp	¹ʊɑlp
tromme	²trumə
Blyant	¹blyːɑnt
Øye	²øyə
helikopter	hɛlɪ¹kɔptər
Flue	²flʉːə
Eple	²ɛplə
Gris	¹griːs
Bukse	²buksə
spøkelse	²spøːkɛlsə
edderkopp	¹ɛdərˌkɔp

APPENDIX 3: Distributed information, parental consent and background questionnaire

Statped

Forespørsel om deltagelse i utviklingsarbeid knyttet til barns uttale

Bakgrunn og formål
Statped er i gang med å utarbeide et kartleggingsverktøy for å identifisere uttalevansker hos norske barn. For å vite sikkert hva som er en vanske, må vi vite hvordan det er vanlig at barns uttaleutvikling foregår, og for å få vite det må vi kartlegge et stort antall barn. Det er første gang dette gjøres i Norge, og det vil gi uvurderlig kunnskap til logopeder, spesialpedagoger og andre som jobber med barn som strever med uttale.

Vi ønsker med dette å invitere ditt barn til å delta i denne utprøvingen.

Hva innebærer deltagelse i studien?
Deltagelse i prosjektet innebærer at man gir samtykke til at barnets uttale blir kartlagt. Det skjer ved at barnet får se i en bok med bilder, og blir bedt om å si hva bildene forestiller. De forestiller hverdagslige ting som er kjent for de fleste barn (klær, dyr, osv). Hvis barnet ikke vet hva et bilde forestiller, vil det bli bedt om å gjenta ordet. Den som gjennomfører kartleggingen, vil være en rådgiver i Statped som er vant til å være sammen med barn eller en logoped (evt masterstudent) fra barnets hjemstedskommune. Kartleggingen finner sted i barnehagen, og dersom barnet ønsker det kan en av de voksne fra barnehagen være med. De foresatte trenger ikke å være til stede. Vår erfaring er at barn synes dette er en lystbetont aktivitet. Kartleggingen tar ca 10-15 minutter.
Vi ber dere også om å fylle ut vedlagte spørreskjema med bakgrunnsopplysninger om barnet. Dette er informasjon vi trenger for at studien skal bli så riktig som mulig. Disse opplysningene vil bli anonymisert.
I tillegg til kartlegging av barnets uttale, vil alder, kjønn og dialektbakgrunn bli registrert. Det vil også gjøres lydopptak, som kun vil brukes til kvalitetssikring av kartleggingen.

Hva skjer med informasjonen om barnet ditt?
Alle personopplysninger vil bli behandlet konfidensielt. All informasjon om barnet vil bli oppbevart i en ikke-identifiserbar form. Det vil si at barnets navn blir erstattet med en nummerkode. En koblingskode mellom nummerkoden og barnets navn vil bli forsvarlig oppbevart hos Statped, men vil ikke være tilgjengelig for prosjektgruppen som skal analysere materialet etter at datainnsamlingen er avsluttet.

Når prosjektet avsluttes vil alle personidentifiserbare data (inkludert koblingskoden og lydopptakene) bli slettet. Resultatene vil bare bli brukt på gruppenivå, ikke på individnivå, og det vil ikke være mulig å identifisere noen av barna.

Informasjonen som innhentes av barn mellom 2 og 3 år i Nord-Østerdal vil også bli brukt i en masteroppgave ved NTNU skoleåret 2017/2018. Masteroppgaven vil være en del av prosjektet ved Statped, og bakgrunnsopplysninger og resultater vil brukes både av masterstudenten og Statped i perioden masteroppgaven skrives. Etter at masteroppgaven er levert den 15.05.2018, vil kun Statped ha tilgang til opplysningene. NTNU er behandlingsansvarlig institusjon for masteroppgaven, og det er inngått en samarbeidsavtale mellom NTNU og Statped. Tittelen på masteroppgaven vil være «Norske 2-åringers fonologiske utvikling.»

Frivillig deltagelse
Det er frivillig å delta i studien, og du kan når som helst trekke ditt samtykke uten å oppgi noen grunn. Dersom du trekker samtykket, vil alle opplysninger om barnet ditt bli slettet. Hvis du er i kontakt med Statped for andre tjenester, vil ikke ditt standpunkt til deltakelsen i dette prosjektet ha innvirkning på dette forholdet.

Hvis du har spørsmål, ikke nøl med å ta kontakt med oss!

Kontaktinformasjon til prosjektansvarlig:
Anne M. Frank: anne.merete.frank@statped.no

Kontaktinformasjon til masterstudent:
Celine Alme: celine.alme@tynset.kommune.no /celinealme1@gmail.com

Kontaktinformasjon til veileder for masteroppgaven:
Anne Dahl: anne.j.dahl@ntnu.no

Samtykke til deltakelse i normering av kartleggingsverktøy for norske barns uttale

Barnets fulle navn_____

Barnets fødselsdato (dd/mnd/år): _____

Navnet på barnehagen: _____

Kontaktopplysninger, foresatte (mobil eller e-post): _____

Barnet mitt vokser opp enspråklig med norsk som morsmål: ☐ ja ☐ nei

Hvis nei, hvilket annet språk: _____ I kontakt med norsk siden: _____

Barnet mitt får spesialpedagogisk hjelp i barnehagen ☐ ja ☐ nei

Jeg har mottatt og lest informasjon om prosjektet og samtykker til at mitt barn kan delta i utprøvingen.

(Dato, signatur)

Statped

Spørreskjema til foreldre/foresatte

Fylt ut av: ☐ Barnets mor ☐ Barnets far ☐ Annen omsorgsperson

1. Barnets navn: _____
2. Fødselsdato: _____
3. Kjønn: ☐ jente ☐ gutt
4. Har barnet søsken? ☐ ja ☐ nei

   Hvis ja, hvilket nummer er barnet i søskenflokken? _____
5. Hvem bor barnet sammen med? _____
6. Barnets dialekt: _____

   Mors dialekt: _____ Fars dialekt: _____
7. Var svangerskap og fødsel normalt? ☐ ja ☐ nei

   Hvis ikke, hvordan: _____
8. Har barnet nedsatt hørsel, eller har han/hun hatt det tidligere? ☐ ja ☐ nei

   Er barnet plaget med gjentatte ørebetennelser, eller har han/hun vært det tidligere?

   ☐ ja ☐ nei

   Har barnet innlagt dren, eller har han/hun hatt det tidligere? ☐ ja ☐ nei
9. Lider barnet av kroniske eller langvarige sykdommer? ☐ ja ☐ nei
10. Får barnet logopedhjelp, eller har han/hun fått det? ☐ ja ☐ nei
11. Er det noen i familien som hatt språk- og/eller talevansker? ☐ ja ☐ nei

    Hvis ja, hvem: _____

12. Er det noen i familien som har eller har hatt lese-/skrivevansker? ☐ ja ☐ nei

    Hvis ja, hvem _____

13. Hva er mors høyeste utdannelse:

    a. Bare grunnskole ☐

    b. Videregående/fagbrev ☐

    c. Høyere utdannelse under fire år ☐

    d. Høyere utdannelse over fire år ☐

14. Hva er fars høyeste utdannelse:

    e. Bare grunnskole ☐

    f. Videregående/fagbrev ☐

    g. Høyere utdannelse under fire år ☐

    h. Høyere utdannelse over fire år ☐

Utfylt skjema leveres til barnehagen

Takk for hjelpen!

APPENDIX 4: Approval from NSD (Ethics Approval)

Anne Dahl

7491 TRONDHEIM

Vår dato: 31.10.2017	Vår ref: 55890 / 3 / PEG	Deres dato:	Deres ref:

Tilrådning fra NSD Personvernombudet for forskning § 7-27

Personvernombudet for forskning viser til meldeskjema mottatt 13.09.2017 for prosjektet:

55890	*Kartlegging av norske 2-åringers fonologiske utvikling*
Behandlingsansvarlig	*NTNU, ved institusjonens øverste leder*
Daglig ansvarlig	*Anne Dahl*
Student	*Celine Alme*

Vurdering

Etter gjennomgang av opplysningene i meldeskjemaet og øvrig dokumentasjon finner vi at prosjektet er unntatt konsesjonsplikt og at personopplysningene som blir samlet inn i dette prosjektet er regulert av § 7-27 i personopplysningsforskriften. På den neste siden er vår vurdering av prosjektopplegget slik det er meldt til oss. Du kan nå gå i gang med å behandle personopplysninger.

Vilkår for vår anbefaling

Vår anbefaling forutsetter at du gjennomfører prosjektet i tråd med:

- opplysningene gitt i meldeskjemaet og øvrig dokumentasjon
- vår prosjektvurdering, se side 2
- eventuell korrespondanse med oss

Meld fra hvis du gjør vesentlige endringer i prosjektet

Dersom prosjektet endrer seg, kan det være nødvendig å sende inn endringsmelding. På våre nettsider finner du svar på hvilke endringer du må melde, samt endringsskjema.

Opplysninger om prosjektet blir lagt ut på våre nettsider og i Meldingsarkivet

Vi har lagt ut opplysninger om prosjektet på nettsidene våre. Alle våre institusjoner har også tilgang til egne prosjekter i Meldingsarkivet.

Vi tar kontakt om status for behandling av personopplysninger ved prosjektslutt

Ved prosjektslutt 15.05.2018 vil vi ta kontakt for å avklare status for behandlingen av personopplysninger.

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

Se våre nettsider eller ta kontakt dersom du har spørsmål. Vi ønsker lykke til med prosjektet!

Vennlig hilsen

Marianne Høgetveit Myhren

Pernille Ekornrud Grøndal

Kontaktperson: Pernille Ekornrud Grøndal tlf: 55 58 36 41 / pernille.grondal@nsd.no
Vedlegg: Prosjektvurdering
Kopi: Celine Alme, celinealme1@gmail.com

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 55890

FORMÅL
Formålet med prosjektet er å samle inn normativ data om norske 2-åringers fonologiske utvikling, som videre skal brukes i et større prosjekt som utføres av Statped. Dette prosjektet er et tverrsnittstudie av den fonetiske og fonologiske utviklingen hos norske barn i alderen 2;6-2;11 år.

UTVALG
Utvalget informeres skriftlig og muntlig om prosjektet og samtykker til deltakelse.

INFORMASJON OG SAMTYKKE
Informasjonsskrivet er godt utformet, men vi ber deg oppgi dato for prosjektslutt (15.05.2018), og å oppgi kontaktinformasjon på veilederen din. Videre ber vi deg presisere at NTNU er behandlingsansvarlig institusjon for ditt prosjekt, og det er inngått en samarbeidsavtale mellom NTNU og Statped som regulerer ansvarforholdet mellom institusjonene. Vi anbefaler også at du presiserer at opplysningene vil bli brukt av Statped også etter at ditt masterprosjekt er avsluttet.

Du opplyser at du kun skal laste opp transkriberte intervjuer, og ikke lydfilder, på PhonBank.
Personvernombudet forutsetter at det transkriberte materialet som lastes opp er anonymisert, slik at det ikke er mulig å identifisere enkeltpersoner i materialet. Vi anbefaler også at du gjengir denne informasjonen i informasjonsskrivet.

BARN I FORSKNING
Merk at når barn deltar aktivt i forskning burde de få informasjon om prosjektet som er tilpasset deres ordforråd. Det er også viktig at barna får informasjon om at de kan velge å ikke delta i prosjektet hvis de ønsker det, selv om foreldrene har samtykket.

SENSITIVE PERSONOPPLYSNINGER
Det behandles sensitive personopplysninger om helseforhold.

SAMARBEIDSAVTALE
Prosjektet er en nasjonal samarbeidsstudie, hvor NTNU er behandlingsansvarlig institusjon for masteroppgaven. Personvernombudet forutsetter at ansvaret for behandlingen av personopplysninger er avklart mellom institusjonene. Vi anbefaler at det inngås en avtale som omfatter ansvarsfordeling, ansvarstruktur, hvem som initierer prosjektet, bruk av data og eventuelt eierskap.

INFORMASJONSSIKKERHET
Personvernombudet legger til grunn at studenten etterfølger NTNU sine interne rutiner for datasikkerhet.

Dersom personopplysninger skal lagres på privat pc/mobiltelefon, må det avklares med NTNU og opplysningene bør krypteres tilstrekkelig.

PROSJEKTSLUTT

Forventet prosjektslutt er 15.05.2018. Ifølge prosjektmeldingen skal studenten ikke lenger ha tilgang til opplysningene. Innen denne dato skal lydfiler og annet datamateriell som studenten har lagret på privat pc e.l. slettes fra studentens enhet(er).

APPENDIX 5: Phone Table

	B1		B2		B3		B4		B5		B6		B7		B8			B9	XXX	G1		G2		G3		G4		G5	
	Diff	Stim	Diff	Stim	Diff	Stim	Diff	Stim	Diff	Stim	Diff	Stim	Diff	Stim	Diff	Stim		Diff	Stim	Diff	Stim	Diff	Stim	Diff	Stim	Diff	Stim	Diff	Stim
p																pø													
b																bø													
t																til													
d																pø	pø												
ʈ				t				t		t		t	t	t	t	ti	ti	t		t	t	t	t		t	t	t	X	t
ɖ				d			d	d		d	d	d	d	d	d	d	d	X		d	d		d		d		d	d	d
k				t						t	t	t	t	t															
g		k	d								d		d	d		dedit	dedit							d	d			d	
m																													
n																n													
ɳ			n	m		n	n	n			n		n	n	n	n	n	n		n	n	n	n	n	m	n	n	n	n
ŋ				m				n	n/l		n		n	n		m	m						n		m	n	n	n	n
f																uf							ʃ						
s										ɵ				ɵ		ls		ɵ											
ʃ		s	s	ts					s			s	s		t	ys	ys	ɵ		s	s	s		s	s	s	s		
ç			s			ʃ		ʃ		s	t	s	t	s		sy	sy	ɵ		s	s		ʃ		s		s	s	ʃ
h																ha													
r			j	ʤ	ð (l)		l	l	j	X			l/j	l		di	di	l		l	l	j	ɵ	l/j	l		X	l	l
l																													
ʊ																e	e												
j													h			je							i						
a																													
e																													æ
i																													
u																													
ɨ																i													
y				i								i		i		i	i								i				
æ																													
ø																													
o																													

Diff = Diffkas

Stim = Stimulability task

APPENDIX 6: Definition of Phonological Processes

Process	Description	Examples[5]
Consonant cluster reduction	Deletion of one or two consonants from a consonant cluster	/ˀdɾʉːəɾ/ → /ˀdʉːəɾ/ /ˈstɾɑn/ → /ˈtɑn/ /ˈhɛst/ → /ˈhɛt/
Fronting retroflex /ʈ ɖ ɳ/	Place of articulation of retroflexes moved to a more anterior position	/ˈteːʃuʈə/ → /ˈteːʃutə/ /gɑˈɖiːn/ → /gɑˈdiːn/ /ˈbjøːɳ/ → /ˈbjøːn/
Fronting velars /k g ŋ/	Place of articulation of velars moved to a more anterior position	/kɑˈkɑːu/ → /tɑˈtɑːu/ /ˈɛg/ → /ˈɛd/ /ˀbalɔŋ/ → /ˀbalɔn/
Lateralisation of /ɾ/	/ɾ/ is replaced with /l/	/ˈɾøː/ → /ˈløː/ /ˀpæːɾə/ → /ˀpæːlə/
Assimilation	A sound is influenced by another sound in the target word	/ˈblɔmst/ → /ˈblɔnst/ /ˈkɔp/ → /ˈpɔp/
Fronting fricatives /ʃ ç /	Place of articulation of fricatives moved to a more anterior position	/ˈteːʃuʈə/ → /ˈteːsuʈə/ /ˀçuːlə/ → /ˀsuːlə/
Stopping fricatives	Fricatives are replaced with stops	/ˀçuːlə/ → /ˀtuːlə/ /ˈflyː/ → /ˈtlyː/
Syllable final consonant deletion	Consonant is deleted in syllable final position	/ˀbuksə/ → /ˀbusə/ /ɑpəlˈsiːn/ → /ɑpəˈsiːn/ /ˀuksə/ → /ˀusə/
Vowel change	Use of a different vowel	/ˈhɔːɾ/ → /ˈhæːɾ/ /ˀmoːnə/ → /ˀmɑːnə/
Gliding /ɾ/	The tap /ɾ/ is replaced with the glide /j/	/ˈɾøː/ → /ˈjøː/ /ˀmɑːɾɪˌhøːnə/ → /ˀmɑːjɪˌhøːnə/
Lateralisation of other elements	Place of articulation is moved to lateral position	/pɪˈjɑːnu/ → /ˈplɑːnu/ /ˀstjæːɳə/ → /ˀlæːɳə/ /ˈkniːʊ/ → /ˈkliːl/
/h/ insertion before vowel	/h/ is inserted before a vowel	/ˈɛg/ → /ˈhɛg/ /ˀøyə/ → /ˀhøyə/
Gliding /l/	/l/ is replaced with the glide /j/	/ˈgɛnsəɾ/ → /ˈgɛnsəj/ /ˈleːgu/ → /ˈjeːgu/
Frication of /ɾ/	The tap /ɾ/ is replaced with fricative /ð/	/ˈhɔːɾ/ → /ˈhɔːð/ /ˈtreː/ → /ˈtðeː/ /ˀdɾɪkə/ → /ˀdðɪkə/
/f/ or /ʊ/ = /h/-onset	/f/ or /ʊ/ is replaced with /h/	/ˈʊɑfəl/ → /ˈhɑfəl/ /ˈfɪŋəɾ/ → /ˈhɪŋəɾ/
Approximant = /h/	Approximants /l/ and /j/ is replaced with /h/	/ˀlʉːə/ → /ˀhʉːə/ /ˀjɛntə/ → /ˀhɛntə/
Weak syllable deletion	Unstressed syllable is deleted	/gɑˈɖiːn/ → /ˈdiːn/ /puˈteːt/ → /ˈteːt/ /tɛləˈfuːn/ → /təˈfuːn/
Metathesis	Sounds or syllables in a word change position	/ˈsɑks/ → /ˈdɑst/ /ˈplɑstəɾ/ → /ˈtɾɑspəɾ/

[1]Examples taken from the assessed group in the present study

APPENDIX 7: Phonological Processes Table

	B1	B2	B3	B4	B5	B6	B7	B8	B9	G1	G2	G3	G4	G5
Systemic:														
Fronting velars /k g/		19				28	23	21			8	13	4	14
Fronting velars /ŋ/						5	4							
Fronting retroflex / ʈ ɖ ɳ/		3		3			6	3	4	5	4	4	4	4
Fronting /ʃ/		4			5				6	7		6	4	
Fronting /ç/		3							3	2		2		2
Stopping fricatives				4		14	20	21			4		5	
Lateralisation of /r/-[l]	8			14			5		20	26		7	8	10
Lat. Of other elements								5						4
Assimilation		15		9			8	14	4			6		7
Gliding /l/		5												
Gliding /r/-[j]		11			12						17			
Frication of /r/			24											
/h/ insert bef vowel				6										7
/f/ or /ʊ/ = /h/ onset				4										
Vowel change		4										7	5	4
Approx = /h/							6							
Structural:														
Cons.cluster reduction	11	34		17	8	17	33	15	10		17	15	32	21
Syllable final cons.del							7	5	4				5	7
Weak syllable deletion		4												
Metathesis								5						
Token per child	19	102	24	57	25	64	112	89	51	40	50	60	67	80
Interdentaliy				4	11				23		5			

APPENDIX 8: Infrequent Variants Table

Processes	B1	B2	B3	B4	B5	B6	B7	B8	B9	G1	G2	G3	G4	G5
Systemic:														
Fronting velars /k g/					1									
Fronting velars /ŋ/		2			1			1				2		
Fronting retroflex /ʈ ɖ/														
Fronting fricative /ʃ/				1		1	3	1			3			3
Fronting fricative /ç/					1									
Fronting fricative /s/							1	1						
Backing plosives/nasals									2	1			1	
Backing retroflex														
Backing fricative /s/				1										
Stopping fricatives		3			1							1		1
Lateralisation of fricatives														
Lateralisation of /r/		2			1			1						
Lat. Of other elements					1			3					1	
Assimilation	1		1		2	2				1	3		2	
Nasalisation														
Devoicing		1		1	2							2		3
Voicing								1			2			3
Voicing of fricatives		1												
Gliding /l/								1						
Gliding /r/				2			3	2				3		
Gliding of other than /l r/		3							1					1
Frication of plosives		1										2		
Frication of /r/		3		2	2	1	3	2	1			1		
Other /r/ substitution						2	1							
Other /l/ substitution														
h insert bef vowel														
/f/ or /ʊ/ = h onset														
Frikativerstatning						3					1	1		
Vowel change	2		1		2	2	3	3		3	2			
Syncope/Apocope	3	1		1			1				2			2
Approx = /h/														
Structural:														
Word initial cluster deletion														
Word final cluster deletion								1						
Cons.cluster reduction			1							1				
Word/syllable initial cons.del	2		1	1		1		3					1	3
Syllable final cons del	2	3		3	2	1				1	2	3		
Word final cons del		1		3					1		1			
Syllable deletion													1	
Weak syllable deletion	1			1	2	2	2	3		1		3	2	3
Intrusive consonant		2			1		1	1		2	2	2		
Intrusive vowel								1						
Reduplication		1						1			1			
Metathesis	2	1	2	1	3	3					3	2		3
Oddies	2	4					1	3	1	1	1		2	5
Nr. of Infrequen Variants	15	29	6	17	22	18	19	29	6	11	23	22	10	27