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2020-07-02

Aalto , E , Saaristo-Helin , K & Stolt , S 2020 , ' Phonological development of Finnish speaking children at 3;6 and associations to previous and simultaneous lexical ability ' , Clinical Linguistics & Phonetics , vol. 34 , no. 7 , pp. 617-633 . https://doi.org/10.1080/02699206.2019.1681517

http://hdl.handle.net/10138/322138
https://doi.org/10.1080/02699206.2019.1681517

acceptedVersion

Phonological development of Finnish speaking children at 3;6 and its associations to previous and simultaneous lexical ability

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doi. 10.1080/02699206.2019.1681517

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Running head: Phonological development of Finnish speaking children at 3;6

Abstract

Previous studies of Finnish children's phonological development focus mainly on children under 2;0. Earlier findings have suggested that phonological and lexical development are strongly associated at an early age. However, less is known about the longitudinal association. This study describes the phonological skills of Finnish-speaking children at 3;6 and compares them with early lexicon size at 2;0 and lexical ability at 3;6 (N=67). The children's phonological development was measured using The Finnish Phonology Test. Lexical development was evaluated using the Finnish, long-form version of the Communicative Development Inventory at 2;0 and the Boston naming test at 3;6 At 3;6, all children mastered the vowels and diphthongs fully, and most of the children also mastered the consonants, with the exception of the phonemes /d/ and /r/. Phonotactic skills had also been acquired well at this group level, although the word-medial and especially -initial consonant clusters were still challenging. The percentage of phonemes correct was 95. Both paradigmatic and phonotactic skills at 3;6 were significantly associated with lexicon size at 2;0. In addition phonotactic skills correlated with naming ability at 3;6. Lexical development at 2;0 explained 21% of the variance in the phonological development at 3;6, whereas, the explaining value of simultaneous lexical skill was limited (9%). Present findings propose that associations between lexical and phonological skills weaken as phonological skills become more honed.

Introduction

Children move towards adult-like pronunciation gradually. In the Finnish language, studies of phonological development mostly cover children under 2;0 (e.g. Kunnari, 2000; Saaristo-Helin, 2011; Saaristo-Helin, Savinainen-Makkonen & Kunnari., 2011; Savinainen-Makkonen, 2001; Turunen, 2003; Torvelainen, 2007; Warren, 2001), and studies focusing on the phonological development in older children are scarce (Kunnari, Savinainen-Makkonen, & Saristo-Helin, 2012). This study describes the phonological development of Finnish-speaking children at 3;6. During the language acquisition process, phonological and lexical development have been proposed to develop hand-in-hand, especially in the early stages of development (Stoel-Gammon, 2011). So-called bidirectional influence between phonological and lexical mental representations has been suggested (Storkel & Morrisette, 2002). Many studies have been published regarding association between phonological and lexical development among toddlers (e.g. Kehoe, Patrucco-Nanchen, Friend, & Zesiger, 2018; McCune & Vihman, 2001; Schwartz, Burnham, & Bowey, 2006; Sotto, Redle, Bandaranayake, Neils-Strunjas, & Creaghead, 2014; Vihman, 2017), but studies of preschool-aged children are fewer (e.g. Macrae, & Sosa, 2015; Martikainen, Savinainen-Makkonen, & Kunnari, 2019; Munson, Edwards, & Beckman, 2011, Zanobini et al., 2012). Thus, the other main aim of this longitudinal study is to analyse the possible association between phonological development at 3;6, and previous (2;0) and simultaneous (3;6) lexical ability. The possible explaining value of previous and simultaneous lexical ability for phonological development at 3;6 is also analysed.

Special characteristics of Finnish phonology

Finnish has a somewhat limited consonant repertoire (13), but it is rich in vowels (8) and diphthongs (18). In paradigmatic development, children tend to learn the easier consonants (stops, glides, nasals) before fricatives and affricates. Both functional load and articulation manner affect the acquisition of consonants. (e.g. Gangji, Pascoe, & Smouse., 2014; Ingram, 1989; Savinainen-Makkonen, 2000; Vihman 2010). For example, in Finnish, the /d/ sound is acquired relatively late, likely due to its low prevalence (Kunnari, 2002; Warren, 2001). Another example of phoneme prevalence is from Turkish, where the /tʃ/ sound is common. It is learned early, even though it is difficult to pronounce (McLeod & Crowe, 2018). By contrast, in Finnish the most difficult but common phoneme /r/ (alveolar trill) is acquired relatively late (Luotonen, 1998) as is the case in many other languages (McLeod & Crowe, 2018). A recent review study (McLeod & Crowe, 2018) of 27 languages showed that children at 3;6 had acquired 93 % of the phonemes, 89% of the consonants, and 97% of vowels. At the age of 5;0, children across the languages had a robust phonemic paradigm. The Finnish language, however, was not part of that study.

Regarding phonotactic development, the Finnish language has specific features as a fully-fledged quantity language (Suomi, Toivainen, & Ylitalo, 2006). Long (geminate) and short (singleton) phonemes change the word meaning (e.g. [tuli] 'fire', [tu:li] 'wind', [tul:i] 'customs'). The length of the phonemes changes the rhythmic pattern of the syllable and word. The length of a syllable can be understood through its moraic structure (Suomi et al., 2006). The first vowel (nucleus) of the syllable forms the first mora, and the following phonemes of the same syllable are each counted as another mora. The consonants before the nucleus are not counted (e.g. the first syllable contains one mora: [ma.to] 'worm'; two moras: [mat.to] 'rug'; 3 moras: [ma:s.to]

'terrain'). Word-initial consonant clusters are relatively rare in Finnish. Word-medial consonant clusters are common, but word-final consonant clusters only exist very rarely in spoken language (e.g. [hups] 'oops').

Even though many phonological processes have been found in Finnish as well as other languages, some seem to be specific to Finnish (e.g. Kunnari, 2003; Saaristo-Helin, 2011; Vihman, 2010). In the early phases, three Finnish language specific processes have been noted. First, word-initial omissions of single consonants are typical at the beginning of acquisition (e.g. [appi] for [nappi] 'button') (Saaristo-Helin, 2009; Savinainen-Makkonen & Salovaara, 2008). Second, initial consonant cluster omissions are still found at five years of age. (Kunnari et al., 2012) (e.g. [taktori] for [traktori] ‘tractor'). Third, omissions in word-medial clusters are extremely rare (Savinainen-Makkonen, Kaikkonen, Saaristo-Helin, & Kovasiipi-Nieminen, 2009; Savinainen-Makkonen, 2006). All word medial consonant cluster omissions have usually disappeared, even from long words by the age of three (Saaristo-Helin, 2009). In contrast to Finnish, omissions in medial clusters are reported to be a typical pattern in many other languages (Cohen & Anderson, 2011; Fox & Dodd, 1999; Gangji et al., 2014; Grech, 2006; Ingram, 1989; So & Dodd, 1995). For example, among English-speaking children in Australia, the omission of medial consonant clusters in typically developing children are found in multisyllabic words as late as at 7;0 (James, van Doorn, McLeod, & Esterman, 2008). Finnish children tend to use consonant assimilation or compensatory lengthening, instead of omission, to ease pronunciation (Savinainen-Makkonen et al., 2009; Savinainen-Makkonen, 2006; Torvelainen, 2007). In assimilation, a child assimilates the difficult phoneme with the other phoneme in the cluster (e.g. [lap:i] for [lapsi] 'a child'). In compensatory lengthening, a child prolongs the adjacent vowel instead of producing the difficult phoneme (e.g. [ki:ja] for [kirja], 'a book'). Some explanations

for the findings have been provided. In a quantity-language, such as Finnish, the geminates may pull a child's attention from the beginning of the word towards its rhythmic pattern (Savinainen-Makkonen, 2006; Savinainen-Makkonen, 2000; Vihman, 2010). Finnish children may also try to pronounce the rhythmic pattern of the word at the expense of the correct phonology (Torvelainen, 2007).

Regarding previous studies of Finnish phonological development, the focus has mostly been on early phases (e.g. Kunnari, 2000; Saaristo-Helin, 2011; Saaristo-Helin et al., 2011; Savinainen-Makkonen, 2001; Turunen, 2003; Torvelainen, 2007; Warren, 2001). Evidence for children older than three years is mostly based on the results of the norming sample of, "The Finnish Phonology Test" (FPT) (Kunnari et al., 2012). Early phonological development in Finnish is described well, but more detailed information is needed especially for children between the ages of 3;0 and 4;0 since phonology is still developing quickly at that age.

The interrelation between phonological and lexical development

A number of studies and reviews have demonstrated the relationship between lexicon size and the phonological development of toddlers (e.g. Davis, Van der Feest, & Yi, 2018; Kehoe et al., 2018; McCune & Vihman, 2001; Schwarz et al., 2006; Smith, McGregor, & Demille, 2006; Sotto et al., 2014; Vihman, 2017). Among preschool-aged children the associations between phonology and lexicon have been studied for example using non-word repetition task (e.g. Edwards, Beckman, & Munson, 2004; Munson et al., 2011) and intra-word inconsistency (Macrae, & Sosa, 2015; Macrae, 2013; Stoel-Gammon 2011; Martikainen et al., 2019) but some also comparing phoneme repertoire and lexical skills (e.g. Zanobini et al., 2012). Most of these studies have found that phonological skills grow with relation to vocabulary size and not the age

of the child. Needless to say, two studies which focused on intra-word consistency did not confirm previous findings (Martikainen et al., 2019; Sosa & Stoel-Gammon, 2011). With regard to longitudinal findings between early lexicon size and later language development, most of them have focused in late talkers (e.g. Bortolini & Leonard, 2000; Hawa & Spanoudis, 2014; Hong, Lee & Kim, 2018; Fletcher et al., 2004, Lyytinen, Eklund, & Lyytinen, 2005; Preston et al., 2010; Rescorla, Mirak, & Singh, 2000; Rescorla, 2005; Rice, Taylor, & Zubrick, 2008). Late talkers have been found to have weaker language performance later in their lives compared to their age mates with typical early lexical development.

A theory proposed to explain association between lexicon and phonology after the first-word period is the so-called bidirectional or two-representation model of word processing (Storkel & Morrisette, 2002). This theory is based on the underlying mental representations of the words. The representations have been seen as holistic at the beginning of lexicon and phonology acquisition. The mental representations of the words become increasingly segmental while vocabulary grows (Edwards, et al, 2004; Metsala and Walley 1998). Children with more extensive lexicon are also more aware of the phonological structures of the words. The larger lexicon may lead to more exposure to the fine-tuned structures of words, and this may, in turn, lead to better pronunciation (Smith et al., 2006). In the bidirectional model (Storkel & Morrisette, 2002), two types of mental lexicon representations affect each other. The lexical representations (word frequency and neighbourhood density) influence the phonological acquisition. In addition, the phonological representations of a word (phonotactic probability) affect lexicon growth. Munson et al. (2011) hypothesized that the quality of mental representations would be specific to the target language. In a language such as Finnish, which contains long words, few difficult consonants, and easy syllable structure, there are fewer words

phonologically close to each other than in languages with short words and high numbers of consonantal phonemes. The simple phonological structure may lead to fewer demands for accuracy of representations, and children may have sufficiently robust phonological skills earlier than in languages which are phonologically more demanding (Martikainen et al., 2019; Munson et al., 2011; Stoel-Gammon, 2011).

Three studies comparing lexical and phonological skills in Finnish children have been published. First, Kunnari et al. (2006) found a significant simultaneous correlation between phonology and the number of word types used in a videotaped sample of 24 children aged 2;0. Second, Martikainen et al. (2019) studied intra-word accuracy in children from 3 to 6 years. A correlation between vocabulary size and token-to-token accuracy was not found when the child's age was taken into account. This finding contradicted most of the previous English studies that have found correlations between intra-word accuracy and lexical development (Macrae, 2013; Macrae, & Sosa, 2015; Sosa & Stoel-Gammon, 2012). Martikainen et al. (2019) proposed that the reason for the different outcomes might be due to phonotactic differences between English and Finnish. Third, a recent study (Vehkavuori & Stolt, 2019) analysed whether very early receptive and expressive lexicons, if measured using the short form version of the CDI during the second year of life, associated with different language domains (lexicon, phonology, morphology, receptive and expressive language ability) at 3,6. It was found that expressive lexical ability, if measured at 24 months of age, had roughly equally strong connections to all language domains studied a year and a half later.

This study is motivated by the need to enrich the understanding of phonological development in Finnish children, and to discuss results in the light of findings from children speaking other languages. This will help increase the knowledge on what kind of phonological development is

typical for Finnish children alone, and what is universal in nature. This study also aims to illuminate the connection between phonological and lexical skills in Finnish-speaking children. Longitudinal studies may give information valuable to the needs of clinicians. The more information there is on the associations between different language domains, the more tools clinicians have. Through research, it is possible to understand the language development process better. Thus, in the light of literature, and especially the discussion of mental lexicon representations and phonological development, it is anticipated that early lexicon size (2;0) and simultaneous lexical ability (3;6) correlate with phonological skills at 3;6 in a representative sample of children learning Finnish.

Specific research questions were as follows:

1. What kind of phonological skills do Finnish children have at 3;6 when measured using the Finnish Phonology Test (FPT)?

2. Is there an association between phonological development at 3;6 and lexicon size at 2;6 and/or lexical ability at 3;6?

3. Which one better explains phonological skills at 3;6, lexicon size at 2;0 or lexical ability at 3;6?

This study is part of an ongoing norming study of the Finnish short-form version of the Communicative Development Inventory (FinCDI-SF, project leader Dr. Suvi Stolt). The ethical committee approved the study protocol of the FinCDI-SF Study in autumn 2010.

Subjects and Methods

Subjects

The subjects were 67 children (37 girls) whose language development was followed longitudinally. The parents of the participating children were invited to the study by a public health nurse at a Baby Health Care clinic in Turku when the children were eight months old. In Finland, families use The Baby Health Care clinics widely. According to the National Institute for Health and Welfare (THL) homepages, 99,7% of new-born babies and their mothers are monitored by a Baby Health Care clinic nurse (THL, 2018). In this study, the inclusion criteria were: healthy, full-term (born at >37 weeks of gestation), and the child growing in a monolingual Finnish-speaking family. The exclusion criteria were: a diagnosis (or suspicion) of cerebral palsy, mental retardation, autism spectrum disorder, or hearing impairment. In addition, exclusion criteria were: narcotic or alcohol addiction, or severe mental health problems, of one or both parents. The educational level of parents was as follows: 51% of mothers and 45% of fathers had university studies or a degree, 34% mothers and 22% fathers had lower university studies or a degree, 12% of mothers and 28% of fathers had vocational studies or a degree, and 3% of mothers and 1% of fathers had a compulsory school degree. The education information was missing from 3% of fathers.

Methods

At 3;6, children's phonological skills were tested using the 'Finnish Phonology Test' (FPT; Kunnari et al., 2012). In the FPT, the child names objects in pictures (90 pictures). The structure of the test and examples are presented in table 1. The test consists of two parts. The first has 36 pictures to name. These words include one to three syllables. The words are closely related to the

child's life and surroundings. The first 10 of these 36 words contain only one consonant. These first words are used to assess the child's consonant and vowel paradigm. The second part of the test (54 words) concentrates on the child's syntagmatic abilities and assesses the ability to produce consonant clusters, for example, different syllable structures and long words up to five syllables. According to the manual of the FPT, the percentile distribution for the age 3-3;11 is as follows: >91 excellent (123-127 points); 84-91 good (118-122 points); 17-83 typical level (80-117 points); 9-16 weak (71-79 points); very weak<8 percentile (0-70 points). In the scoring, phonetic allophones of the sound /s/ and /r/ are ignored because there is only one sibilant and one trill in Finnish. Furthermore, the pronunciation of these sounds also varies among adult speakers.

Table 1.

The lexical skills were assessed in two different age points at 2;0 and 3;6. Since in Finnish, there is no such assessment method which would provide representative and valid information from both mentioned age points, different methods were used. At 2;0, the children's lexicon size was measured using the standardized Finnish long-form version of the MacArthur-Bates Communicative Development Inventory (Fenson et al., 1994; Lyytinen, 1999). The number of words in the FinCDI inventory (toddler form) is 595 words. The FinCDI has been normed for Finnish children (Lyytinen, 1999) and it has been shown to provide valid information on the lexical development of children at two years of age (see, e.g. Lyytinen, 1999; Stolt et al., 2009). The method has been used extensively in research, and it is a well-known tool in a clinical context. It measures expressive lexicon size by using a parent report questionnaire. Children's language skills were assessed within two weeks of the second birthday of a child. Families brought the completed FinCDI inventory to the assessment. The FinCDI inventory was sent to families shortly before the assessment.

At 3;6 the Boston Naming Test (BNT, Kaplan, Goodglass, & Weintraub, 1983) was used to assess the children's lexical ability. The BNT has been translated into the Finnish language and standardized originally with children 5;0 and older (Laine, Koivuselkä-Sallinen, Hänninen, & Niemi, 1997). The BNT has also been used on younger children, in Finland: from 3;0 to 9;0 (Loukusa, 2007) and 3;6, (Lyytinen et al., 2005). It has been noted to be suitable for children as young as 3;0. BNT contains 60 pictures and is designed to assess both the naming ability and speed. The total score includes correct spontaneous answers, and correct answers received with the help of semantic cues. It was considered important that valid and representative information on lexical ability could be gained at both age points. At 2;0, the FinCDI provided rough information on the width of the early lexicon. At 3;6, this kind of information is not possible to get anymore in typically developing children since their lexicon is already extensive. Thus, the naming ability was assessed instead.

Data handling and analysis.

Paradigmatic and phonotactic skills were scored according to the instructions in the FPT manual. (Kunnari et al., 2012). In this study, the scores of paradigmatic and phonotactic skills were summed to form a score of total phonological skills (max. 164 points).

Percentages of consonant correct (PCC), vowels correct (PVC) and phonemes correct (PPC) were calculated using 90% criterion. Consonants, vowels, and diphthongs were included in the PPC.

Correlations between phonological and lexical ability were calculated using Pearson's correlation coefficient values. The Mann-Whitney U-test was used to analyse gender differences. A multiple linear regression analysis was used to study if lexicon size at 2;0 or lexical ability at 3;6 explained phonological development at 3;6. In this analysis, the outcome variable was the total FPT score, and the predictor variables were fitted in two models: 1. total lexicon size measured using the FinCDI score, maternal basic education level, and child's gender. 2. the total BNT score, maternal basic education level, and child's gender. The statistical significance was assessed using ANOVA.

Regarding lexicon size at 2;0 and naming ability at 3;6, children were divided into two subgroups based on percentile values (weak: <16 percentile; typical: >16 percentile) — the 16th percentile correspondences to 1 standard deviation from the mean. The phonological development of the children in these subgroups was compared using the Wilcoxon rank-sum test. The significance limit was $p<0.05$.

Results

Phonological skills at 3;6.

Descriptive statistics for the paradigmatic development are presented in Table 2 and the variation between individual children is presented in Figure 1. Sixteen children (24%) had a complete consonant inventory. All children correctly used the phonemes /p/, /t/, /m/, /n/ and /h/, and at least 90% used the phonemes /k/, /s/, /l/, /v/, /j/ and /ŋ/. The last acquired phoneme was /r/. It was used in the initial position by 21 children (31%), and medially by 25 (37%). The phoneme /d/

was used in the initial position by 44 children (66%) and medially by 45 (67%). The PCC value was 85, PVC 100, and PPC 95.

Table 2.

Figure 1.

Descriptive statistics for phonotactic development at 3;6 are presented in Table 2 and Figure 2. The children used correct phoneme length, syllable, and word length. More variation existed in the ability to combine different phonemes (Figure 3). The lowest level of correct production was found in initial consonant clusters (Median 0). The FPT contains three initial cluster words. All of them include /r/. All of these three words were pronounced correctly by two children (3%). A majority of the children (N=45, 72%) omitted /r/ in these three initial consonant clusters.

Based on the percentile distribution given in the FPT manual, the percentiles of phonotactic skills of children were as follows: 12 children (18%) had excellent skills, one child (2%) had good skills, 53 children (79%) had typical skills, and one child (2%) had very weak phonological skills at 3;6. Paradigmatic and phonotactic skills correlated strongly with each other ($r= 0.85$, $p <.001$). The FPT total score did not differ between boys and girls ($U=625$, $p =0.38$).

Figure 2.

Figure 3.

Associations between the phonological and lexical ability

Lexicon size at 2;0 and lexical ability at 3;6

Table 3. presents descriptive statistics for lexicon size at 2;0 and lexical ability at 3;6. The mean lexicon size was 271 at 2;0. Eleven children had a small lexicon size (percentile <16; lexicon size 82 words or less) and eleven children had a very large lexicon size (percentile >84; lexicon size 431 or larger) at 2;0. Girls had a significantly larger lexicon size than boys at 2;0 ($U=714$, $p< 0.05$).

At the age of 3;6, the mean BNT score of the group was 23 words. Twelve children had weak lexical ability (percentile ≤16; 17 or less), and twelve children had very good lexical ability (percentile >84; 29 or more) at 3;6. Boys and girls did not differ in terms of their BNT score ($U=550.5$, $p>0.1$).

Table 3.

Lexicon vs. phonology

Pearson's correlation coefficient values between the phonological and lexical variables are presented in Table 4. All correlations were positive and statistically significant, except for paradigmatic skills and BNT ($r=0.20$ $p>0.1$).

Two multiple linear regression models were fitted to the data to predict FPT scores. The first was based on the maternal basic education level, the child's gender and FinCDI scores, while the second was based on the maternal basic education level, the child's gender and BNT scores. Results of the first model (FinCDI): a significant regression equation was found ($F(3,63)=7.00$,

p=0.0002), with adjusted R squared of 0.21. The children's phonological skills were predicted as follows: the intercept was 115.4, and the slope for FinCDI was 0.046. The FinCDI score at 2;0 was a significant predictor for the FPT score at 3;6 (ANOVA p<0.0001) while the maternal basic education level (ANOVA p>0.1) and the child's gender (ANOVA p>0.1) were not significant. Results on the second model (BNT): significant regression equation was found (F(3,63)=3.158, p=0.02), with an adjusted R squared of 0.09. The children's phonological skills were predicted as follows: the intercept was 118.3, and the slope for BNT scores was 0.67. The BNT score at 3;6 was a significant predictor for the FPT score at 3;6 (ANOVA p<0.02) while the maternal basic education level (ANOVA p>0.1) and the child's gender (ANOVA p>0.1) were not significant.

Phonological development (FPT total score) at 3;6 differed between the children who had small lexicon size at two years of age (percentile <16, N=11) at 2;0 and the rest of the group W = 127.5, p-value = 0.0009 as measured by the Wilcoxon rank-sum test. There was no significant difference in phonological development (FPT) at 3;6 in children with weak/typical-strong lexical ability (BNT) at the same age.

Table 4.

Discussion

This study describes the phonological development of Finnish children at 3;6 as measured using the Finnish Phonology Test (FPT, Kunnari et al., 2012). In addition, the associations between phonological development and lexical ability (lexicon size at 2;0, naming ability at 3;6) were also studied. Analyses were also made of whether previous lexicon size and/or simultaneous

lexical ability could explain phonological skills. Most of the children mastered the Finnish consonant paradigm at 3;6, with the exception of the phonemes /d/ and /r/. Phonotactic skills were also acquired well at the group level, although the ability to combine different consonants was still challenging for some children if the consonant appeared in word-medial and especially in the word-initial position. Moderate associations were found between lexicon size at 2;0 and phonological development at 3;6. The correlation between simultaneous skills was weaker. Roughly 21% of phonological development at 3;6 could be explained by lexicon size at two years of age when measured using the long-form version of FinCDI and when maternal basic education and the child's gender were taken into consideration.

Phonology

Finnish children mastered nearly all Finnish phonemes at 3;6 with a PPC 95. This is a slightly higher PPC value than reported in a review study of other languages (93; McLeod & Crowe, 2018). The PVC in Finnish was 100 and thus higher than in other languages (PVC 97; McLeod & Crowe, 2018). In contrast, the PCC was lower in Finnish (85) than in other languages (89; McLeod & Crowe, 2018). Even though, Finnish children's PCC was lower than that of children speaking other languages, the PPC was higher, maybe because Finnish has many vowels (8) and diphthongs (18) and a low number of consonantal phonemes (13). Due to the importance and amount of vowels in Finnish, children may concentrate on acquiring vowels early. Despite the lower PCC of Finnish children, they mastered all the consonantal phonemes except two: /r/ and /d/. Less than one-third of the children had acquired the phoneme /r/ at 3;6. This is in line with other languages (McLeod & Crowe, 2018). Late acquisition may be due to the challenging articulation manner of this phoneme. Furthermore, /r/ is the only phoneme in Finnish that was reported to be acquired later that 3;11 in other languages (McLeod & Crowe, 2018). In contrast

to other languages, less than 70% of the Finnish children used the phoneme /d/ correctly. This is probably due to the low functional load of /d/ in Finnish (Kunnari, 2002; Warren, 2001).

In this study, phonotactic skills were acquired well, except word-medial and especially word-initial consonant clusters. Children mastered the rhythmic patterns of the word and the moraic structure of the syllable fully. Thus, children did not use any omissions in the word medial consonant clusters. Even though children did not master all the word-medial consonant clusters, they used other phonological processes (e.g. assimilation and compensatory lengthening) than omission to cope with a sound which was not included in their paradigm. These findings may reflect the language-specific phonological pattern of Finnish (Savinainen-Makkonen et al., 2009; Savinainen-Makkonen, 2006; Torvelainen, 2007). Present results differ from the findings of some other languages, where word medial cluster omissions are typical (Cohen & Anderson, 2011; Fox & Dodd, 1999; Gangji et al., 2014; Grech, 2006; Ingram, 1989; James et al., 2008; So & Dodd, 1995). One explanation for the difference between the findings may be the preference for the rhythmic pattern (Torvelainen, 2007) or the "geminate pull effect" (Vihman, 2010). The geminate-pull effect might also explain omissions in the initial consonant cluster in Finnish: consonant omissions in the word-initial clusters appears to be typical at 3;6 (72% of the children). Previously this pattern has been found in some children up to the age of 5;0 (Kunnari et al., 2012). Word-initial omissions do not violate the mora structure of the word and do not change the rhythmic pattern of the word. The rare occurrence of word-initial clusters in Finnish (Suomi et al., 2006) may contribute to the late acquisition of initial consonant clusters. Furthermore, all the initial clusters in the FPT included the challenging phoneme /r/. This may have influenced the present findings on initial consonant clusters. In contradiction to initial consonant cluster omissions, in word-*medial* clusters, all children used substitution or

compensatory lengthening when /r/ was not included in their paradigm. Thus, the present results provide further support for the view that word-initial consonant clusters are particularly challenging for children acquiring the phonology of Finnish and remain as the last phonological process.

Associations between lexical abilities and phonology

The present results propose that children who have proceeded well in their early lexical development have more advanced phonological skills a year and a half later than their age mates. This can be concluded since children with weak lexical size at 2;0 had significantly weaker phonological skills at 3;6 than the rest of the group. Early lexicon size also had 21% predicting value to later phonological development when the maternal education level and the child's gender were taken into account. This finding is in line with the other studies on late talkers and their language skills later on in their childhood (e.g. Hawa & Spanoudis, 2014; Hong et al., 2018; Fletcher et al. 2004; Lyytinen et al., 2005; Rescorla et al., 2000; Preston et al., 2010; Rescorla 2005; Rice et al., 2008; Bortolini & Leonard, 2000). It may be that when a child's lexicon grows, mental lexicon representations connected to the lexemes become more precise. This may, in turn, influence phonological forms of the words. In the light of the current results, it can be suggested that growing lexicon affects phonological representations of the words not only in late talkers but also typically developing children. Children with advanced lexicon early in their lives may complete their phonological targets younger than children with modest vocabularies. According to the bidirectional model by Storkel and Morrisette (2002), the correlation of early lexicon size and later phonology in this study support the view that at least lexical skills are influencing phonology to some extent. The current study did not investigate if phonological development

explained lexical skills. Thus, the study provides partial support (from lexicon to phonology) to the bidirectional theory.

In this study, simultaneous lexical ability, naming (BNT), correlated weakly with phonotactic skills and the total score of the FPT, but not with the paradigmatic skills at 3;6. The BNT scores explained only 9% of the FPT outcome when the maternal basic education and the child's gender were taken into account. Most of the earlier studies have found associations between lexical and various phonological skills when measured at the same age (e.g. Edwards et al., 2004; Macrae, & Sosa, 2015, Macrae, 2013; Stoel-Gammon 2011; Storkel & Morrisette, 2002; Zanobini, et al., 2012) but not all (Martikainen et al., 2019; Sosa & Stoel-Gammon, 2012). The finding of the present study that simultaneous lexical ability had hardly any explaining value for phonological skills, is somewhat surprising. It could be assumed that associations between the simultaneous results were stronger than longitudinal results. The present finding could be explained for example, by the fact that most of the Finnish children have relatively robust phonological skills at 3;6 and the analysing method should have been more fine-tuned to find the correlations.

Based on the present findings, early lexicon at 2;0 can be used to predict later phonological skills at 3;6; at least to some extent. In addition, the findings showed that naming ability at 3;6 had hardly any explanatory value for phonological skills when measured at the same age.

In the future, we see value in studying phonological development, and its associations to other linguistic domains, separately in different languages. This kind of study enriches our understanding of language-related and universal patterns of language acquisition.

Strengths and limitations

The strength of the present study is a relatively large representative group of study subjects. In addition, the present study provides a description of phonological development at 3,6 in an understudied language. Thus, the present results add data to the growing international comparisons of phonological acquisition in different languages. The present results also provide information on the association of different language domains, between lexicon and phonology specifically.

The limitations of the present study are as follows. In this study the lexical ability was assessed using different expressive language measures in different age points due to the absence of methods covering both age points in Finnish. Furthermore, information on phonology from both age points (from 2 and 3,6 years) would have strengthened the present results

Clinical implications

By supporting the lexical development of late-talking children, their phonological ability could as well be aided for an extended period. An increasing lexical ability may affect phonological representations of words in the mental lexicon, and this may, in turn, support phonological development. Furthermore, in the case of delayed phonological development, also lexical skills should be assessed and supported if needed. In addition, the phonological development of late talkers should be followed up to age 3;6, at least. The early prevention resources could be allocated to late talkers and children with modest lexicon size at an early age by using community-based recourses (e.g. library services, parent-toddler play, music, and story groups).

Conclusions

This study provided information on the phonological development in a representative group of Finnish children at 3;6 in a reasonably large sample. The findings showed that although children had acquired most of their phoneme paradigm at three and a half years of age, one challenging phoneme (/r/) and one phoneme low in prevalence (/d/) were still developing in most of the children. Findings also showed that medial and especially word-initial consonant clusters were difficult at this age at least for part of the Finnish children. The present results share the view that phonological development is language-specific. In this study, early lexical development at 2;0 associated stronger with phonological development at 3;6 than the simultaneous lexical ability. Early lexicon size explained 21% of the phonological ability a year and a half later, whereas the simultaneous lexical skills had hardly any predictive value. These results support the view that early lexical development provides a basis for phonological development.

Acknowledgements

We would like to thank you all the families and other participants of this study.

Disclosure statement

The authors report no conflicts of interest.

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Table 1. *Examples of the categories included in the Finnish Phonology Test (FPT)*

	variable	*example*	*max.*
Paradigmatic skills			
Consonant inventory	Initial	tyyny (pillow) /t/	12
	medial	tyyny /n/	13
	final	kengät (shoes) /t/	2
Vowel inventory	medial/final	kukka (flower) /u/	8
	initial	auto (car) /a/	2
Phonotactic skills			
Length of phoneme	V geminate	Tyyny (pillow) /y:/	6
	C geminate	Kukka (flower) /k:/	8
Length of syllable	2 moras	Lin.tu (bird)	6
	3 moras	Lamp.pu (lamp)	6
Length of word	2 syllables	Ka.la (fish)	6
	3 syllables	Sam.mak.ko (frog)	6
	4-5 syllables	Kil.pi.kon.na (turtle)	6
Combining of phonemes	Two consonants separately in a word	Vene (boat) /v/-/n/	39
	diphthong	Vauva (baby) /au/	8
	Medial consonant cluster	Tähti (star) /ht/	33
	Initial consonant cluster	Prinsessa (princess) /pr/	3

Table 2. *Phonological skills of Finnish children measured using the Finnish Phonology Test (FPT) at 3;6. Mean and median values, standard deviation, and the minimum and maximum values of the group are presented.*

	mean	sd	median	Min-max
Paradigmatic skills				
Initial consonants	11	1	11	7 – 12
Medial consonants	12	1	12	8 – 13
Final consonants	2	0	2	0 – 2
Vowels	8	0	8	8
Words with initial vowel	2	0	2	2
Paradigmatic skills total score	34	2	35	25-37
Phonotactic skills				
Length of syllable	26	1	26	20 – 26
Length of vowel	6	0	6	6
Length of consonant	8	0	8	7 – 8
2 moras	6	0	6	4 – 6
3 moras	6	0	6	1 – 6
Word length	18	1	18	11 – 18
2 syllables	6	0	6	6
3 syllables	6	0	6	3 – 6
4-5 syllables	6	1	6	2 – 6
Combining of phonemes	63	13	64	21 – 83
Consonants in separated positions	33	6	35	6 – 39
Diphtongs	8	0	8	5 – 8
Medial consonant clusters	22	7	21	3 – 33
Initial consonant clusters	1	1	0	0 – 3
Phonotactic skills total score	108	13	109	52 – 127
FPT total score	142	16	143	77-164

Table 3. *The lexicon size of the subjects measured using the Finnish long-form version of the Communicative Development Inventories (CDI) at 2;0, and the lexical ability measured using the Boston Naming Test at 3;6.*

	Mean	Sd	Median	Min.-max.
Lexicon size at 2;0 (CDI)	271	149	288	10 – 528
Lexical ability at 3;6 (BNT)	22.5	6.07	21	10-35

Table 4. *Pearson's correlation coefficient values between phonological skills (paradigmatic and phonotactic skills) measured using the Finnish Phonology Test (FPT) at 3;6, lexicon size measured using the Finnish long-form version of the Communicative Development Inventory (CDI) at 2;0, and lexical ability measured using Boston Naming Test (BNT) at 3;6.*

	Phonological development at 3;6		
Lexical development	FPT / Paradigmatic skills	FPT / Phonotactic skills	FPT / Total score
Lexicon size at 2;0 (CDI)	0.45***	0.45***	0.46***
Lexical ability at 3;6 (BNT)	0.20	0.29*	0.28*

*p<0.05, **p<0.01, ***p<0.001

Figure 1. *Variation in the paradigmatic skills, measured with Finnish Phonology Test, in children at 3;6 described using a box plot. The variations in the initial consonant (C-), medial consonant (-C-) and final consonant (-C) inventory, as well as the variation in the vowel inventory (V) and the ability to pronounce vowels in the initial position (V-), are presented.*

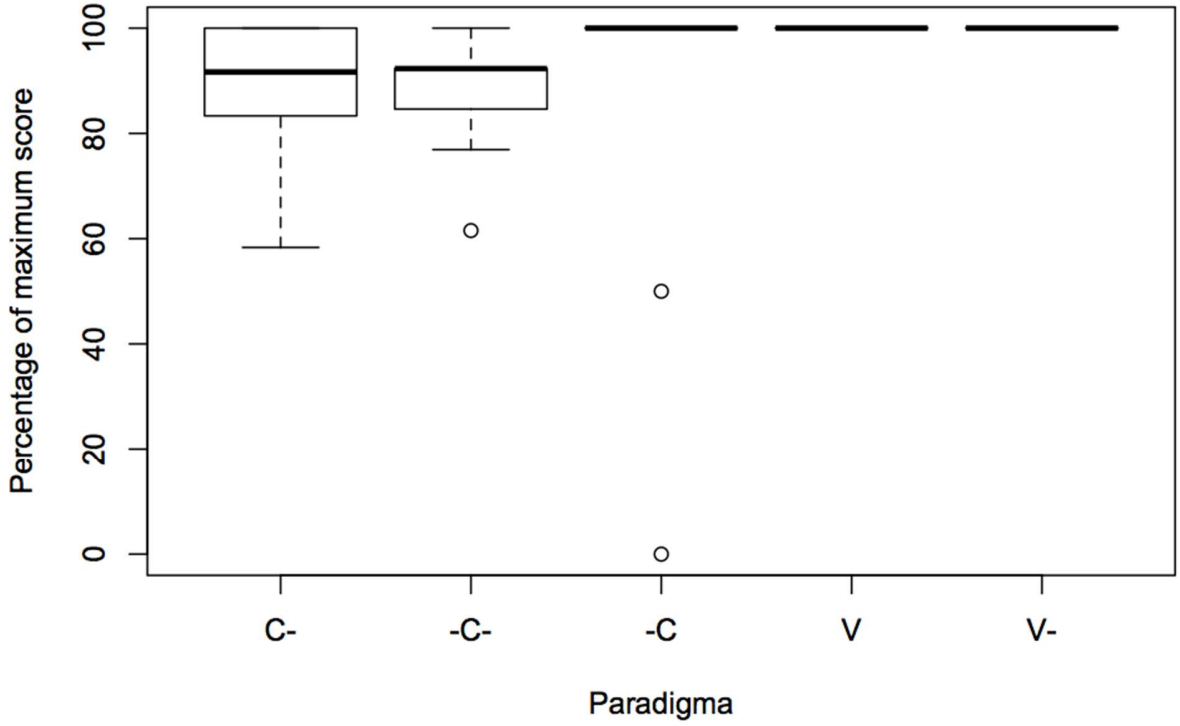

Figure 2. *Variation in the phonotactic skills, measured with Finnish Phonology Test, in children at 3;6 described using a box plot. The variations in the phoneme and syllable length (PH- SL), word length (WL), and in the ability to combine different phonemes (Comb.) are presented.*

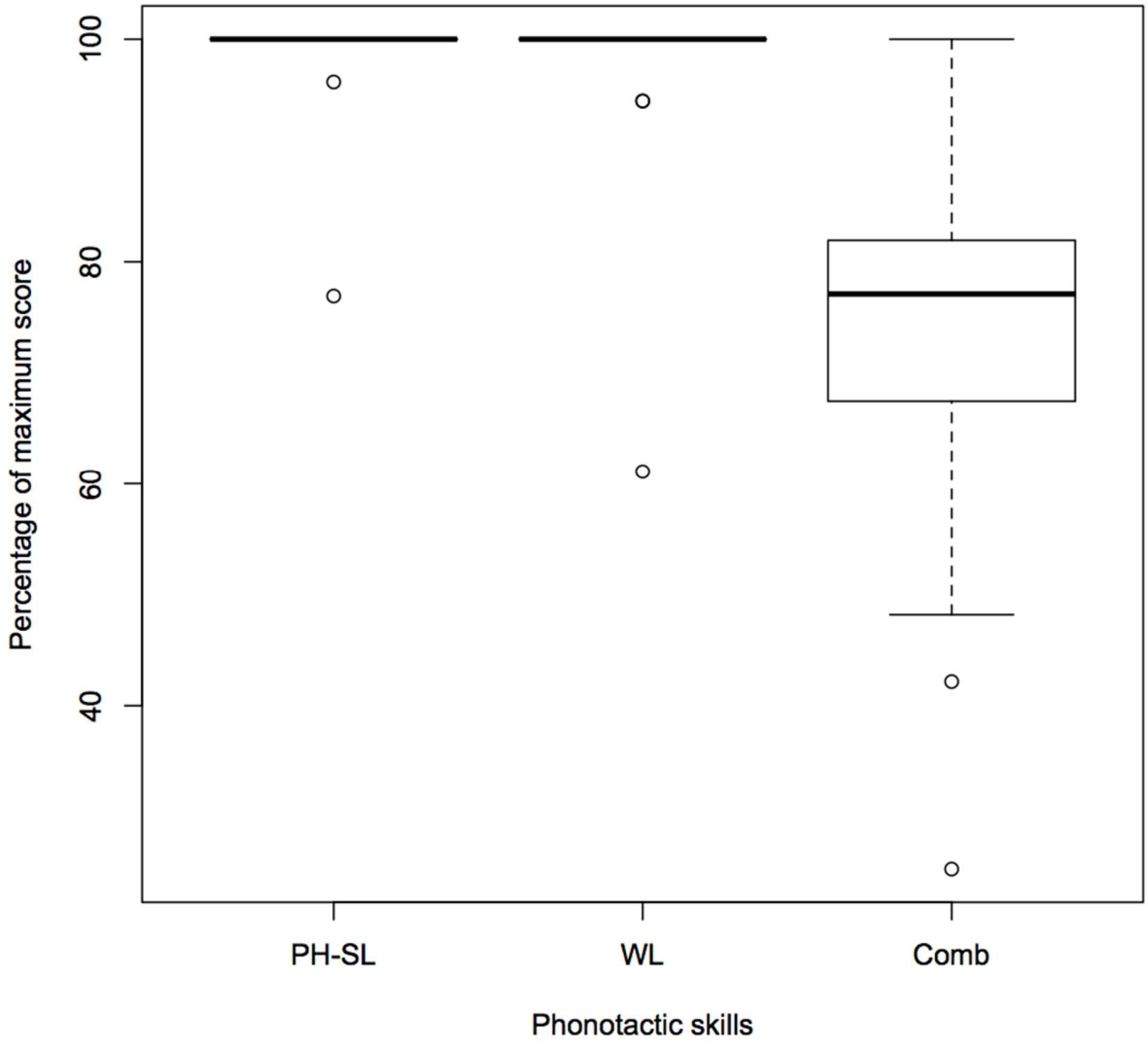

Figure 3. *Variation in the ability to combine different phonemes at 3;6 described using a box plot. The variations in the ability to pronounce consonants in separated position (C-C), diphthongs (VV), word-medial consonant clusters (-CC-) and word-initial consonant clusters (CC-) are presented.*