# Pirjo Turunen

# Production of Word Structures

## A Constraint-based Study of 2;6 Year Old Finnish Children at-risk for Dyslexia and Their Controls

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UNIVERSITY OF JYVÄSKYLÄ

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# ABSTRACT

This study investigates Finnish children's phonological acquisition from a constraint-based account. An aim was to construct a hierarchical model in which different levels from word, syllable, phonotactic through to phoneme level were taken into account. The model is implicatory indicating that prosodic elements govern phonotactical and phoneme level elements in the acquisition of word structures.

Secondly, a purpose was to compare children at-risk for dyslexia (N=105) and their controls (N=91) in order to find possible early precursors of familial dyslexia. In addition, subgroups of late talkers were studied in order to explore the developmental aspect of acquisition of word structures.

Cross-sectional naming task data at age 2;6 were used to provide normative information and to compare the phonological skills of the different groups. The results showed that at-risk children had a lower number of target-like productions in several word-specific analyses, however, using a more general phonological scoring based on the same naming task data, at-risk children did not prove to be significantly weaker than controls. Late talkers were less advanced than other children in all analyses.

The relationship between early phonological ability and later reading skills was further examined in a retrospective analysis of poor, middle and good readers, a division based on a test measuring word recognition skills at age 7. The results found that poor readers were significantly weaker in the prosodic as well as in some phonotactical analyses. This result indicates a correlation between early phonology and later reading skills and supports an analysis based on a hierarchical model of word structure.

Keywords: dyslexia, Finnish, language development, Optimality Theory, phonological acquisition, speech production, word structure

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# FOREWORD

This study was originally initiated in a seminar for undergraduate students at the Finnish Department, in which Professor Matti Leiwo introduced the fascinating questions about dyslexia as well as language acquisition. Since that seminar Professor Leiwo has encouraged me to go on with my studies. I would like to thank him for his endless support and guidance on my way to becoming a researcher.

of course not have been possible. Finally, I wish to thank my friends and especially my family for their loving support.

# CONTENTS

# 1   INTRODUCTION

## 1.1   Study on Finnish phonological acquisition

This study combines three different areas of research: linguistic theory, language acquisition and dyslexia. The main focus is on Finnish children's word production at the age of 2;6, which is investigated from two aspects. First, phonological skills are studied in a general sense by focussing on inter-individual variation, and secondly, the study aims to identify possible early precursors of genetic dyslexia. In order to study this aspect of dyslexia, tools for comparing different groups of children had to be created. Thus this study attempts to construct a theory of phonological development in which the whole word structure from word and syllable level to phonotactics and phoneme level is taken into account.

This study is part of the linguistic project Early Language Development and Dyslexia (ELDD) taking place in the Finnish Department at the University of Jyväskylä. ELDD is part of the large interdisciplinary project, the Jyväskylä Longitudinal Study of Dyslexia (JLD) headed by Heikki Lyytinen. JLD takes place at the Department of Psychology, also at the University of Jyväskylä. In the JLD-project approximately 200 children have been followed from birth to school age when possible reading and writing problems become evident. The selection of at-risk and control children in the JLD-project was based on evidence that dyslexia is highly heritable and thus one can expect that a high proportion of the children of dyslexic parents will show problems in reading and writing.

Moreover, an aim is to connect the analysis of children's phonology to current developments of linguistic theory, namely to the constraint based account used in Optimality Theory (OT). The basic theoretical idea is to combine the universal and language specific features of phonology in terms of describing Finnish acquisition data by universal constraints.

Based on a hierarchical and constraint-based model of word production, the data were quantified in order to compare different groups of children.

Although the main focus regarding group comparisons is on children at-risk for dyslexia and their controls, retrospective analyses are conducted for groups based on success in a test measuring reading skills at age 7. In addition, two groups of late talkers are also studied, those who, based on tests, were identified as less advanced in their linguistic skills at the age of 2 and at age 5. The purpose of studying late talkers is to shed light on developmental aspects of the hierarchical and constraint based model for acquisition of word structures.

Generally children's productions differ from the productions of adults in the direction of simplification and variation occurs both inter- and intra-individually. The speed of development varies within individuals, which enables the investigation of children at different developmental stages in this study by using cross-sectional data. Intra-individually the variation of forms usually shows a developmental trend towards the input grammar, that is, adult grammar. Cases of so-called chronological mismatch are usually typical only for language impairments. Children generally perceive the input forms more specifically than they are able to produce them, thus the mispronunciations are due to production factors rather than perceptual factors. (e.g. Bernhardt & Stemberger 1998: 11–13.) In this study the aspect of "production factors" is examined in terms of the phonological constraints developed within Optimality Theory (OT).

The core of OT is in universal, violable constraints. Although the theory itself has developed 4 and is still developing 4 in the recent years, the idea of constraints is in fact not new to acquisitionists as pointed out by Pater (1997). Also the concepts of universality and markedness have long been inherent in phonological theory. Due to the violable nature of constraints, the theory has been quite rapidly applied to child language, and phonological acquisition has been one of the key research areas from the beginning of the theory's first formulation and publication (e.g. Gnanadesikan 1995; Pater 1997; Stemberger & Bernhardt 1997; Bernhardt & Stemberger 1998). The competition of constraints illustrates well the developing system of child phonology, both inter- and intra-individual variation. Universality of constraints on its behalf ensures the interlinguistic comparison of production characteristics.

In phonology, linguists have always searched for universal characteristics. The same fascinating thought of finding something common to all languages has also held appeal among acquisitionists and there have been attempts to show similar acquisition patterns in learners across languages. At first, a child's phonology is characterised by unmarked features, which in OT terms means that these structural constraints are ranked highly in the constraint hierarchy. In time, language specific features appear in the child's speech and thus faithfulness to input forms increases; in other words, constraint ranking changes towards the constraint ranking of adult Finnish. Some of the constraints remain higly ranked, some are ranked so low in the hierarchy that their effect is not easily seen on the surface. According to OT, however, these constraints are still part of the system and may have their effect in some

situations even in adult language. The interplay of these two forces 4 complex characteristics of a mother tongue and simplification towards unmarked structures 4 can be considered a core of phonological development, as well as a theoretical starting point for this study. The purpose regarding the linguistic theory in this study is to apply it to the context of Finnish phonological acquisition rather than to further develop the theory.

The first studies in the field of child language acquisition were diary studies and these are still being carried out. Menn and Stoel-Gammon (1995: 336) distinguish so-called cross-sectional studies as a second type of child phonology research and mention that setting of norms is the main purpose of these type of studies. For this reason the number of subjects is usually fairly large in order to set norms of development. This type of study with a higher number of subjects was lacking in the Finnish acquisition field until recently, especially in phonology, however, a larger amount of children was examined in Toivainen's (1990) study which concentrated on morphological development.

The third major type of design includes small studies using experimental or naturalistic methods in order to explain the linguistic characteristics of child phonology. The recent Finnish child phonology studies mainly fall into this category: Savinainen-Makkonen (2001) studied six children. Kunnari's study (2000) of ten children has perhaps more emphasis on the setting of norms (see Kunnari 2000: 11). Richardson's (1998) experimental and cross-sectional study on production and perception of the quantity contrast differs from these studies in its experimental nature and very specified testing of hypotheses. Similarly Aoyama (2001) has investigated the quantity contrast; she compared the perception as well as production of nasal quantity contrasts in Finnish and Japanese children. Finnish and Japanese children were compared also in a study by Kunnari, Nakai and Vihman (2001) who investigated the acquisition of geminates.

Unlike in English speaking contexts, the research on child phonology has been quite limited in Finland. Most of the information thus far has come from case studies of one or two infants, e.g. Laalo (1994), Savinainen-Makkonen (1996), Iivonen (1994)[1] and Leiwo's (1977) study on delayed language development. Case studies provide important information on individual patterns of development, but can not be generalised to show the average developmental progression. Characteristics of Finnish are reflected in the results of phonological studies, for example Kunnari (2000: 54) found out that Finnish children's early words are mostly bisyllabic unlike in some other languages. Moreover, Savinainen-Makkonen (2000c) has emphasised that unlike in English, word initial consonant deletion is a normal developmental process in Finnish. Recently the lack of larger, systematic studies of child phonology has been noted and within the last few years studies on larger groups of children have emerged.

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[1]    Iivonen (e.g. 1986; 1990) has also considered child language acquisition in a more general sense.

The present study falls into the third category of the research types defined by Menn and Stoel-Gammon (1995: 337). It is experimental in nature, it is based on linguistic theory and attempts to test hypotheses concerning dyslexia. However, it also has some goals characteristic to cross-sectional studies in its purpose to set norms for Finnish children's phonological skills. In it's cross-sectional method this study differs from the latest longitudinal studies on Finnish child phonology by Savinainen-Makkonen (2001) and Kunnari (2000). The research done by Savinainen-Makkonen is, however, especially related to the present study through her investigation of the phonological structure of words during the first years of life. Her longitudinal study provides valuable information on individual developmental paths.

Cross-sectional data in this study is from age 2;6 and chronological data provided by the JLD-project is used only for selecting subjects for group comparisons. Therefore the data analysis can not adequately provide exact knowledge about developmental stages. However, the large number of subjects includes children from several developmental stages, by which means the data offers tentative information on developmental stages. In addition, the developmental aspect arises from the analysis of late talkers.

In order to construct adequate hypotheses for phonological acquisition in Finnish children in general as well as in at-risk children and late talkers, one has to consider the characteristics of the Finnish phonological system. The emphasis is on finding such characteristics, which may cause problems for children with possible difficulties in phonological processing. Theoretically this means that phonological structures are analysed from the point of view of complexity and markedness; one could hypothesise that complex elements are acquired later in normally developing children and that they cause more problems for children with difficulties in phonological processing.

A prosodic characteristic of Finnish is a trochaic foot form. Since the main stress is fixed upon the initial syllable and secondary stress on the third and every second syllable after that, stress is usually not quantity sensitive. In other words, heavy syllables can remain unstressed, which causes conflicts with stress and heaviness of syllables. Lehtonen (1970) has pointed out the importance of taking the word's overall structure into account in his study on Finnish quantity distinction. He found out that a phonetic realisation of the quantity distinction includes secondary durational cues: in CVCV word forms the final vowel is longer than in a CVCCV-structure. In this study the interplay of prosody and syllable structure is investigated from the point of view of truncation patterns of long words and shortenings of heavy syllables. From the constraint based account the idea is that in order to learn the Finnish system, structural constraints striving for unmarked characteristics such as bisyllabic word form or CV-syllable structure will in time be ranked low enough to allow longer words and heavy unstressed syllables into the child's grammar.

Phonotactically Finnish is characterised by complex consonant sequences in coda position and across syllable borders, but not in onset positions. Phonotactical complexity arises also from the eighteen diphthongs in which 4

as well as in all vowel combinations within a word 4 Finnish vowel harmony plays a role. In this study concerning phonotactics I will mainly concentrate on consonant sequences and diphthongs. Phoneme level is analysed mostly from the point of view of phonological context. In addition, I will endeavour to investigate the interplay of different types of phonological elements.

The effect of a child's mother tongue can be seen from the very earliest stages and thus it is essential that the characteristics of the language being learned are taken into account in studying language acquisition. However, it is of interest in this study to find out how a phonological theory which aims to define universal constraints can account for Finnish phonological acquisition.

Phonological quantity distinction as a special characteristic of Finnish was the topic of Richardson's (1998) study. She investigated how children at risk for dyslexia and their controls perceive durational information as early as 6 months of age. In addition to perception, she studied how the children produce quantity distinctions at the age of 18 months. Her findings showing that at-risk children indeed had more difficulty with quantity distinctions have had an impact on this study.

The term dyslexia refers to a reading and writing difficulty, which runs in a family; it is not caused by cognitive or social factors but is a specific problem for the individual in encoding and writing texts. The mystery of dyslexia has interested researchers and it is currently assumed that the problems lie in the processing of phonological information. Since dyslexia can not be diagnosed until school age when reading and writing difficulties emerge, thus far it has not been possible to prevent it before the problems actually appear at school. However, as researchers find out the different factors implicated in familial dyslexia, one comes closer to defining the symptoms at an early age, which will enable the development of specified training methods.

In the remaining of this chapter I will first introduce the basics of Optimality theory from which the concepts for analysing the production of word structures are mainly drawn. I will then present the main hypotheses of causes of dyslexia and the studies on early precursors. Finally, I will bring these two perspectives together and present more specifically the main research questions of this study.

## 1.2 Optimality Theory

In the 90's Optimality Theory (OT) (Prince and Smolensky 1993) spread across the area of phonology.[2] Kager (1999) emphasises that although most of the research within OT has been on phonology, and especially prosody, it is a general theory of grammar. Child phonology has been one of the research areas from the beginning (e.g. Gnanadesikan 1995; Demuth 1995; Pater 1997; Bernhardt & Stemberger 1998; see Kehoe & Stoel-Gammon 1997). Some OT analyses of Finnish have also emerged, for example, Harrikari (2000) has

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[2]    For a short introduction of Optimality Theory see Archangeli (1997).

studied segmental length in Finnish, Elenbaas (1999) the stress system in Finnish and Ringen and Heinämäki (1999) vowel harmony. There are also studies on morphological issues by Anttila (e.g. 1997). Besides general consideration of applying OT into child language acquisition (Leiwo et al. 1999) to my knowledge thus far, there are no OT studies on Finnish language acquisition.

Optimality Theory is an extension of Generative Grammar focussing on formal description and on universal principles. Nonetheless, it differs from earlier generative theory in that it assumes universal constraints to be violable. Kager (1999: preface) emphasises the interaction of constraints: "Optimality Theory is not a theory of representations, but a theory of interactions of grammatical principles." The core of OT is thus violable, universal constraints. The basic idea is that a surface form is the result of constraint conflicts, or in other words, rankings. Differences between languages are due to language-specific rankings of the same set of universal constraints. These constraint hierarchies choose the optimal surface form, which means that it incurs the least serious violations. (Kager 1999: preface.) In other words, the optimal pronunciation of a word does not violate the very important constraints but it violates the less important constraints (Stemberger & Bernhardt 1997: 215).

The violable nature of constraints and their different rankings enables the description of a child's developing and continuously changing phonology. Different constraint types shed light on this matter: OT makes a difference between constraints that deal with the relationship of input and output (Faithfulness constraints) and those concerned only with the output (Structural constraints). According to Levelt and Van de Vijver (1998) input is assumed to be similar to the adult output except for some perceptual loss (see also Pater 1997: 208). Structural constraints require unmarked features for the output and Faithfulness constraints require similarity between input and output. In the early stages of phonological development constraints on structure of output are ranked high, but in the course of phonological development, a child's word forms gradually come to better resemble adult forms, indicating that the so-called Faithfulness constraints (that input and output should be identical) become more highly ranked (Gnanadesikan 1995: 1; Levelt et al. 1999: 294; Pater 1997: 210). In fact, Hayes (1999: 27) notes that the initial low ranking of Faithfulness corresponds to the child's inability to say anything at all.

Structural constraints are related to markedness in the way that they reflect the unmarked features of universal grammar. According to Kager (1999: 3–4) unmarked values are cross-linguistically preferred in all grammars and marked values are cross-linguistically avoided and used by grammars only to create contrast. Markedness is thus a relative concept: a marked element is ill formed only in comparison to other linguistic elements. It is also based on articulatory and perceptual systems. (Kager 1999: 3–4.) Perhaps due to the basic observation that children's forms are typically unmarked as compared to adult target forms, the idea of constraints is not new in the acquisition field (Pater 1997: 210; see e.g. Menn 1978; Nettelbladt 1983). In the course of development, as the child's productions becomes more similar to an adult's pronunciation,

more marked structures emerge and in OT this change is described by a reranking of the constraints in their hierarchy.

One of the main differences between OT and earlier constraint based views of phonological acquisition is that when a child overcomes a constraint which simplifies the structure of a word, the constraint is not completely turned off. Rather, it will continue to be satisfied only when it does not come into conflict with any other more highly ranked constraint. This means, that constraints in a child's phonology also play a role in the adult system, although the constraint hierarchy is different and the effect of constraints may not be as visible. (See e.g. Pater 1997.)

Besides unmarkedness, variability is characteristic of child phonology. Although general developmental trends and patterns can be described, variability occurs both inter- and intra-individually. Kehoe & Stoel-Gammon (1997: 141) argue that the advantages of constraint based theory lie in the violable nature of universal constraints which accounts for intersubject differences and is expressed through constraint ranking.

Stemberger and Bernhardt (1997: 212–213) discuss the differences between OT and a process-based framework (e.g. Stampe 1973; Ingram 1976). They say that in a process approach the focus is on the differences between the child and adult forms, while OT draws attention not just to differences between child and adult pronunciations, but also to similarities. For example if the word *big* is pronounced ΨΘβ in a process framework one talks of Final Consonant Deletion. Stemberger and Bernhardt point out that although this is useful, it ignores the matches between the adult and child forms. According to them, OT requires us to examine the child's pronunciation of words as reflecting the child's phonological system and it also requires us to focus on the matches or differences from the adult's system. (Stemberger & Bernhardt 1997: 212–213.) In Bernhardt & Stoel-Gammon (1994) it is suggested that although phonological process analysis can describe some aspects of child phonology, its basic weakness is that it only describes error patterns which occur in the child's productions.

Processes could be understood as results of constraints: they are strategies the child uses in order to satisfy a constraint. Thus investigations of production strategies and processes may reveal the constraints behind them. For example, if the child says ΨΘβ instead of Ψℨβ the constraint causing Final Consonant Deletion is a constraint preventing codas (a). This constraint, in this case, is more highly ranked than the Faithfulness constraint (b). This example also shows a child's preference for unmarkedness. (For the definitions of constraints see Kager 1999: 67, 94).

    a) NO-CODA
       Syllables are open.

    b) MAX-IO
       Input segments must have output correspondents.
       ("No deletion")

In this study, the constraint in (b) is mostly expressed as a general faithfulness constraint. Some phonetic syntagmatic processes may indicate that the child is overcoming the constraint although is not yet able to produce a complete match. Nettelbladt (1983: 68) proposes processes called temporal spacing and effortful articulation. The former refers to a pause between syllables and may be related to the lack of timing control, the latter indicates "strong" articulation and may be related to muscular effort (Nettelbaldt 1983: 68). A pause between syllables may help the child to produce, for example, a complex consonant sequence.

Besides processes, production templates have been used to explain children's deletions of phonological elements. Gerken (1994) proposes a hypothesis for a metrical S(W) template stating that children have a template for producing a strong, stressed syllable followed by an optional weak, unstressed syllable. Kehoe and Stoel-Gammon (1997: 114, 139–140) argue against this template hypothesis because it is unable to explain English speaking children's tendency to preserve the final unstressed syllable in their truncations of longer words. They point out that the template hypothesis does not take into account prominence, edge-based factors and segmental effects. Kehoe and Stoel-Gammon also argue for OT with its promising way of explaining these effects by constraint interaction.

Although OT is based on traditional concepts like universality, constraints, markedness and on concepts of nonlinear phonology, it has brought forth a new type of formalism. Bernhardt & Stemberger (1998) criticise the standard formalism and present a revised version of it, e.g. by renaming constraints. Although many of the changes they suggest are well motivated I will use both the constraint names suggested by them as well as those typical to most of the works in OT.[3] In addition, elaborate constraint tables typical to OT are not constructed in this study. The purpose is rather in finding the constraints which characterize Finnish grammar and child's phonological system.

## 1.3  Dyslexia

This study examines the possible signs of developmental dyslexia in language production. In contrary to the term *acquired* dyslexia, referring to dyslexia that is caused, for example, by an injury to brain, the term *developmental* is used here to refer to the dyslexia type that an individual has had from birth. Estimations of dyslexia's frequency range between 3 to 15 percent of the population (Richardson 1998: 17). The fact that dyslexia tends to run within families, or in other words, the fact that about half or more of the dyslexics have a familial

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[3]  For the discussion of this matter and for a review of Bernhardt's & Stemberger's *Handbook of Phonological Development from the Perspective of Constraint Based Nonlinear Phonology*, see Pater (1999).

background of dyslexia (e.g. DeFries & Gillis 1991; Lyytinen et al. 1995) has enabled the selection of at-risk children in the JLD-project, by screening parents who have self-reported reading and writing problems.

Since dyslexia is a complicated and still very much unsolved phenomenon which is studied within several scientific disciplines, from neurology and cognitive psychology to special education and linguistics, I will here point out only the relevant aspects for the present study. For a more detailed introduction of dyslexia from the point of view of the JLD-project see e.g. Richardson (1998).

Researchers agree on dyslexia's heritable nature, but the exact cause of developmental dyslexia is still unknown and thus an exclusionary criteria is often used in definitions. The following definition is from Scarborough (1990: 1728) but the core of the definition summarises the proposal made previously to members of a congress of neurologists by Critchley (1970):

> Dyslexia, or reading disability, refers to severe reading problems that cannot be attributed to sensory, intellectual, emotional, or socio-economic handicaps or to other known impediments to learning to read.

Catts (1989a) notes that the exclusionary nature of this type of definition makes it hard to identify dyslexic individuals, as the presence of reading difficulties is the only sign of the disorder. Consequently, by the time of diagnosis the children have already experienced academic failure (see also Scarborough 1990: 1728).

Several proposals have been made about the causes of dyslexia over the years. Examples of these proposals range from impairments in the visual system to impairments in the formation of general cognitive skills and to defects in temporal processing. However, since many studies have proved a correlation between phonological skills and later levels of reading achievement, the most common suggestion as to dyslexia's cause is that it is a linguistic deficit with a primary impact on the phonological system. (Locke et al. 1997: 72473.) It is also proposed that a phonological deficit hypothesis is incomplete since slow naming speed also accounts for reading disability. Wolf and Bowers (1999) have proposed the so-called double-deficit hypothesis in which slow naming speed is independent from the phonological deficit. [4]

Locke et al. (1997: 72474) outline three main language-related deficit models explaining dyslexia. The first posits a linguistic deficit, and more specifically a phonological deficit, in which dyslexic children have been found to have problems with metalinguistic awareness in tasks concerning, for example, segmentation or manipulation of the sound units (phonemes, syllables) in words (see Catts 1989a). A second view extends the phonological deficit hypothesis; there is a defect in the representation of speech or in the perceptual system that creates and manipulates them. More specifically, Elbro, Borstrøm & Petersen (1998) hypothesise dyslexia as a phonological disorder in which problems in processing phonological information may be due to a fuzzy

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[4]     On the history of the investigations of dyslexia see  Fawcett & Nicholson (1994: 14) or Seymour (1986).

representation. According Elbro et al. (1998) this kind of deficit can influence the acquisition of phonological recoding in reading via the development of phonemic awareness. From the point of view of perception, an auditory temporal deficit in perceiving speech and nonspeech sounds is suggested by Tallal (1980; for discussion of this suggestion see Studdert-Kennedy & Mody 1995). Also Richardson's (1998) results suggest that dyslexics have got problems in perceiving temporal, and in fact durational information. A third model links dyslexia beyond phonology to a wider range of language dysfunctions, for example to syntactic analysis (e.g. Scarborough 1991).

To combine various suggestions about the deficits underlying dyslexia, Catts (1989a: 56–57) has formulated the following definition for dyslexia:

> Dyslexia is a developmental language disorder that involves a specific deficit(s) in the processing of phonological information. The disorder is generally present at birth and persists into adulthood. A prominent characteristic of the disorder is a specific reading disability. Preceding, accompanying, and following this reading disability, the disorder manifests itself in various difficulties in phonological coding, including problems in encoding, retrieving, and using phonological codes in memory. In addition, difficulties may be observed in speech production and in the metalinguistic awareness of speech sound segments.

Although the research on dyslexia is abundant, the investigation of its precursors before school age is more limited. Since dyslexia appears only in reading and writing but not in speech 4as is perceived in ordinary communicative situations with dyslexic children and adults4 the gap between the symptoms of dyslexia (such as mistakes in writing) and oral speech productions seems at first to be large. However, the processes of oral and written language production are both related, since just as speech is made up of strings of abstract, meaningless phonological units, so visual representation of words are arbitrary and provide no meaning directly (Libermann 1985, according to Richardson 1998: 14). Also Catts (1986) suggests that deficits in phonological processing which appear as problems in reading, should also have some effect on oral language. A more precise connection between oral language production and the symptoms of dyslexia for this study arise from an extensive study by Richardson (1998) within the JLD-project.

Since it is typical for Finnish dyslexics to make mistakes in marking the phonological quantity distinction orthographically,[5] the aspect of studying the perception and production of quantity in Finnish dyslexics was pointed out by Lyytinen et al. (1995). In addition, earlier studies have shown that dyslexia may be related to perception of durational or temporal information (e.g. Tallal 1980). As these perspectives are taken together with the goal of searching for early precursors of dyslexia Richardson (1998) studied the at-risk and control children's ability to perceive durational information as early as 6 months of age. The study revealed significant differences between the two groups of children: the at-risk children needed longer durational time in order to categorise a

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[5]    In Finnish, short quantity is marked with one letter and long with two letters, e.g. *kuka* 'who', *kukka* 'a flower'.

sound as long. The groups also differed in their ability to produce quantity distinctions at the age of 18 months. The same tendencies were found in dyslexic adults and their controls (parents of at-risk and control children). Thus, relevant for the present study is that the problem of dyslexia is indeed reflected in speech production and that this relationship can be grasped by careful experimental method.

Richardson examined 6 month old infants, but even earlier results regarding the age of at-risk subjects are reported by Leppänen (1999) who examined the brain responses (ERP) to speech stimuli of new-born at-risk and control infants also in the JLD-project. Both Leppänen's and Richardson's results concurred that there were significant differences between the at-risk and control groups.

Perhaps the most extensive follow-up study is that of Scarborough (1990) who investigated high-risk children from the age 2;6 onwards and used data from spontaneous speech. She found that dyslexic children made more errors in the production of consonants. From the first 100 identifiable words in the data of each child, omissions, additions, substitutions and transpositions of consonants were counted. Based on the coding, she concluded that dyslexic children are less accurate in consonant production, but she does not report more specifically what kind of accuracy failures appear. Besides consonant production accuracy, dyslexic children had simpler sentences, and later, at the age of 3 or 4, vocabulary deficiencies, poor rhyme recitation skills and worse phonemic awareness skills.

Since Scarborough's findings suggest that there may be signs in spoken language development that can be used to anticipate dyslexia in individual children, Locke et al. (1997) studied spoken language through play sessions of potentially dyslexic (PD) children with an average age of 15 months. In phonetic analysis based on transcriptions, they investigated the number of consonant clusters in utterances. An interesting finding related to the present study is that although the difference was not statistically significant, 6.9 % of the utterances in the PD group included consonant clusters, whilst the proportion in the control subjects was 10.9 %. Similar tendencies, controls outscoring PD subjects but not significantly, were also found in syntactic analysis by using the IPSyn method at the age of 30 months. This may indicate that the linguistic deficit is not limited to phonology (Locke 1997: 89; Scarborough 1990), which in fact could be expected when dimensions of language such as phonology and morphology are so interwoven with each other.[6] Locke et al. (1997) also found significant differences in pre-literacy measures before entry to kindergarten in auditory discrimination, rhyme production and naming letters.

Gallagher, Frith & Snowling (2000) used a retrospective analysis of children who were tested at the ages of 45 months and 6 years. The at-risk children who scored below the normal range at age 6 were classified as literacy

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[6]    In Finnish, for example, a type of case ending for a word is chosen on the basis of vowel harmony, e.g. *talossa* 'in a house', *kädessä* 'in a hand'.

delayed. These children scored more poorly in tests at the age of 45 months on several language measures, for example, in letter knowledge, expressive vocabulary development and in expressive language, which included ideas recalled from a story. They also found that the literacy delay group performed more poorly than the control group (but not significantly worse than the literacy normal at-risk children) in sentence length.

Besides studies on early precursors, an interesting result regarding the hierarchical word structure model used in this study is by Catts (1986). Through studying naming, repetition of multisyllabic words and phrases among reading disordered children (mean age 14 years, 3 months) he found out that the reading disordered children made significantly more errors in all tasks, for example, by omitting or substituting segments. Catts (1986) pointed out that these phonological errors in production seemed to be word-specific rather than misarticulations of same sound segment(s) across words. He concluded that reading disordered children may thus often have difficulties in encoding the phonological detail of multisyllabic words. Moreover, this is in line with Snowling's (1981) conclusion that reading disordered children have problems in determining the precise order of phonemes in words, which causes problems especially in phonologically complex words. This type of result emphasises the importance of the syntagmatic aspect within phonological analysis. In this study word specific analyses are conducted in order to find out whether at-risk children's potential phonological deficit is reflected in early phonological production. In these word analyses phonological complexity is taken into account, for example, by examining the production of multisyllabic words.

## 1.4   Main research questions and outline of the study

Since the purpose of this study is to construct a hierarchical and constraint based model of the acquisition of Finnish word structures, the main research questions concern the production of phonological elements at different hierarchical levels in different groups of children. The hierarchical levels include word and syllable level, phonotactics and phoneme level. From the point of view of phonological theory, the main research question is which constraints can be used to explain the phonological processes found at each hierarchical level in children's productions.

In addition to this general aim, I will here more specifically address the hypothesis and research questions concerning dyslexia in this study. The starting point is that familial dyslexia may involve impaired phonological development. What this phonological deficit might more specifically be, is not a focus of this study. Instead, the aim is to investigate how it may manifest in phonological production during language acquisition. However, a hypothesis based on Richardson's (1998: 179) finding is that dyslexics' problems with categorisation and representation are due to indistinct perception of durational

information. If this kind of problem in perception leads to indistinctness in phonological representation, it may also cause problems in production during the first years of phonological development (c.f. Elbro, Borstrøm & Petersen (1998). Richardson's study revealed that there were indeed differences between the groups, not only in the categorisation of quantity but also in production of the quantity distinction at the age of 18 months, in an imitation task. But could these problems be somehow also manifested at a later age in other aspects of word structure, in syllable number and heaviness, phonotactics or in specific phonemes?

The extension of the hypothesis has to do with the assumptions within the phonological theory of this study. The main idea in this study is that of hierarchical aspects of word structure: prosodic elements govern phonotactic and segmental phenomena. For example, heavy CVV-syllables precede diphthongs. Quantity distinction in Finnish has to do with the relative length of segments within a word. In addition to phonological distinctions in moraic structure there are phonetic, durational differences between segments. These differences depend on whole word structure, e.g. final vowel in CV.CV structure is longer than in CVC.CV structure (Lehtonen 1970: 111). This led us to think that the at-risk children may have more problems with the whole word structure in general, that is, not only in quantity distinctions but the overall syntagmatic structure of the word. More specifically, as quantity has to do with prosody, it is hypothesised in this study that also other types of prosodic aspect such as the interaction between syllables and stress may be problematic. In addition, prosodically marked features may be especially problematic in production, for example extrametrical syllables in longer words or heavy unstressed syllables. From the point of view of constraints, there is evidence that strong prosodic constraints are more detrimental in phonological disorders than segmental problems (Nettelbladt 1983). From these aspects a hypothesis concerning dyslexia in this study is that constraints on prosodic structures are stronger in children at-risk for dyslexia.

Prosodic complexity is connected to syntagmaticy and thus the hypothesis is extended to include syntagmatic complexity in general, including complex consonant sequences and diphthongs. In other words, the main hypothesis in this study is that the at-risk children may have more problems in the production of prosodically or otherwise syntagmatically complex structures in words, such as complex consonant sequences, and that this is due to fuzzy representations of word structures. In fact, Catts (1989a; 1989b) has reported, that dyslexic subjects were slower and /or less accurate than normally developing subjects in the rapid and continuous repetition of complex speech sound sequences. Based on these findings, he concluded that dyslexics' phonological coding deficits may disrupt phonological programming during the planning stages of speech production.

It may be, however, that manifestations as in Catts study appear only in experimental situations. This would mean that the at-risk children do not deviate noticeably from controls in everyday language use. The method used in the present study is a test situation. On the other hand, an experimental naming

task, when carried out in a book reading situation, is a familiar situation for the children. Thus, by using this method it is more likely that the possible differences may be revealed than for example in a spontaneous play situation. However, it is less likely that the possible differences may be revealed by this method than by pure experimental methods, e.g. by repetition of nonwords or rapid and continuous repetition of sound sequences as in Catts (1989b) study.

To summarise, it is hypothesised in this study, that words are perceived as wholes and hence, based on Richardson's results, children at-risk for dyslexia have more problems in the accurate identification of prosodic whole word structures. Moreover, this inability is reflected in phonological acquisition, especially in identification and production of prosodically 4as well as phonotactically4 complex word structures. This deficit may be realised as simpler word structures produced by at-risk children than by children without a genetic risk for dyslexia.

Despite the main focus being on group comparisons of at-risk and control children, the analyses of late talkers as well as of poor, middle and good readers based on tests at age 7, are integral to this dissertation. In general, similar research questions and hypotheses concern these groups of children as at-risk and control children. Late talkers in this study are hypothesised to have more problems in the production of complex structures. In other words, prosodic as well phonotactic constraints are more highly ranked in their grammar than in that of others. A retrospective analysis of poor, middle and good readers similarly concerns the production of phonological elements at different hierarchical levels in a word. The hypothesis is that the children who were behind their peers at the onset of reading are less advanced also in early phonological skills. This analysis sheds light on the general connection between reading skills and early phonology. If the poor readers at age 7 prove to be less advanced in early phonology, it is of importance which specific elements in a word's structure were most problematic. The main research questions are summarised below:

1. How do Finnish children at age 2;6 produce different phonological elements at word and syllable level, at phonotactic and at phoneme level?

2. Which constraints can be used to explain the variation and phonological processes found at different hierarchical levels in children's productions?

3. Are the children at-risk for dyslexia phonologically less advanced than control children at age 2;6? If they are, which specific phonological elements are most problematic for them?

4. Which phonological elements are problematic for late talkers? Which constraint can be used to explain the patterns found in their word production?

5. Are the poor readers who were less advanced in a test measuring reading skills at age 7 less advanced also in their early phonology at age 2;6? If they are, which specific phonological units are most problematic for them?

The study will proceed from a theoretical modelling of word acquisition to data analyses. In chapter 2, I will first present the prosodic hierarchy inherent to most of the phonological studies concerning prosodical elements and then proceed to review previous studies which have been based on a hierarchical perspective of word structure. I will also present the hierarchical model used in this study. Each level is discussed from the point of view of the Finnish phonological system and constraints. In addition, more specific research questions concerning each level are presented after the description of each level.

In chapter 3, the selection of subjects as well as data collection procedure are reported. Chapter 4 includes the word specific analyses from bisyllabic target words to tri- and four syllable targets. Chapter 5 is a more general application of the hierarchical acquisition model and word specific analysis. In it children's productions are scored for statistical analyses of groups.

# 2    A HIERARCHICAL AND CONSTRAINT-BASED MODEL FOR THE ACQUISITION OF WORD STRUCTURES

In this chapter I will first discuss the topics which outline the hierarchical and constraint-based model for the analysis of word structures in this study. The hierarchical perspective for this study is drawn from nonlinear phonology, from so-called Prosodic Hierarchy that differentiates between different levels, or tiers, of word structure. In addition a syntagmatic perspective, which takes into account the phonological environment, is inherent in the model. I will also introduce child language studies in which a word is seen as a hierarchical structure. The hierarchical levels used in this work are further specified in chapter 2.3. in which I will also discuss the possible constraints behind the typical production types regarding each level.

## 2.1  The word as a unit of acquisition and its prosodic structure

This study focuses on the phonological structures of words in children's productions. An earlier view on children's words was that they were sequences of individual phonemes (Menn & Stoel-Gammon 1995: 345), thus the phoneme was seen as a basic unit of acquisition. However, currently a word is considered to be the earliest phonological unit in language acquisition instead of an isolated phoneme (Menn & Stoel-Gammon 1995: 345; Nettelbladt 1983: 19). Also, over the last decades a hierarchical (autosegmental) perspective on early word structures has emerged and recently researchers have started to focus on prosodic aspects of acquisition (see Demuth 1995; Vihman 1996: 7) which has led to a focus on larger phonological units, for example on foot structure within a word.

There have been some suggestions that the syllable may also be the basic unit but according to Menn & Stoel-Gammon (1995: 345) this is not the case in

the sense that young children can not freely combine syllables to produce words: CVCV-words have restrictions on both consonants and vowels. Chiat (1979: 603) notes that usually the phonological changes in a child's productions do not eliminate the integrity of a word, that is, processes usually do not apply across word boundaries. This would also speak for the view that a word is a consistent, basic unit of acquisition. Peters (1983: 2) suggests that a unit of early speech production may also be a multimorphemic phrase or sentence that forms a single item in the child's lexicon. This might be true in earlier stages of language development but in this study, children being 30 months old, it can be assumed that lexical and phonological knowledge is already quite advanced for most of them.

A more accurate view of the word as a basic unit of acquisition is the concept of a minimal word which sets a lower bound on word size (McCarthy & Prince 1995; see Demuth 1996: 6; Pater 1997: 205): A minimal word must contain at least one binary foot which can be composed of either two syllables (e.g. CVCV) or two moras (e.g. CVV, CVC). Pater (1997: 208) notes that for children, during the time that syllable quantity has not yet emerged, the minimal word is composed of bisyllabic feet rather than bimoraic feet. Bernhardt and Stemberger (1998: 198) consider the minimal word from the Optimality theoretical point of view and see it as a consequence of constraint interaction and not as a constraint itself: constraint FTBIN states that feet are binary either at moraic or at syllabic level and NotComplex(PrWd) limits a word to one foot:

> FTBIN
> Feet are binary under moraic or syllabic analysis (Kager 1999: 156).

> NotComplex(PrWd)
> A prosodic word may contain only one foot (Bernhardt & Stemberger 1998: 468).

Even if the minimal word for Finnish children could also be bisyllabic rather than bimoraic, a minimal word in Finnish can actually be both CVV or CVCV, e.g. *luu* 'bone', *tuli* 'fire' (e.g. Elenbaas 1999: 101). In Finnish children's early productions bisyllabic forms dominate and this is the case also in their mother's child directed speech: In Kunnari's (2000: 53) analysis of mothers' speech 54.3 % of the words were bisyllabic. Bisyllabic words are also the most common type of word structure in Finnish, and in addition to syllable number, the second syllable is an open CV-syllable in most cases, e.g. *käsi* 'hand', *koira* 'dog'. Monosyllabic bimoraic words are rare in the lexicon but they are amongst the most common words, e.g. *hän* 'she/he', *jos* 'if'. (See Karlsson 1983: 217.)

The way in which the concept of the minimal word takes into account prosody reflects the change in phonological studies in the 70's. Perhaps one of the first to emphasise the prosodic aspect of child phonology was Waterson (1971; 1987: 25). Prosody, together with autosegmental (Goldsmith 1976), or so-

called nonlinear theory,[7] formed a new perspective in the studies of phonological acquisition. Menn and Stoel-Gammon (1995: 355) summarise the core of these approaches: a word is seen as a complex of simultaneously occurring events. According to Vihman (1996: 39) the first to describe some issues of child phonology by using nonlinear model was Menn (1978). The latter says that the benefit of autosegmental theory is that it is possible to look beyond segments to syllables and words (Menn 1978: 166). For a hierarchical approach to word structures, autosegmental phonology provides widely accepted concepts, which are also used in OT (Kager 1999: 146). The main point in autosegmental theory is that phonological elements are represented on separate horizontal levels called "tiers" and that the elements are simultaneous if an association line connects them (Goldsmith 1976; Bernhardt & Stemberger 1998: 75–76; Menn & Stoel-Gammon 1995: 355).

Prosodic Hierarchy by Selkirk (1980) (also Nespor & Vogel 1986) combines the hierarchical and prosodic aspects and also provides concepts for this study from mora to syllable and foot level :

Pw (Phonological word)
√
Ft (Foot)
√
ω (Syllable)
√
σ (Mora)

There are, however, slightly different ways of picturing the phonological word and syllable structure (see e.g. Bernhardt & Stemberger 1998; Bernhardt & Stoel-Gammon 1994; Broselow 1995). Differences arise for example in the concept of timing unit: instead of the mora, some models use CV or X –tiers. If we look at the hierarchical structure of the word *kenkä* 'shoe' in Finnish (see Figure 1 below) starting from the segments,[8] so-called timing units indicate that a segment is present. In the picture below, the concept of a mora is used, but there are several proposals about the nature of timing units. First, the so-called skeletal CV-tier makes a distinction between syllabic and nonsyllabic timing units, and secondly, a variant of the CV-tier called the X-tier[9] only refers to the pure unit of time and the feature Ϋsyllabicβ is not part of it. (Bernhardt & Stemberger 1998: 105–107.)

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[7] Besides the terms autosegmental and nonlinear phonology, the term multilinear phonology has also been used for this approach, see Bernhardt & Stemberger (1998: 75) for discussion.

[8] In nonlinear theory features of segments are united by Root nodes, which serve as an anchor for the features defining a segment, in other words, segments themselves have an intrasegmental hierarchical structure (Broselow 1995: 175; see Vihman 1996: 39).

[9] According to Broselow, the cases from different languages show that the empty slot can be filled either by vowels or consonants and this again raises the question of how skeletal slots should be defined: by X-slots or by more specific C/V –slots (Broselow 1995: 183.)

PrWd

Ft

ω ω

σ σ σ

k e ξ k ä
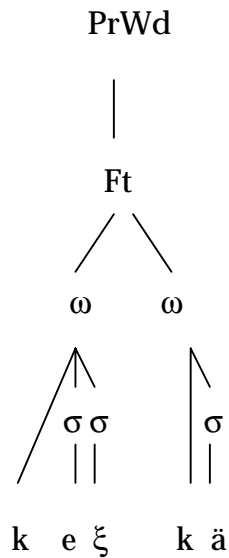
FIGURE 1 An example of prosodic structure in a Finnish word *kenkä* 'shoe'.

A third view on timing units is moraic theory (see Kager 1999: 147) which differs from CV- and X-theory in that onsets do not have moras although consonants in coda position do have moras, that is, a skeletal tier assigns a slot to each segment, but a moraic tier assigns a slot (a mora) only for segments in weight-bearing positions as seen in examples below (Broselow 1995, 1996: 193–195). A known phenomenon, compensatory lengthening, illustrates the existence of timing units. In compensatory lengthening a deleted segment leaves a "trace" which is filled by the spread of another segment (Broselow 1995: 183, 194). The following pictures illustrate compensatory lengthening in Finnish language acquisition through a typical example from the word *kenkä* 'shoe' (production example from Iivonen 1994: 56). (b) shows the empty timing slot, a deletion of /ξ/ which is perhaps due to avoidance of the consonant sequence /ξk/, and in (c) this slot is filled by lengthening of the preceding vowel /e/.

(a)  (b)  (c)

ω ω  ω ω  ω ω

σ σ σ  σ σ σ  σ σ σ

k e n k ä  k e k ä  k e e k ä
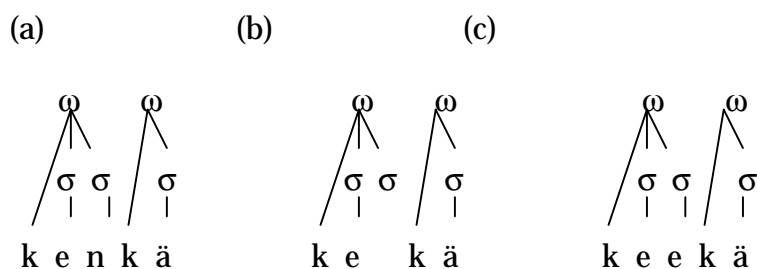
Syllables link the segments together and as a prosodic unit it is one on which phonologists agree. It is also usually easy for native speakers to count the syllables in a word. Again, syllables are linked to feet. The foot has to do with the stress of the language; some syllables are more prominent (stressed) than others and this creates the rhythm of the language. Finally, the ultimate organising node is called the Prosodic word. It can include several feet but it

usually has one primary stress (Bernhardt & Stemberger 1998: 110, 1184119, 121.) In early phonology children may have limitations on the maximal size of the word but in Finnish there does not seem to be an upper bound for word size since long words are common due to agglutinative inflection.

Syntagmaticy was pointed out by Chiat (1979: 605) who proposed that in the early stages of phonological development syntagmaticy has priority over paradigmaticy. In Finnish child phonology studies, Iivonen (1994) has emphasised the syntagmatic perspective. He mentions that syntagmaticy has to do with linearity in language, the way in which phonemes and syllables interact, and paradigmaticy, on the contrary, refers to the acquisition of individual phonemes. In this study syntagmaticy and prosody are connected through the way that the former includes the latter: prosody deals with units of language which are larger than segments, so-called suprasegmental units.

In the process framework a difference is made between paradigmatic and syntagmatic processes. Paradigmatic processes, for example phoneme substitutions, deal with changes in phonemes and are context-free whereas syntagmatic processes such as assimilations or syllable deletions are context-sensitive. In early phonology paradigmatic processes are more invisible due to many extraction processes. As Nettelbladt says, during phonological development, paradigmatic processes become more salient as syntagmatic processes become less pervasive. In her study on dysphonology she found out that children with more severe dysphonology were characterised by strong syntagmatic restrictions, for example by reduplication. (Nettelbladt 1983: 65, 155.)

Stoel-Gammon (1996: 77) argues against pure phoneme based analysis because it ignores contextual effects; she specifies examples in which the environment affects phoneme production:

1. Position within the word: Phonemes are often produced more accurately in word-initial position.
2. Word length: Pronunciation is often less accurate in longer words.
3. Position of stress (prominence): Phonemes in stressed position tend to be produced more accurately than in unstressed position.
4. Phonetic environment: Production of phonemes may be influenced by neighbouring phonemes.
5. Grammatical role: Phonemes in content words are often produced more accurately than in function words.

Her arguments point out that in fact there may not be pure paradigmatic, context free, processes concerning phonemes. Instead, phonological context in a word may affect the production of an individual phoneme. Perhaps pure paradigmatic processes only deal with articulatory problems, or distortions, mainly in the final stages of phonological acquisition when paradigmatic processes become more visible.

In addition to syntagmaticy, the concept of phonotactics is traditionally used to refer to the conditions facilitating well-formed phonological words (Goldsmith 1995: 1). In this study the term phonotactics is used in the context of

diphthongs and consonant sequences and syntagmaticy is used in referring to combinations of phonological elements in a broader sense.

## 2.2 Hierarchical models in acquisition studies

Based on the hierarchical models of a word's internal structure, the interplay of the elements such as phonemes, moras, syllables and feet should not be ignored in the phonological analysis of child language. As Kehoe and Stoel-Gammon (1997: 139) say, prominence effects such as stress, word edges, syllable structure as well as segmental factors play a role in forming the content of child's productions. In this study I attempt to capture the interaction of different phonological elements by specifying the levels of word structure that could be relevant in describing the data in this study, and also by determining the possible constraints causing syntagmatic processes in the child's production compared to that of an adult.

Stoel-Gammon (1996) has applied the hierarchical structure to an analysis of child's speech. She examined the number of syllables and word stress, onset–rime and CV structures and initial and final consonants. The similarity for the present model is that at word level she simply looked at the number of syllables in the productions of the subject. Also her investigation of CV structures is similar to the syllable structure analysis of this study. She also took into account the relationships between various levels in the hierarchy, for example, a child's failure to produce a match at CV-level also caused a mismatch at the segmental level (Stoel-Gammon 1996: 82, 85):

|  | Target | Joye's production |
|---|---|---|
|  | /kar/ | ˈkaβ |
| CV-structure | C  V  C | C  V  C |
|  |  \|  \|  \| |  \|  \|  \| |
| Segmental | k  a  r | k  a  ∴ |

The advantage of the hierarchical approach is that it is possible to specify the problematic level for the child, and the investigation of how different levels interact provides a more complete picture of the child's phonological system (Stoel-Gammon 1996: 85).

In her study of Swedish dysphonological children Nettelbladt (1983: 55–58) divides word structure into three different levels: word level, syllable level and segment level. At the word level she examined the number of syllables in children's word productions. For example, the children with severe dysphonology had mostly disyllabic productions whereas children with milder dysphonology also had polysyllabic words.

Like Stoel-Gammon, at the word level she also studied prosodic contrasts in the children's productions. In stress patterns she found that it is crucial for a Swedish speaking child to differentiate between word initial and word final stress. At the syllabic level Nettelbladt examined the syllable shapes (CV, CVC etc.). At both word and syllable levels she studied the co-occurrence and positional restrictions of segments. Co-occurrence restrictions refer to syllable and to consonant and vowel harmony within a word and by positional constraint she means, for example, a case where the child had no consonant contrasts in word-initial position. Finally, at the segment level Nettelbladt studied the consonant and vowel inventory of each subject. She also included contrastive vowel length and diphthongs at this level. (Nettelbladt 1983: 55–58.)

She identified two types of dysphonology in her data: the more severe syntagmatic group and less severe paradigmatic group. According to her, the syntagmatic group was characterised by strong syntagmatic constraints as well as paradigmatic constraints while in so-called paradigmatic group paradigmatic constraints dominated. (Nettelbladt 1983: 172.)

The advantage of Nettelbladt's work is that besides looking at the realised syllable numbers in words, she also defines constraints affecting the child's output, for example harmony restrictions. The model for the current study is an extension of that of Nettelbaldt's. Following her model, a basic differentiation is made between word, syllable and segment level. However, I have added one more level, which I call phonotactics. Within phonotactics I will examine consonant and vowel sequences, mainly diphthongs and consonant sequences.

Demuth (1995) has applied the concept of a prosodic word model to the early acquisition of word structures. She identifies different stages in the development of prosodic word structure: The first stage concerns the production of so-called core syllables (CV). Then a child produces minimal words, which are binary at either syllable or at moraic level (CVCV, CVC, CVV). After this, the productions develop into forms which are larger than the binary foot, and finally, at the fourth stage, productions of the child are match with target forms. The developmental aspect is interwoven into the hierarchical model in this study although cross-sectional data limits the verification of the developmental assumptions.

## 2.3 Constraints on hierarchical levels of word structure

The model according to which children's productions are investigated in this study is based on the syntagmatic point of view in which phonological elements are assumed to interact with each other. A hierarchical emphasis is also inherent in the model: word structure is viewed at several levels, from prosodic features to phonotactics. At the so-called word level footing construction is examined in terms of realised syllable numbers. In this as well as in the analysis of syllable level in terms of moras the target's stress pattern is taken into account. At the phonotactical level I will look at the realisation of diphthongs

and consonant sequences and at the phoneme level, individual phonemes in certain phonological contexts.

There are several goals in designing this hierarchical model of word structure. The first aim is to provide tools to understand how different phonological elements interact in a Finnish child's speech production, in other words, how the children produce different phonological elements in certain word contexts. Secondly, the aim is to create a system, which helps to define a child's phonological skills and enables the comparison of children. In this chapter I will first introduce the general outlook of the model, then I will look at each level more specifically from the points of view of the Finnish phonological system, constraints and  acquisition. I will proceed by attempting to identify the possible difficult elements for children and hypothesise how children possibly solve the problem of producing these complex elements. An explanation for these solutions in terms of constraint interaction either between different Structural constraints or between Structural constraints and Faithfulness constraints will then be critically examined. The production of elements classified as complex at each level will then be analysed quantitatively in results section. The definition of complexity is based on markedness theory and universal phonological constraints.

Besides syntagmatical and hierarchical aspects, a theoretical assumption in examining the production of word structures in this study is that prosodic factors have a strong impact on the word production patterns. I assume that in order to produce specific features correctly the child first has to master the overall structure of the word. This leads to implicatory thinking which means for example, that a prerequisite for producing a coda consonant is the syllable length in moras, e.g. in the first syllable of *lentokone,* 'aeroplane' the child may first produce the required length in moras, as in ʮeetokonEβ (Mikael 2;6), and after this stage he specifies the coda segment. This could be compared to Stoel-Gammon's hierarchical analysis in which she pointed out that a non-match at CV-level caused a non-match at the segmental level (Stoel-Gammon 1996: 82, 85).

The similarity in Stoel-Gammon's (1996) and Nettelbladt's (1983) models is that they both look at the number of syllables in children's productions and intersegmental relationships such as assimilations (see Stoel-Gammon 1996: 92). I look at both word level and phonotactics as well. Although phonotactics is studied in Nettelbladt's model, the difference is that in the present study the phonotactic level is separated at an individual level. The difference in the segment level is that in this model the realisation of certain phonemes is examined in their environmental context, that is, in the specific word, for example /r/ in a word *porkkana.* Nettelbladt studied the traditional phoneme inventory whereas Stoel-Gammon examined phoneme production from a syntagmatic perspective by taking the position in the word into account (word initial–word final).

The following Figure 2 illustrates how the syntagmatic perspective is divided into several levels of word structure, of which certain aspects are chosen to be the focus in the word analyses of this study. The model takes into

account footing construction in the sense that it is assumed that the word's overall syllable number and accompanying stress pattern govern the word structure, regardless of the syllables' segmental content. Here the focus is on longer tri- and four syllable words since they are prosodically more complex than trochaic bisyllabic words. It is expected, for example, that some children may truncate trisyllabic words in order to produce a singe bisyllabic foot. Similarly at syllable level segmental content is not focused on, but rather the heaviness of the syllables in terms of moras. Since word stress in Finnish is fixed on the word initial syllable, there are cases in which heavy syllables appear in an unstressed position later in a word causing a conflict between the stress and heaviness of the syllable, especially in the case of so-called superheavy syllables. Thus the realisation of such syllables are more specifically studied. An extreme example of this kind of word structure in Finnish is *a.vain,* 'key' with main stress on the light initial syllable. At the phonotactic level exact segmental content is likewise not a focus but instead, the realisation of consonant sequences with or without same place of articulation: a heterorganic sequence may be realised even though segmentally the production is not yet target-like, e.g. /lkk/ instead of /rkk/. Similarly a diphthong can be realised although it is not segmentally complete, e.g. /ai/ instead of /au/. Phonotactics in this study focuses on sequences and diphthongs although assimilatory and harmony constraints are also touched upon in the word specific analyses.

The phoneme level is also studied mainly from a syntagmatic point of view, although in some cases the question may be about paradigmatic changes. However, since phonemes are always produced in certain phonological environments I assume that the environment affects the segment's realisation, it could be, for example, that a difficult phoneme /r/ is first realised in a phonologically simpler structure than in a more complex structure. This is also pointed out by Iivonen (1994: 36) as he says that the child may first be able to produce a segment in a paradigmatic sense but is not able to use it syntagmatically in all word structures. Basically substitutions are understood as paradigmatic processes but it may also be difficult to define when the reason for substitution is in fact syntagmatic assimilation or harmony constraints.

| Syntagmatic | 1. Word level | | Four syllable words<br>Trisyllabic words |
| --- | --- | --- | --- |
| | 2. Syllable level | | Heavy unstressed syllables |
| | 3. Phonotactics | | Heter- and homorganic con-sonant sequences<br>Diphthongs |
| | 4. Phoneme level | | Phonemes in certain context |
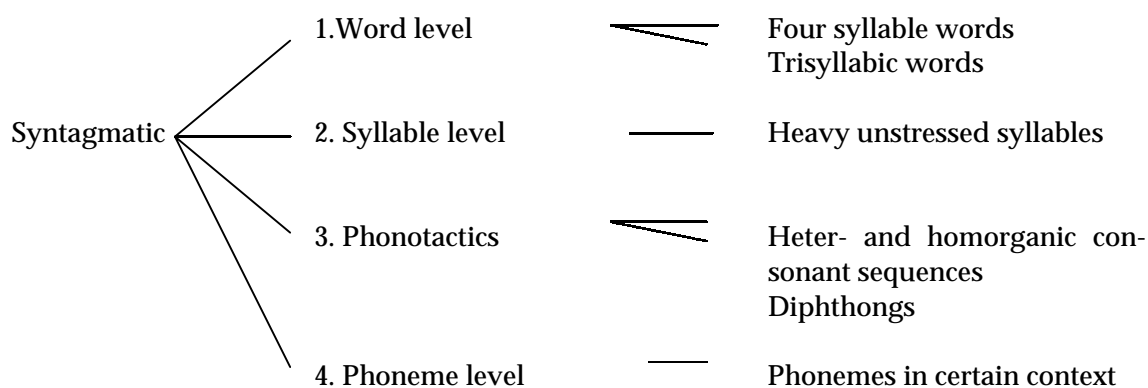
FIGURE 2   Hierarchical levels of a word structure and phonological elements which are on focus in the present study.

Due to the cross-sectional nature of the data, exact developmental paths for the acquisition of word structures can not be shown. The aim is, however, to define children's productions from simple unmarked structures to more target-like marked structures, which possibly reflects developmental changes. In the literature there is some evidence that this type of implicatory analysis could describe a developmental path. An example is from Savinainen-Makkonen (1996: 47) in which she presents Sini's development of the trisyllabic word *ämpäri* 'bucket' (on the left the stages are described in terms of levels used in this study):

| | | | |
|---|---|---|---|
| 1. | Word level not complete: | ˈæpæβ | 1;6:24–1;7:0 |
| 2. | Syllable level not complete: | ˈæ.pæ.iβ | 1;8:0–1;8:1 |
| 3. | Phonotactics not complete: | ˈæpæ.itβ | 1;9:0 (*ämpärit* Plural) |
| 4. | Phoneme level not complete: | ˈæm.pæ.liβ | 1;9:2 |
| 5. | A target-like word structure: | /r/ produced systematically at age 3;6 | |

Savinainen-Makkonen (1996) described the developmental path as follows: first the trisyllabic words truncated to bisyllabic forms, then trisyllabic forms emerged but productions included phoneme omissions. In the third stage the consonant sequence did not emerge but by vowel lengthening the form further resembled the adult form. The consonant sequence then emerged but /r/ was substituted by /l/. In the final fifth stage /r/ was realised. This developmental path includes exactly the same elements I aim to investigate in this study, from a constraint-based account.

The stages in Sini's production of *ämpäri* in this theoretical framework could be explained in the following way: In the initial stages the child's word form was affected by strong prosodic constraints driving for a bisyllabic, trochaic foot form. One extrametrical syllable then emerged but the syllables in the trisyllabic form were unmarked CV-syllables. In the third stage, by vowel lengthening the child achieved the required length of syllables (the bisyllabic form included a bimoraic initial syllable but Sini was not able to preserve it in a trisyllabic form). In the fourth stage phonotactical elements such as consonant sequences emerged which are possible after the required syllable length at the moraic level. Finally the phoneme level was completed by also acquiring /r/ in this context. This means that the development of the word structures could be described in terms of constraints concerning word length in syllables, heaviness of syllables at the moraic level, phonotactics dealing with sequences of consonants and diphthongs and finally individual segments.

Another developmental example by Savinainen-Makkonen (1996: 49) is from the word *appelsiini* 'orange':

| | | |
|---|---|---|
| | Sini: | |
| 1. | ˈæppiβ | 1;3:1, 1;3:3 |
| 2. | ˈæppiχχii.aaβ | 1;6:3 (*appelsiinia* Partitive) |
| | ˈæppeχχiiβ | 1;7:3 |
| | ˈæppeχχi.aβ | 1;8:0 (*appelsiinia* Partitive) |
| 3. | ˈæppeχχiiniβ | 1;11:2 |

In this long word the initial stage was also a bisyllabic form, then the number of syllables increased and with a partitive ending the productions contained four syllables but the stem remained trisyllabic (/a/~/aa/ refers to a partitive ending). Finally the child reached a four syllable stage but the production lacked the phonotactical consonant sequence (Savinainen-Makkonen 1996: 49), and due to that, there was also a non-match to adult forms at phoneme level. Notice also that in this word the prosodic whole word structure in terms of syllable number was realised before the phonotactics.

In the following example I will further illustrate the model according to which children's forms are analysed in this study. As an example I will use the word *porkkana,* 'carrot'*,* which is one of the target words in this study. In the word analyses I will define the relevant elements in each specific word, for example, word level analysis may not be essential in bisyllabic words and syllable level analysis focuses only on words with a  heavy unstressed syllable.

1.  Word level not target-like: *pokka*

    Typically a starting point for Finnish children is a bisyllabic word form. In the initial stages of development, the phonotactics are simple and sequences are usually assimilated.

2.  Syllable level not target-like: *pokkana*

    In early stages of development heavy syllables tend to shorten, at least in an unstressed position. Since syllable quantity is essential for the consonant sequence in this word, the consonant sequence will not appear until the required length emerges.

3.  Phonotactics not target-like: *pookkana*

    As the required length of syllable has emerged, the prosodic structure serves as a basis for more complex phonotactical elements to appear.

4.  Phoneme level not target-like: *polkkana*

    When complex phonotactical elements start to appear, a child may produce a heterorganic consonant sequence but substitute /l/ for /r/. Nevertheless, she produces a complex sequence and is thus progressing phonologically.

5.  Complete, target-like form: *porkkana*

At the final stage, which is here called the phoneme level, the prosodic structures as well as phonotactics are acquired with target-like segment structure. I assume that at the final stages of phonological development only substitutions and other paradigmatic changes appear.

In the following section I will first shortly describe the aspects of Finnish grammar relevant for this study and then discuss the hierarchical levels more specifically, concentrating on the Finnish phonological system as well on possible Optimality Theoretical constraints from the point of view of acquisition.

### 2.3.1 Characteristics of Finnish phonology

Finnish has eight vowel phonemes /a, e, i, o, u, y, ä, ö/. A specific characteristic regarding vowels is vowel harmony. Vowel harmony in Finnish means that vowels are either harmony vowels or neutral vowels. Harmony vowels are divided into front /y, ö, ä/ and back /u, o, a/ vowels. These vowels never co-occur in the same word. However, neutral vowels /i, e/ can be combined both with front and back harmony vowels, e.g. *kesä* 'summer', *kela* 'reel'. [10]

Vowel harmony decreases the number of possible diphthongs. For example, diphthongs such as */oy/ or */äu/ do not exist in Finnish. In addition, the second component of a diphthong is never /a/ or /ä/, thus diphthongs such as /ia/ or /eä/ do not exist (Karlsson 1983: 85). There are, however, eighteen diphthongs in Finnish altogether, e.g. /au/, /yö/, /ei/, /oi/.

Words of Finnish origin include thirteen consonants /p, t, k, d, m, n, ξ, r, l, s, h, v, j/. It is to be noted that /r/ is trilled. The consonant /d/ is often omitted in dialects and it is naturally substituted by /t/, e.g. *radio>ratio* 'radio'. In addition, there are a few consonants which also occur in Finnish, but are not part of the original grammar. /b/ and /g/ appear only in loan words and they are commonly substituted in colloquial speech, e.g. *bussi>pussi* 'bus'. /f/ is to some degree part of the system, because there are words such as *farkut* 'jeans' and *firma* 'firm'. In addition, the pronunciation of /f/ is not problematic for Finnish speakers. However, word-medial /f/ and /ff/ are often substituted in loan words, e.g. *sohva* 'sofa', *kahvi* 'coffee'. To summarise, /f, b, g, š/ are so called marginal consonants. (Karlsson 1983: 57–59.)

Word-initial consonant clusters appear only in loanwords, e.g. *planeetta* 'planet', but are quite common. Instead, complex codas, e.g. *kanssa* 'with', as well as word-medial consonant sequences belong to the original grammar. According to Karlsson (1983: 116) there are at least 57 word-medial consonant sequences in the original vocabulary, e.g. *kanto* 'tree stump', *täplä* 'spot'.

There are ten basic syllable structures in Finnish: (C)V, (C)VV, (C)VC, (C)VCC, (C)VVC. If word-initial consonant clusters are also included as typical syllable structures in Finnish, the number of syllable structures increases by five. (Karlsson 1983: 113–114.)

The phonological quantity distinction is perhaps the best known characteristic of Finnish phonology. It means that short and long quantity in vowels as well as in consonants form minimal pairs such as *tuli – tuuli* 'fire –

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[10]    The issue of vowel harmony in phonological acquisition is being studied in the JLD-project (Leiwo et al. 2000).

wind', *kisa* – *kissa* 'competition – cat'. All vowels and consonants (except /j, v, h/) can be either long or short. Only long consonants are restricted in that they do not occur at the beginning or at the end of a word. The quantity distinction is also visibly marked in Finnish orthography; a short segment is written with one letter and a long segment with two identical letters. (See e.g. Richardson 1998.)

Main stress in Finnish is always fixed on the word-initial syllable and secondary stress falls on every other syllable after that. Final syllables are usually not stressed, at least when light. After the initial trochaic feet, heavy syllables may attract stress which results in partial quantity sensitivity and ternary patterns word-internally. These issues as well as Finnish syllable structure, phonotactics and issues concerning the production of phonemes are more specifically described in the following chapters in the light of Optimality Theory and phonological acquisition.

## 2.3.2 Word level constraints

### 2.3.2.1 Characteristics of Finnish prosody

Overall prosodic structure of a word is comprised of an interplay of syllable number and stress pattern in which also syllable heaviness also plays a role. In this chapter I will shortly introduce those issues of the Finnish phonological system which are relevant from an acquisition point of view to this study.

To summarise the Finnish stress system one could generalise that first of all, the main stress is always on the initial syllable, resulting in a trochaic foot form. Secondly, however, Finnish has both binary and ternary patterns due to partial quantity sensitivity and a tendency to leave final syllables unstressed. Partial quantity sensitivity has to do with syllable structure: although secondary stress usually falls on every second syllable after the initial main stress, exceptions to this are heavy syllables later in a word which may optionally attract stress. However, adjacent syllables are never stressed. In the following description of constraints forming Finnish prosody I will mainly rely on Kager 's work on Optimality Theory (1999). A thorough formulation of the Finnish stress system within the OT framework has been carried out by Elenbaas (1999).

The stress system of a language can be illustrated in terms of foot construction. Feet serve an essential role in a prosodic hierarchy since they are the organising units for syllables. More specifically, feet are defined as "minimal rhythm units organizing pairs of syllables into strong–weak or weak–strong relationships" (Kager 1994: 2). According to Kager (1994) maximal rhythmic organization is guaranteed by exhaustivity, that is, all syllables must be organized into feet. This is required by the constraint PARSE-SYL:

> PARSE-SYL
> Syllables are parsed by feet (Prince & Smolensky 1993; Kager 1999: 162).

In Finnish this constraint is not undominated since in a word with an odd number of syllables, at least one syllable will remain unparsed, e.g. Ψ(o.me).natβ

'apples', resulting in a ternary pattern. Constraint NONFIN prevents stress in final position and in trisyllables in Finnish this latter constraint dominates over PARSE-SYL:

> NONFIN
> Stress may not be final in the word (Elenbaas 1999: 118).

In addition to exhaustivity, wherever possible maximal rhythmic organization must form a foot of maximal size (Kager 1994). The foot must universally have at least two moras either in one syllable or in two syllables. The Foot Binarity constraint ensures that feet are strictly binary:

> FTBIN
> Feet are binary under moraic or syllabic analysis (Kager 1999: 156).

Since the initial syllable of the foot in Finnish is stressed, the foot form of Finnish is a trochee which refers to, "a disyllabic foot with initial prominence" (Hayes 1995: 63). An Optimality Theoretical constraint for determining the rhythmic type of feet to be trochaic is:

> RHTYPE=T
> Feet have initial prominence (Kager 1999: 172).

According to Elenbaas (1999: 111) this constraint is undominated in Finnish. For an iambic foot form the corresponding constraint is:

> RHTYPE=I
> Feet have final prominence (Kager 1999: 172).

In Finnish, foot construction starts at the left-hand edge of the word and proceeds towards the right-hand edge. After fixed initial main stress, secondary stress falls on the third and every second syllable, leaving the final syllables unstressed. Main stress falls on the initial syllable regardless of its heaviness. Thus, even when a second syllable is heavy it does not attract stress, as in the words [(a.vain)] 'key', (he.del).mä β 'fruit'. In an OT account the issue is about an undominated constraint which forces a word to begin with main stress (Elenbaas 1999: 111):

> ALIGN-HD: ALIGN (PrWd, L, Head, L).
> Align the left edge of the prosodic word with the left edge of the head of the prosodic word (McCarthy & Prince 1993).

Or, optionally this strong orientation towards the left-hand edge of the prosodic word could be expressed by an alignment constraint which forces the left edge of the prosodic word to coincide with the left edge of a foot. However, in this case, one would need an another constraint requiring the main stress to be one initial syllable, namely constraint RHTYPE=T resulting in a trochaic foot form. (Elenbaas 1999: 111.)

Basically there are no unpredictable exceptions to this pattern since loanwords with a different stress pattern also follow the strong–weak relationship. However, as mentioned earlier, in longer words, after the word initial foot heavier syllables may attract the secondary stress, causing ternary patterns within a word. Finnish is thus described as having both binary and ternary stress patterns (Hanson & Kiparsky 1996: 301; Elenbaas 1999). Elenbaas clarifies a distinction between stress system and stress pattern; a binary stress system is a stress system in which the basic stress pattern is binary but in which a ternary pattern may occasionally arise. She also argues for factors resulting in ternary patterns in Finnish: quantity-sensitivity, non-finality of stress, avoidance of clash and morphological factors. (Elenbaas 1999: 8.)

Quantity sensitivity concerns the stress and heaviness of a syllable of which a light syllable is (C)V, whilst others, e.g. (C)VV and (C)VC, are heavy. Quantity sensitivity is seen for example in the word [ˌma.te.ma.ˈtiik.ka] 'mathematics', in which the fourth heavy syllable receives secondary stress instead of the light third syllable. However, since this happens only after the initial foot, Finnish is a partially quantity sensitive language. (Elenbaas 1999: 107, 113.) A constraint that requires heavy syllables to be stressed is called the Weight–to–Stress–Principle:

WSP
Heavy syllables are stressed (Kager 1999: 155).

The constraint is violated by a heavy syllable that is not prominent (Kager 1999: 155). If WSP is highly ranked, stress is quantity sensitive and no heavy syllable can be unstressed (Bernhardt & Stemberger 1998: 196). In Finnish, ALIGN-HD is more highly ranked than WSP in word initial position, because main stress is fixed on word-initial syllable regardless its heavyness. The constraint WSP dominates PARSE-SYL as can be seen in words with ternary pattern (Elenbaas 1999: 113).

Bernhardt and Stemberger (1998: 197) rename WSP and propose two separate constraints based on Stress–to–Weight and Weight–to–Stress - principles:

Heavy(Stressed)          Stressed syllables should be heavy.
Light (Unstressed)       Unstressed syllables should be light.

Heavy(Stressed) causes stress to be placed on heavy syllables, or that an extra mora is inserted into a light syllable if it is stressed. Conversely, if a heavy syllable is forced to be unstressed, Light(Unstressed) forces the syllable to become light either by shortening of the vowel or deletion of a coda consonant. (Bernhardt & Stemberger 1998: 455.) In this study I will make use of these two constraints rather than WSP.

Syllable structure plays a role also within a foot: Cross-linguistically even trochees (**LL**) are preferred to uneven trochees (**HL**) (Hayes 1995; see Kager 1999: 173–174 for discussion and constraints.) According to this, an "optimal" trochaic word form would be, for example, *ta.lo* 'house', *tuli* 'fire', however,

Finnish children seem to prefer the CVC.CV word type in their first words,[11] e.g. ˈloppuβ *loppu* 'finished' Sini 1;2 (Savinainen-Makkonen 2000b: 230; 2001: 41; example from Savinainen-Makkonen 1998: 68). Thus, perhaps the (**LL**) preference is not very strong during the early stages of grammar in Finnish. If initially stressed, children's CVC.CV productions satisfy Heavy(Stressed) (and WSP) which is in contrast to first words in some other languages.

Harrikari (2000: 109–110) presents a hierarchy of syllabic trochees emphasising that even the trochees (CV.CV), (CVC.CVC), and (CVV.CVV) are favoured over uneven trochees. The worst of uneven syllables would be (CV.CVV) with an initial light syllable and unstressed CVV-syllable which she, contrary to traditional analysis, considers heavier than a CVC-syllable. Kager (1999: 172) also classifies trochees according to their violation of WSP and FT-BIN:

    1. Satisfy WSP and FT-BIN:   (**H**), (**LL**), (**HL**)
    2. Violate WSP:   (**LH**), (**H**H)
    3. Violate FT-BIN:   (**L**)

Traditionally it is understood that two types of trochaic systems exist, so-called syllabic and moraic trochees. A syllabic trochee means that the foot construction simply counts syllables, ignoring their internal structure. A moraic trochee means that the foot consists of two moras, of which the first is stronger; this results either in a disyllabic moraic trochee or monosyllabic moraic trochee in the case of heavy syllables. (Hayes 1995: 63, 69.)

According to Hanson & Kiparsky (1996: 302–303) the Finnish stress system points to moraic trochees with resolution, that is, it requires primary word stress to fall on initial syllables, and disallows degenerate feet (a light syllable forming its own foot). Thus, it allows (**LH**) trochaic strings, so-called resolved trochees, word-initially but later in the word LH sequences are dealt with by skipping light syllables. Elenbaas' (1999: 116) analysis shows that in long words later in the word, the optimal output is due to avoidance of this kind of "bad trochee" and thus results in quantity sensitivity. The optimal output thus includes unparsed syllables, because constraint *(**LH**) preventing resolved foot is ranked above PARSE-SYL, e.g. ˈ(paimen)to(ˌaisel)laβ vs. *ˈ(paimen)(ˌolai) (ˌsella)β (Elenbaas 1999: 116.)

Harrikari (2000: 108) suggests quantity sensitivity for syllabic trochees in Finnish on the basis of dialectal gemination effects, (e.g. *pataa:pattaa* 'a pot' Partitive), which aim for a more balanced syllabic trochee (also in Nahkola 1987: 17). Anttila (2001: 329) notes, based on Hanson and Kiparsky (1996), that another possibility to describe the Finnish footing system is a moraic trochee. Whatever the explanation, it is evident that after the initial trochaic foot, some quantity sensitivity exists in the way that heavy syllables attract stress. In fact, Kager (1999: 175) criticises the division between the syllabic and moraic trochee

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[11]    The high frequency of long quantity among the first targets of Finnish children may affect the preference for the CVC.CV word type as noted by Savinainen-Makkonen (2001: 41) (see also Kunnari 1997).

and suggests that constraint rerankings produce various degrees of quantity sensitivity. Also Aoyama (2001: 119) discusses the division between mora- and syllable timed languages and concludes that the prosody of a language should be examined in a light of several phonological characteristics, such as syllable structures, pitch contour, length and intensity, which together result in different patterns. Hence, according to Kager (1999) languages range from fully quantity sensitive systems, in which every heavy syllable is stressed, to systems which assign more importance to other factors, such as binary rhythm, at the expense of stress on heavy syllables. Instead of attributing a quantity-disrespecting effect to the syllabic trochee, he attributes rhythmic constraints to it such as:

> *CLASH
> No stressed syllables are adjacent (Kager 1999: 165).

This means that of adjacent heavy syllables, only one is stressed, resulting in a binary stress pattern. This constraint is undominated in Finnish; there is an absolute ban on clashes. (Elenbaas 1999: 108, 114.)

Elenbaas (1999: 106, 107) has also clarified different types of stress pattern in Finnish in the following way. Her data is based on transcriptions from speakers of Finnish and the transcriptions were also looked at by Finnish linguists (Elenbaas 1999: 97).

1. If the word consists of light syllables, stress falls on every odd-numbered syllable and results in binary pattern:

   | (ˈmäki) | 'hill' (Nominative) |
   | (ˈrepeˌämä) | 'crack, rupture' (Nominative) |
   | (ˈpuheˌlimeˌnani) | 'telephone' (Essive, 1.sg.) |

2. Light final syllables are never stressed. Thus when the odd numbered syllable is the final syllable in the word, this syllable will not be stressed. As a result there is a ternary pattern word-finally:

   | (ˈperijä) | 'inheritor' (Nominative) |
   | (ˈpuheˌlimena) | 'telephone' (Essive) |

3. When an odd-numbered light syllable is followed by a heavy syllable, the light syllable is skipped and the heavy syllable is stressed, which results in ternary patterns within a word:

   | (ˈmatemaˌtiikka) | 'mathematics' (Nominative) |

4. In long words binary count is resumed after ternary pattern.

   | [ˌpaimentoˌlaisiˌani] | 'nomads' (Partitive, 1.sg.) |

5. If the heavy syllable is word-final, stress on this syllable is optional.

   | [ˌravintoˌlat] ~ [ˌravinˌtolat] | 'restaurants' (Nominative) |

6. In general, stressing the final heavy syllable is optional:
   | (ˈkuninˌgas) ~ (ˈkuningas) | 'king' |

The second example in (6) can be explained by ranking NᴏɴFɪɴ above Pᴀʀsᴇ-Sʏʟ. However, variation in trisyllabic words in this matter is due to nonranking of NᴏɴFɪɴ and Pᴀʀsᴇ-Sʏʟ (Elenbaas 1999: 119.) Hanson and Kiparsky (1996: 302) discuss that the obligatory final stress is true at best for isolated pronunciations. They point out that expressions such as *omena viipaleina* 'sliced apple' and *omenat viipaleina* 'sliced apples' can be rhythmically identical. When a heavy clitic follows such words, secondary stress can appear on the clitic instead of on the final syllable of the word, e.g. ˌomenat³kaan. This type of case includes a ternary pattern in which the second unstressed syllable is actually heavy. (Hanson & Kiparsky 1996: 302.)

To summarise, then, quantity-sensitivity, non-finality of stress, avoidance of clash and morphological factors can be the reason for ternary patterns in Finnish (Elenbaas 1999: 8). The ternary pattern is essential in this study since trisyllabic words are focused on in the analysis of the data. Basically there are two views on the extrametrical syllable after binary feet. They have either been assigned as degenerate (sub-binary) as in (a) below, or they have not been assigned to feet at all as in (b). (Crowhurst & Hewitt 1995.) Some versions of prosodic theory disallow degenerate feet completely by Foot Binarity (FᴛBɪɴ) (Kager 1994). Hammond (1997) uses the concept "partial foot licensing" (parsing) which allows at most one unstressed syllable between any foot and the edge of the domain or between any two feet, thus his definition for syllable parsing allows one unfooted syllable.

    a. (ωω)(ω)
    b. (ωω)ω

Crowhurst & Hewitt (1995) discuss the parsing problem of syllables which do not fit into the binary footing. These syllables are usually thought to be parsed directly to the Prosodic Word, which is in conflict with the effects in segmental parsing where an unparsed segment fails to surface in actual output. They argue for a solution where two sets of constraints could be used. These are parsing constraints, which require inclusion in some category but not necessarily immediate dominance of a category (thus parsing the extra syllable directly to the Prosodic Word would satisfy the constraint), and link constraints, which require strict dominance from either bottom up or top down (Crowhurst & Hewitt 1995).

In acquisition studies Pater (1997) follows the recent prosodic theory which allows nonexhaustive parsing, which means that an odd numbered syllable is not parsed to the foot, but is parsed directly to the Prosodic Word. On the other hand, Bernhardt and Stemberger (1998) assume that syllables may never link directly to prosodic words, instead, their suggestion is that trisyllabic words form a derived trisyllabic foot. Elenbaas (1999:110) argues that it is not necessary to extend metrical phonology with ternary feet or any other special device to account for the ternary patterns. Instead, using binary feet and constraint interaction there results both binary and ternary patterns. Following Elenbaas' view, I suggest that it would be expedient to explain child phonology

with the same elements as adult phonology, thus the concept of a derived trisyllabic foot is not used. Perhaps due to nonexhaustive parsing one syllable is sometimes omitted in young children's production of trisyllabic words; the deleted syllable may in most cases be the final unparsed syllable.

In terms of constraints, the question of the odd numbered syllable can be viewed as a conflict of PARSE-SYL and FTBIN: both can not be true in the output. In trisyllabic words in Finnish FTBIN is ranked above PARSE-SYL parsing all syllables would violate FTBIN (Elenbaas 1999:112). Children however, may not violate either of these constraints and a solution would be a deletion of the target's unparsed syllable, however, this solution violates Faithfulness constraints. In time, Faithfulness constraints become more highly ranked and productions start to include unmarked features in increasing numbers.

Since syllable structure is interwoven with stress, stressed syllables are more prominent than unstressed, which means that stressed syllables are more likely to appear in a child's output and the elements in such syllables are more likely to appear than elements in unstressed syllables.

## 2.3.2.2 Word level from an acquisition point of view

In this chapter I will examine the kinds of processes reported to happen with the number of syllables in children's productions. The focus is on longer words, especially trisyllabic words, which are prosodically complex due to one unparsed syllable, but four syllable words also feature, being prone to truncations with their two feet structure. It could be that words with unparsed syllables are more complex for the children than words without them, and it is suggested that four syllable words with two feet may be easier for the child than trisyllabic words (Räisänen 1975: 256).

Since the starting point for Finnish children is a bisyllabic word form, the number of syllables is expected to be target-like in the productions of bisyllabic targets. Kunnari (2000: 47) studied the first words of ten Finnish children and found that most of the early words were disyllabic at the 4-word (66.4 %), 15-word (73.3 %) and 25-word points (72.8 %). Kunnari (2000a: 47) also found that there was only one child who had more monosyllabic words than bisyllabic at the 4-word point, thus it seems that bisyllabic forms are the dominant form of early words for Finnish children. There are only a few examples in which a monosyllabic word is produced as bisyllabic by a Finnish child, e.g. *hisu* for *hius* 'hair' (Laalo 1994). Similarly rare are the cases in which a bisyllabic target is produced as monosyllabic, e.g. [ku] for *bansku*, 'banana' (colloquial form) (Savinainen-Makkonen 2000a: 216).

The picture is different in the production of longer words, in which syllable deletion is a common syntagmatic process. Thus the truncation of trisyllabic words, which could also be called a bisyllabic maximum on word size, has long been noted in language acquisition. Besides Finnish, this pattern is reported from learners of several languages including, for example, English (e.g. Echols & Newport 1992), Spanish (Demuth 2001) and Dutch (Wijnen, F., Krikhaar, E. & den Os 1994). There are several theoretical suggestions to explain

the pattern although most of them include the concept of a production template. Gerken (1994: 567) and Wijnen et al. (1994) suggest a S(W) (strong-weak) production template, which is based on the trochaic foot structure. Fee (1992) and Fikkert (1994) propose a Minimal Word template that similarly limits a word to a single foot. (See Pater 1997: 204–205.) Allen & Hawkins (1978) were probably the first ones to present the idea of trochaic bias as a cause of some syllable deletions. Later Vihman, DePaolis and Davis (1998) and Demuth (1996) have pointed out that it is not a universal pattern although it is found in the learners of some languages. Taken together, common to these explanations is the fact that the truncations are due to the prosodic factors of the language being learned. In this study I will also assume that prosody plays an integral part in truncations, however, as Pater (1997: 205) argues, the templates used to explain these processes can be reduced to an interaction of independent constraints. OT also differs from the template-view in that constraints affecting the child's phonology are not completely turned off in the course of development. Instead, they continue to play a role in adult language thus supporting a unified approach to child and adult phonology (Pater 1997; Kehoe & Stoel-Gammon 1997).

Examples of truncated trisyllabic words of Finnish children are reported in several case studies (Räisänen 1975; Laalo 1994; Iivonen 1994; Savinainen-Makkonen 1996), but the theoretical explanation of bisyllabic productions is less discussed. An exception to this is the most recent and extensive study by Savinainen-Makkonen (2000a) who focussed specifically on the production of longer words by six children and looked for possible support for a metrical SW-pattern.

According to earlier reports, the existence of the phenomena in Finnish children is thus unquestionable even though the extent to which it appears naturally varies within individuals as well as according to age. Truncations of attempted longer words usually apply around the age of two in the speech of English and Dutch children (Pater 1997). In reported case studies of Finnish children, the age when more trisyllabic words start to appear varies from 1;6–1;7 to 2;6. In Savinainen-Makkonen's (2000a) study of six children they succeeded in producing trisyllabic targets by the age of 2;0. It can thus be expected that at the age of 2;6 at the latest, most Finnish children are past the bisyllabic stage of word production and are able to produce multisyllabic, both uninflected and inflected forms. Therefore I assume that most of the children in this study are able to produce multisyllabic words but that there may be some who are behind the average limits of normal development and perhaps for some them the pattern, if it continues to be persistent, could even be a sign of delayed language development. As Nettelbladt (1983) states, if the child is not able to overcome strong structural constraints (or in OT terms, to re-rank the constraints), such constraints may block the expansion of vocabulary. Inter-individual variation should however be kept in mind. For example, Iivonen (1994: 47) reports that the first trisyllabic word for subject E appeared at the age of 2;3 (*tommomon* 'tommonen' 'that kind of') and still at the age of 2;7 he truncated trisyllabic words, whereas subject J produced his first trisyllabic word

as early as at the age of 1;10 (*mummuaa* 'mummulaan' 'to grandma's'), and next ones started to appear at the age of 2;0.

In addition to its relation to vocabulary growth, production of multisyllabic words in Finnish is related to morphology in the sense that morphology interacts with phonology; when words are inflected they usually become longer, as a case ending or some other morpheme adds a syllable to the stem. In addition, inflection of words usually causes changes in the stem itself, e.g. *purkki : purkissa* 'a jar : in a jar'. This characteristic raises a question in child language development: if Finnish children are used to hearing long words and the ability to produce multisyllabic words is a prerequisite for inflection, and thus for more advanced language production 4 when and to what extent do the truncation patterns appear in speech production? It may be, that in some cases a strong tendency to truncate long words hinders the growth of morphology, or the child has to find different strategies to overcome the strong constraints. In the following, perhaps rare, examples word truncation has hindered the production of case endings: *mole lusi* 'molemmilla lusikoilla' 'with both spoons' (TL 1;7) (Laalo 1994) and *ka tumpu* 'kaksi tumppua' 'two mittens' (E 2;5) (Iivonen 1994).

In this study morphological issues can not be directly studied due to the naming task type of data which leads the children to produce the words in nominative forms. Nonetheless, the number of truncations is studied, which sheds light on the frequency of the pattern at the age of 2;6 when morphosyntax is also usually advanced. There is some evidence of a relationship between phonological truncation patterns and morphosyntax. We analysed the MLU (Mean lenght of utterance) and FIPSyn (Finnish index of productive syntax) scores of five children who in the naming task truncated trisyllabic words and the results showed that those children indeed scored lower than others. The production of morphosyntax was, however, not completely blocked since some children used different strategies to overcome the constraint, for example, specific syntactical frames which they had acquired. (Turunen, Korhonen & Nieminen 2000.)[12] Thus morphology is not necessarily completely hindered by truncation.

Pater (1997) has presented a possible constraint ranking for truncation of trisyllabic words in the context of English, but his suggestions of the relevant constraints can also be applied to Finnish, which illustrates the universal nature of the constraint based approach. Following Pater (1997) a truncated bisyllabic form of a trisyllabic word in a child's production can be explained by ranking the Faithfulness constraint MaxI-O ("Every element in the input has a correspondence in the output") below the constraints PARSE-SYL and FTBIN:

> FTBIN, PARSE-SYL >> MaxI-O

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[12]     Turunen, P., Korhonen, P. & Nieminen, L. 2000. Interaction between phonology, morphology and sentence production in children with strong prosodic constraints. Paper presented in Turku Symposium on First Language Acquisition, 1.–2.9.2000. University of Turku.

This means that rather than producing an unparsed syllable (or a degenerate foot), a child will delete one syllable. However, in the course of development, MaxI-O is promoted over these constraints and trisyllabic words start to occur in the child's speech. Gradually the ranking changes and trisyllabic and even longer words begin to emerge in the child's speech. But as argued by Pater (1997), the effect of the prosodic constraints continue to play a role in adult speech.

Hammond (1997: 47–48) presents an Optimality Theoretical analysis on syncope in fast speech in English, e.g. *opera* becomes [ɒpra]. When pronounced as trisyllabic, the final syllable on the right is left unfooted and no vowel is deleted. In cases of fast speech, deleting a vowel results in improved foot licensing (parsing), that is, in a prosodic word with no unfooted syllables. According to him the pressure towards foot syllables exceeds the pressure to pronounce all the syllables. The same could in fact be applied to language acquisition: a bisyllabic foot for a multisyllabic target word is produced at the expense of one syllable.

There are also examples of adult truncation in Finnish, for example in the formation of nicknames, e.g. *Inkeri > Inkku*. They are common in colloquial speech as well but in these forms  morphological factors also play a role, e.g. *talossa > talos* "in a house".

It is a commonly accepted view that syllable deletions are not due to lack of perception (see e.g. Wijnen et al 1994). For example a conflation of two syllables speaks for the view that the child indeed perceives all the syllables although the number of syllables decreases, for example [moti] for *tomaatti* 'tomato' (Antti) (Savinainen-Makkonen 2000b: 277).[13] Kehoe and Stoel-Gammon (1997: 139) hypothesise that since perceptual salience is unable to explain the form of children's truncated productions, there is a role for prominence effects, that is, a relative importance of stress, syllable structure and segmental factors. In this study I will examine which factors play a role in determining the elements that survive.

There are different hypotheses on the matter. First of all, it has been suggested that in English the stressed first syllable and word-final unstressed syllable are more likely to survive in initially stressed trisyllabic targets (Echols and Newport 1992). This view is supported by Pater (1997), but he extends it by saying that although the truncations almost always preserve the final rime, for a large set of words the onset of the second syllable survives instead of the onset of the third syllable, and that the survival of onset depends on sonority. The onset of the second syllable survives only when it is lower in sonority than the onset of the final syllable, e.g. [baki] 'broccoli'. (Pater 1997: 220–222; see Bernhardt and Stemberger 1998.) The basic  Sonority hierarchy is as follows (e.g. Blevins 1995; Pater 1997):

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[13]    Savinainen-Makkonen (2000b: 277) suggests that in [moti] first and third syllable realise from the target *tomaatti*. However,  the production is an example of a conflation, because the word-initial consonant is assimilated from the second syllable onset and thus the production includes segments from all syllables.

Vowel > Glide > Liquid > Nasal > Fricative > Stop

This also indicates the fact that children perceive the syllables and the segments in the syllables which they omit, so the reason for the omissions of unstressed elements can not be due to the lack of perception.

Wijnen, Krikhaar and den Os (1994) as well as Demuth (1996) support the view that it is equally likely for either the second or third syllable to survive with the stressed syllable (examples also from Dutch). Bernhardt & Stemberger (1998: 451), on the other hand, emphasize the role of the Faithfulness constraint called Contiguity and suggest that there may be a tendency for the syllable that is adjacent to the stressed syllable to survive with it. A deletion of the medial syllable violates the constraint:

> Contiguity
> Elements next to each other (contiguous) in the underlying representation must be contiguous on the surface (Bernhardt & Stemberger 1998: 712).

It could thus be predicted that Finnish children usually omit the last unparsed syllable  and avoid any violation of Contiguity. This prediction is indeed supported in Finnish case studies and in Savinainen-Makkonen's data from six children. The stressed first syllable and the second syllable were preserved most often (Räisänen 1975; Iivonen 1994; Laalo 1994; Savinainen-Makkonen 1996; Savinainen-Makkonen 2001: 34), for example [ikku] *ikkuna* 'window', [pelo] *pelottaa* 'to be afraid' (examples from Laalo 1994). Savinainen-Makkonen (2001) notes that although the SW[1]-pattern was typical, also the first and second syllable were sometimes omitted. Kunnari (2000: 50) reports that at the early 25-word point, five out of ten children omitted the last syllable, or last two syllables, one child always produced the first and third syllable and one child, interestingly, always produced the final two syllables; in addition, three other children did not show any consistent pattern in truncation. Kunnari's findings confirm that in the production of polysyllabic target words there is a tendency for word initial syllables to survive but that also other strategies may exist. She does not differentiate three-, four- and five syllable words and treats all of them within the category of polysyllabic words. I assume that in order to find typical patterns it is essential to differentiate the word types according to different prosodic patterns and consider sonority effects which may affect the truncation processes.

Contrary to the English data, in all of the productions reported by Laalo (1994) the second syllable rime survived, however, there was some variation in the survival of onsets. According to Laalo (1994), the third syllable onset was sometimes chosen in order to replace a difficult segment with an easier one, e.g. [penu] *peruna* 'potato', [pääny] *päärynä* 'pear'. This is also pointed out by Savinainen-Makkonen (2000a: 217) since in her data one child (Antti) preferred the so-called SW[2] –pattern when the last syllable included a stop consonant. Usually Antti preferred the SW[1]-pattern. These examples follow the sonority hypothesis (Pater 1997): the surviving third syllable onset is lower in sonority

than the deleted second syllable onset, as also in the following examples: [haka], [haaku] *haarukka* 'fork' (Iivonen 1994). To conclude, Contiguity is sometimes violated in order to produce an articulatory easier and less sonorant segment at the time.

According to Räisänen, the word *elefantti* with two feet was easier for the child to produce than trisyllabic words at the age of 2 (Räisänen 1975: 256). Also Savinainen-Makkonen (2000a: 215, 217) found that for one subject (Antti) four syllable words were easier than trisyllabic, and for another subject (Melina) for a short period of time four syllable targets were realised as four syllables while some trisyllabic words were still truncated into bisyllabic forms. Despite some evidence that four syllable words may be easier than trisyllabic words, probably due to their rhythmic characteristics, four syllable words may also shorten due to their complexity arising through the high syllable number. There are some examples in which the child has truncated a four syllable (compound) word into a bisyllabic form:

[lolo] *joulupukki*   'Santa Claus'   E 2;2 (Iivonen 1994: 69)
[paija] *papukaija*   'parrot'   Sini 1;6, 1;8 (Savinainen-Makkonen 1996: 54)
[eeko] *lentokone*   'aeroplane'   Sini 1;5 (Savinainen-Makkonen 1996: 53)

These productions include one bisyllabic foot and a constraint behind the pattern could be:

NotComplex(PrWd)
A prosodic word may contain only one foot (Bernhardt & Stemberger 1998: 468).

Based on reports of other languages as well on these examples, it is not always predictable which foot survives in truncations into bisyllabic forms. Bernhardt & Stemberger (1998: 469) suggest that usually the two syllables to survive are from a same foot, but they also refer to Kehoe's (1995) study in which she reports deviations to this, for example segmental factors. The examples above indeed show that it is not necessary for a foot to survive as such, but conflations of syllables are possible as in *paija.* However, one could predict that there is a tendency in Finnish for the word initial foot to survive since it bears the main stress. Of the above examples *lolo* shows a reduplicative pattern and *eeko* is probably comprised of the two foot- initial syllables which in the target form bear the main and secondary stress. In this form Contiguity is violated as in some examples of truncations of trisyllabic targets.

In terms of prosodic constraints more problematic are four syllable words that are truncated into trisyllabic forms. Savinainen-Makkonen (2000a: 212–214) presents examples of this kind:

[mul4nen] *muurahainen*   'ant'   Sara 2;2
[konene]˘ *lentokone*   'aeroplane' Vinsu 1;9
[hDmDkʃ] *hämähäkki*   'spider'   Pyry 2;1

It could be hypothesised that in truncations of four syllable words to trisyllabic forms an unstressed syllable is omitted. More specifically, the deleted unstressed syllable would be from the foot with secondary stress, as Faithfulness is ranked lower in these feet (Bernhardt and Stemberger 1998: 471). These examples do not directly support this as production of *appelsiini* as ʼappeχχi.aβ does (example from Savinainen-Makkonen 1996: 49). In it final syllable was deleted and the sequence /ls/ was assimilated to /ss/ (which was further substituted by /tt/). The production satisfies NotComplex(PrWd) since it does not have two feet but instead, it violates PARSE-SYL. The examples above show conflation effects, e.g. *hämäkki,* in which segments are extracted from all syllables. Sonority and geminate factors may also play a role in the production of four syllable targets as well as morphology: in *mulanen* the final unstressed syllable may be preserved since the ending is a common diminutive derivative.

Production of five syllable words is not studied in this work, but similar truncation patterns could also take place in them. In a word in which the footing construction leaves the final syllable unparsed it would be deleted: (X.X).(X.X).X > (X.X).(X.X). This type of truncation violate NotComplex(PrWd) but satisfy PARSE-SYL. There is an example outside the main data in this study showing this kind of truncation: [hiekka-haakko] (Asser CB) *hiekkalaatikko* 'sand box' (he produced the word with a slight demarcation between the syllables). It would be interesting to find out how quantity sensitivity affects the truncation patterns in five syllable words, which are footed (X.X).X.(X.X) like *matematiikk*a.

To summarise the constraint-based view of the word level in children's phonology, it is assumed in this study that the reason for deleting syllables from a trisyllabic target word is to achieve more optimal parsing of syllables into feet. By satisfying PARSE-SYL a child produces a word with a single bisyllabic foot without extrametrical syllables. This kind of production, however, violates Faithfulness towards input forms. In time Faithfulness increases and trisyllabic productions emerge. In truncations of four syllable words into bisyllabic and trisyllabic forms a child's production satisfies NotComplex(PrWd) although in trisyllabic forms PARSE-SYL is violated. In time faithfulness increases and words with two feet emerge.

The form of the truncations in Finnish acquisition will perhaps include the two initial syllables forming the foot in trisyllabic targets; such productions satisfy Contiguity. However, based on earlier reports, segmental factors may play a role in choosing the extracted elements. Similarly in truncations of four syllable targets, an initial foot may be most likely to survive, or the elements of the foot-initial stressed syllables which would violate Contiguity. In those cases the prominence of stressed syllables is shown; Faithfulness is higher in those positions.

Besides deletion of syllables, one should consider insertion of syllables as a solution for more optimal footing. This would for example happen in trisyllabic words in which a child may insert a syllable: (X.X).X > (X.X).(X.X). Based on earlier reports these kind of examples are rare and are not expected to take place in this study. The children's production are clearly more likely to

tend towards deletion than insertion (see Savinainen-Makkonen 2000a: 217). To conclude, expected changes in syllable number would be

1. (X.X).X $\quad\quad\quad\quad$ ⇓ $\quad$ (X.X.)
2. (X.X).(X.X) $\quad\quad\quad$ ⇓ $\quad$ (X.X)
3. (X.X).(X.X).X $\quad\quad$ ⇓ $\quad$ (X.X).(X.X) (not studied)

On the other hand, unexpected changes would be:

4. (X.X) $\quad\quad\quad\quad\quad$ ⇓ $\quad$ (X)
5. (X.X) $\quad\quad\quad\quad\quad$ ⇓ $\quad$ (X.X).X
6. (X.X).(X.X) $\quad\quad\quad$ ⇓ $\quad$ (X.X).X


## WORD LEVEL RESEARCH QUESTIONS AND HYPOTHESES

### *Research questions*

1. To what extent do children truncate three and four syllable words at age 2;6? Are there more truncations of three syllable than of four syllable words?
2. What is the form of truncated productions: what is preserved? What factors other than stress play a role?
3. Do at-risk children truncate longer words more often than control subjects?
4. Do late talkers truncate longer words more often than others?

### *Hypotheses*

1. At the age of 2;6 most children are past the stage when they truncate long words, but there are some children for whom longer words are still problematic. Trisyllabic words are truncated more often than four syllable words due to an unparsed syllable.
2. The children will usually omit an unstressed syllable and thus in trisyllabic words the first two syllables are preserved. Similarly in four syllable word targets the word initial foot will survive and in truncations to trisyllabic forms one unstressed syllable will be deleted. Segmental factors, more specifically sonority of onset consonants, may be an exception to this pattern.
3. At-risk children produce more truncations than control children, because they have more problems in the accurate identification of complex word structures. This deficit may be manifested through simpler word structures produced by at-risk children than by children without a genetic risk for dyslexia.
4. Late talkers produce more truncations than other children, because truncated productions are typical to an earlier stage of phonological development.

### 2.3.3 Syllable level constraints

### 2.3.3.1 Characteristics of Finnish syllable structure

Syllables can not be dealt separately from their position within a word: in every word some syllables are more prominent than others depending on the stress patterns (see e.g. Bernhardt & Stemberger 1998: 193). In Finnish, the word initial stressed syllable, which is the head of the prosodic word and the word initial trochee, is the most prominent. Unstressed syllables are less prominent. In this study, on syllable level, I will focus on processes affecting heavy unstressed syllables in terms of moraic structure. It is of interest in this study to examine how the children produced syllables which are structurally marked and in a less prominent (unstressed) position in the target word. The interest arises through the conflict of the stress and heaviness of a syllable. It is attempted to explain differences between target words' syllable structure and the child's syllable structure by prosodic constraints. It is also noted, however, that structural constraints concerning the syllables' internal structure may affect a child's syllable productions.

The syllable, as well as the whole prosodic word structure, can be seen as a hierarchical constituent of elements, not only as a string of phonemes. Syllables are also defined as prosodic categories organising segments, and syllables themselves are linked to feet. There are several ways to illustrate syllable structure; Kager (1999:91) pictures the onset, nucleus and coda (a), but also CV-structure (consonant, vowel) could be used (b) (see Bernhardt and Stemberger 1998: 112):

a)
```
        ω
       ╱ | ╲
      O  N  C
      |  |  |
      t  e  m
```

b)
```
        ω
       ╱ | ╲
      C  V  C
      |  |  |
      t  e  m
```

Also a more hierarchical structure can be used to describe the elements within a syllable; these models first separate onsets and rimes, and then specify rimes into nucleus and coda (see Bernhardt and Stemberger 1998: 112). This type of

structural model is used in the context of literacy: Treiman (1987: 525) suggests that phonological awareness develops from larger to smaller units, from words to syllables, from syllables to onsets and rhymes and finally to individual segments.

Besides these illustrations, a possibility to describe syllable structure is a moraic theory in which onsets are usually prosodically inert and do not assign a mora, and also, mora assignment of other segments is language specific (Hayes 1995: 51452). Hayes' examples (1995: 52) could also be used as an illustration of Finnish syllables:

a) Light syllable CV
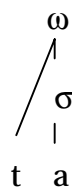


b) Heavy syllables CVC, CVV
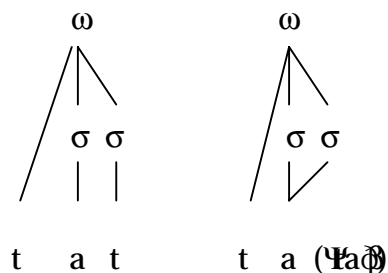


A benefit of the moraic model as compared to the CV-model is that when timing units are defined as moras, it is not relevant whether the phonemes are consonants or vowels, thus for example both CVV and CVC –syllables have the same bimoraic status. In using the CV-model or the onset–nucleus–coda -model the abstraction is more fine-grained. For example, Kehoe and Stoel-Gammon (2001: 408) defined the forms ΨΧβ and ΨΧβ for *snake* to be identical at rhyme level although the onsets varied. and the forms ΨΧβ and ΨΧkβ were coded as identical at rhyme level because they both contained a tense vowel and a coda.

From the prosodic point of view, a light syllable in Finnish is (C)V, other syllables (CVV, CVC, CVCC, CVVC) are heavy (onsets are optional) (Elenbaas 1999: 111; Hanson & Kiparsky 1996: 301). According to Häkkinen (1978) the CV-syllable is the most frequent syllable in Finnish is (40,4 %) and the percentage of CVC-syllables is 27,5 %.

The picture above also illustrates that long segments are considered single at the segment level but at the moraic level they are assigned two timing units. Syllables are thus basically divided into light and heavy syllables using a two-way distinction. A problem arises with so-called superheavy syllables in

Finnish such as CVVC with a branching nucleus and CVCC with a branching coda. A concept of "superheavy syllables" is used in some contexts (e.g. Hayes 1989: 292; Hayes 1995: 67). Traditionally in Finnish phonology a three-way distinction is used: CV is monomoraic, CVC and CVV are bimoraic and CVVC and CVCC trimoraic (Karlsson 1983: 134). In moraic theory, however, only syllables with one or two mora are expected, in other words, syllables which are either light or heavy (Hayes 1995: 52; Hanson & Kiparsky 1996: 305).

Harrikari (2000) suggests that CVCs are lighter than CVVs. Her argument is based on the dialectal gemination which takes place before a CVV syllable but not before a CVC syllable in order to create a more optimally balanced trochee. These syllable types, however, attract secondary stress later in the words and thus both could be considered as heavy. A deeper analysis of the so-called superheavy syllables in Finnish and their relation to moraic theory[14] is beyond the scope of this study. In this study, besides using the CV-formalism, I will mainly adhere to the concept of the mora in a traditional way in examining the changes in heaviness of the syllable in the unstressed position. I will also use the concepts of light (monomoraic) and heavy syllables (bi- and trimoraic).

As at word level, a starting point for the Optimality Theoretical account of syllable structure is that, at first, the Structural constraints are ranked above Faithfulness constraints, resulting in structurally unmarked productions. The structural constraints concerning syllable structure has to do with phonotactics regarding complex consonant and vowel sequences (diphthongs). Levelt and Van de Vijver (1998) and Levelt, Schiller & Levelt (1999: 295) have listed the constraints concerning syllable markedness structures (for contraint names see also Kager 1999: 93–97). In addition to their list, the fifth syllable structure constraint is from Bernhardt & Stemberger (1998: 370):

1. ONSET — A syllable should have an onset.
2. NO-CODA — A syllable should not have a coda.
3. *COMPLEX-ONSET — A syllable should not have a complex onset.
4. *COMPLEX-CODA — A syllable should not have a complex coda.
5. *COMPLEX-NUCLEUS — A nucleus may only have one segment.[15]

These constraints form the most unmarked syllable CV (e.g. Levelt et al. 1999: 296). The syllable V violates the constraint requiring an onset. The CVC-syllable violates NO-CODA.

*COMPLEX-ONSET is highly ranked in Finnish since in basic vocabulary there are no syllable initial consonant clusters. Karlsson (1983; 105) has criticised the view that the Finnish phonological system does not have word initial clusters since at least some CC-clusters, although originally loanwords, are clearly part of the system. Many of these could also be part of a child's vocabulary, e.g. *krokotiili* 'crocodile', *knuunu* 'crone', *prinssi* 'prince' (examples

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[14] In moraic theory syllable weight is viewed as a binary opposition of either one or two moras. However, Hayes (1989: 291-293) argues that trimoraic syllables must be allowed.

[15] Bernhardt & Stemberger (1998: 370) use the name NotComplex(Nucleus) for this constraint. I will use the form *COMPLEX-NUCLEUS for the consistency with other syllable structure constraints.

from Karlsson 1983). Thus the constraint can not be completely undominated and while learning (standard) Finnish the child has to learn complex onset as belonging to the grammar. If the syllables' heaviness is viewed according to moraic structure, complex onsets will not increase heaviness since a mora is not assigned for consonants in onset.

In contrast, *COMPLEX-CODA increases syllable heaviness in moras and it is lower ranked in Finnish, thus syllables with complex codas are allowed, e.g. in the word *kars.ki* 'rough'. They do not, however, appear in word final position. These constraints are not enough to prevent heavy syllables such as CVV and CVVC as for example in words *takaa* 'from behind', *kaunis* 'beautiful', *avain* 'key' and *rattaat* 'strollers'. *COMPLEX-constraints include a constraint preventing diphthongs (Bernhardt and Stemberger 1998: 370, 710) which is added in the list above as *COMPLEX-NUCLEUS. Stemberger and Bernhardt (1998: 409) also extend this constraint to prevent long vowels since they are complex in the sense of forming two timing units. Later they also redefine the constraint focussing on vowel length in the following way: "A nucleus may contain only a short vowel" (Bernhardt & Stemberger 1998: 448, 449). They assume that a child may not tolerate complexity brought by long vowels and may shorten them (Bernhardt & Stemberger 1998: 410).

Besides these syllable-internal structural constraints, prosodic constraints may affect syllable productions. Heavy(Stressed) causes stress to be placed on heavy syllables, or an extra mora to be inserted into a light syllable if it is stressed. Conversely, if a heavy syllable is forced to be unstressed, Light(Unstressed) forces the syllable to become light either by shortening of the vowel or deletion of a coda consonant. (Bernhardt & Stemberger 1998: 455.)

## 2.3.3.2 Syllable level from an acquisition point of view

The interaction between stress and a heaviness of the syllable can be looked at from two perspectives. First, stress placement may adjust according to syllable structure and secondly, syllable structure may adjust according to stress placement. Quantity sensitivity later in a word is an example of the first. In language acquisition, on the other hand, heavy syllables in unstressed positions may shorten at least in the initial stages of phonological development, e.g. Sini 1;3 [awa] *avain* 'key', Sini 1;2–1;3 ᵠβaappaβ *saapas/saappaat* 'boot/boots' (examples from Savinainen-Makkonen 1998: 68). Savinainen-Makkonen presents these examples in the context of final syllable deletion which highlights children's drive towards open syllables. I assume that the effect of structural constraints is higher in the less prominent unstressed position of the final syllable and for this reason either the constraint NO-CODA or the prosodic constraint Light(Unstressed) causes the deletion of the final consonant. Savinainen-Makkonen emphasises that final consonant deletion was a clear tendency among the first words in her case study; there were very few forms with a word final consonant. Later in speech production heavy syllables, also in unstressed word final position, have to emerge due to morphology, e.g. *kuk.ka:ku.kat* 'a flower: flowers'.

As Carter Young (1991) has observed, in English early acquisition the constraint Light(Unstressed) causes the second syllable to lighten as in Ψ℧»_t aβ *balloon* as a stress reversal leads the second syllable to be unstressed. The stress reversal is due to achieving a left –prominent trochaic foot. (Bernhardt and Stemberger 1998: 455.)

The very initial stages of phonological development in Finnish may shed light on the acquisition of syllable types. Sini's first 50 words resemble the statistics that show the most common syllable type in Finnish to be CV: the percentage of CV-syllables in her speech was 39.0 %, however, 23 % of the syllables had a coda consonant (VC, CVC, CVVC) (Savinainen-Makkonen 1998: 60). Savinainen-Makkonen takes the whole word structure into account by emphasising that in word final position the syllables were open and that closed syllables were usually part of the geminate in the word. Thus, instead of specifying syllable structures in early words, it would be more relevant to consider the whole word structure which typically would be (C)VCCV for a Finnish child. (Savinainen-Makkonen 1998: 61.)

Kunnari's (2001: 60) findings confirm that statistically the CV-syllable is the most frequent syllable structure among the first words of Finnish children. Her results from ten Finnish children are also in line with Savinainen-Makkonen's case study in that there were no syllables with a coda consonant in final position although CVV-syllables were produced in that position. Bernhardt and Stemberger (1998: 376) state that most often codas are not possible at the earliest stages of acquisition although there is evidence that some English speaking children begin phonological development with an adult-like ranking of NO-CODA. This means that the constraint is ranked low enough to permit codas (Bernhardt & Stemberger 1998: 375; see also Kehoe & Stoel-Gammon 2001: 403–404). Also studies of dysphonology characterise the main syllable types to be (C)V in the early stages of development in English (Stoel-Gammon 1991: 28) and in Swedish (Nettelbladt 1983: 147–148, 172).

Children's first productions seem to resemble the theoretical assumption that an unmarked syllable structure is CV, the so-called core syllable (e.g. Demuth 1995; Levelt & Van de Vijver 1998). This is also true in Finnish language acquisition especially regarding unstressed syllables. However, the evidence for Finnish children's preference for the (C)VC.CV word structure, in addition to geminate attraction as proposed by Savinainen-Makkonen (2001: 41), could be explained by prosodic factors: this word form has a heavy stressed and light unstressed syllable thus optimally satisfying the constraints Heavy(Stressed) and Light(Unstressed). The high ranking of Heavy(Stressed) may explain why Finnish children produce heavy CVC-syllables from the very first words onwards. In such a word type, constraint Heavy(Stressed) is ranked higher than NO-CODA in the stressed word initial position .

There is another issue in the initial word forms of Finnish children regarding unmarked CV-syllables: unlike for children in some other languages it is typical for Finnish children to delete word initial onset consonants, e.g. Nℵ[`DP*lehmä* 'cow' (Sara 1;10) (Savinainen-Makkonen 2000c: 177). When onset,

coda and nucleus form the basic elements of syllables, it should be noted that the essential part of the syllable is the nucleus, which is universally obligatory (Kager 1999: 91). It seems, that the constraint ONSET is lower ranked in the initial stages of grammar of Finnish children than for example in a language such as English.

In general, the satisfaction of the structural constraints result in violation of the Faithfulness constraint MAX-IO (Kager 1999: 102) if the satisfaction requires deletions of segments. This is basically what could be observed in above example by Sini and hypothetically in the productions in this study. For example, Light(Unstressed) may cause heavy unstressed syllables to shorten as in an example above ˈɑvaβ *avain* 'key'. In *avain* the constraints responsible for the deletion processes may also be NO-CODA causing the deletion of word final /n/ and *COMPLEX-NUCLEUS preventing the diphthong in the nucleus. I suggest, however, that these shortenings are due to prosodic factors: an extreme word structure (e.g. V.CVVC as in *avain*) has a conflict between stress and heaviness of the syllable and by shortening the syllable the child creates a more optimal trochaic foot (**L**.H>**L**.L).

If the stress is not forced to be on the initial syllable resulting in a trochaic pattern, stress shift might be a strategy to satisfy Light(Unstressed), hypothetically resulting in forms such as *aˈvain.* In a developing grammar, this might be possible but otherwise the constraint RHTYPE=T (Feet have initial prominence) is basically undominated in Finnish (Elenbaas 1999: 111). In addition, constraint NONFIN (Stress may not be final in the word) (Elenbaas 1999: 118) may prevent stress shift.

Another solution would also be the stressing of both syllables, but this is prohibited by the undominated constraint *CLASH. This would be possible in an effortful articulation, and perhaps in deviant phonological development. I predict that the most common process to satisfy the constraints preventing heavy unstressed syllables would be to preserve the trochaic foot by deleting segments from the heavy unstressed syllable. This violates Faithfulness but in time the constraint Light(Unstressed) is reranked lower and heavy unstressed syllables will be allowed. A CV-syllable will also satisfy the syllable structure constraints presented above. For example, an unmarked form from the word *rattaat* would be *ratta* (**H**L) which, besides satisfying Heavy(Stressed) (also WSP) and FTBIN, satisfies syllable structure constraints in the final syllable.

The prosodic constraints concerning syllable structure may also play a role in three and four syllable words in which a heavy unstressed syllable may shorten, but the possible deletions of segments may also be due to phonotacticconstraints preventing complex consonant sequences.

## SYLLABLE LEVEL RESEARCH QUESTIONS AND HYPOTHESES

### *Research questions*

1. To what extent do children shorten heavy unstressed syllables at age 2;6?
2. What other strategies are used to overcome the conflict between stress and length?
3. Do at-risk children have more problems with heavy unstressed syllables than controls?
4. Do late talkers have more problems with heavy unstressed syllables than others?

### *Hypotheses*

1. At the age of 2;6 most children are able to produce heavy unstressed syllables.
2. Production of light CV-syllables instead of heavy syllables (deletion of segments) is the most common strategy to satisfy a constraint requiring light unstressed syllables. Other strategies such as stress shift may occasionally occur.
3. At-risk children produce more CV-syllables instead of heavy syllables than controls, because they have more problems in the accurate identification of complex word structures. This deficit may be manifested through simpler word structures produced by at-risk children than by children without a genetic risk for dyslexia.
4. Late talkers produce more CV-syllables instead of heavy syllables than others, because light unstressed syllables are typical to earlier stage in phonological development.

### 2.3.4 Phonotactic constraints

### 2.3.4.1 Characteristics of Finnish phonotactics

In this chapter I will introduce the constraints preventing phonotactical complexity. Phonotactics has to do with syntagmaticy of phonemes, i.e. the way they are combined. It is bound together with syllable structure in the sense that complexity in phonotactics causes complexity at the syllable level, e.g. a diphthong makes a syllable heavy (CVV). I assume that the syllable's prosodic structure is a prerequisite for acquiring phonotactical elements, for example, in order for a child to produce a diphthong, she must first learn to produce the required length of syllable, e.g. *pöölä>pyörä* 'bike'and the same applies in order to produce a complex coda, e.g. *pook>polk* in *porkkana* 'carrot'. Because of this, the constraints presented in the chapter regarding syllable level, also explain phonotactics in this study.

In this study, at phonological level, I mainly concentrate on word internal diphthongs and consonant sequences. By consonant sequences I mean both

complex codas within a syllable as in *po<u>rk.</u>ka.na* and complex consonant sequences across syllable borders as in the word *sa<u>k.</u>set*. In general complex sequences also refer to word initial complex onsets but the production of those clusters is not studied here, although they are quite common in loanwords and the child has to learn complex onset as belonging to the grammar. For example, boy E produced <u>*kr*</u>*uunu* 'crone' at the age of 4;11 (Iivonen 1998: 18). Interestingly, Iivonen (1998: 18) has suggested that consonant sequences appear in the speech of Finnish children earlier than in the speech of English speaking children. According to him, the reason for this could be that Finnish consonant sequences usually appear across syllable positions and not so often in syllable internal position.

In this study, codas and consonant sequences across syllable positions are investigated from the point of view of children's ability to produce adjacent consonants that are pronounced articulatory differently. I will make a difference between consonant sequences of same and different place of articulation and assume that the latter case is more complex and thus more prone to changes in acquisition. Consonant and vowel harmonies are only touched upon in some individual word analyses although they are also within the realm of phonotactics.

Compared to *COMPLEX-ONSET, *COMPLEX-CODA is lower ranked and Finnish allows syllables with complex CC-codas. In the data, the only target word including a complex coda is *pork.ka.na*. According to Karlsson (1983: 108–109), /rkk/ is a typical string of a resonant consonant /l, r, m n, ξ/ and obstruents /p, t, k, s/ in Finnish. As the geminate in *porkkana*, also in words with three different consonants the string continues from the coda to the onset of the following syllable, e.g. *vils.ke* 'a bustle'. (Karlsson 1983: 108–109.)

I will mainly look at consonant sequences in terms of place of articulation, for example /rkk/ would be a string of dental and velar. In word analyses, however, manner of articulation is also relevant. For example, a child may produce *polkkana* instead of *porkkana* in which the sequence is heterorganic but the manner of articulation is not target-like.

In Finnish, there are approximately 80 CC-sequences of which at least 57 belong to basic vocabulary (Karlsson 1983: 122).[16] In Häkkinen's study (1978) of frequencies based on text corpora, the most common CC-sequences were the following:

1. /ll/
2. /tt/
3. /st/
4. /ss/
5. /nn/
6. /kk/
7. /ks/
8. /nk/ (/ξk/)
9. /lt/

---

16    Karlsson (1983) has included geminate consonants into CC-strings.

10.  /nt/
     /sk/

Häkkinen has included geminate consonants into frequences and they were the most common among CC-strings. The high frequency of dentals is a universal rather than language specific tendency (Karlsson 1983: 127).

　　　Besides syllable internal constraints such as *COMPLEX-CODA, one needs a constraint to explain complex consonant sequences across syllable borders. Bernhardt and Stemberger (1998: 237) make use of a NoSequence-constraint which can be applied at segment level (Root adjacency) across segments in place, manner and voicing, of which place and manner are relevant in this study:

　　　NoSequence(A...B)
　　　Given two segments, A cannot be in the first segment if B is in the second segments.

According to Bernhardt and Stemberger (1998: 238), for example the following constraints are highly ranked across languages:

　　　NoSequence(Dorsal...Labial)
　　　NoSequence(Labial...Dorsal)

This means that for example in Finnish consonant sequences such as */jp/ do not exist.[17]

　　　In Finnish there are eighteen diphthongs three of which end with a more open vowel than the first vowel in a diphthong. Regarding complexity, these diphthongs are perhaps more difficult than the ones ending with more closed vowel, e.g. /yö/ in *pyörä* may be more complex than /öy/ in *pöytä*. Again, Karlsson (1983: 85) has described the constraints preventing vowel combinations, for example vowel harmony prevents some combinations, e.g. */äu/, because front and back vowels are not combined in a word. In general, diphthongs can be prevented by the constraint *COMPLEX-NUCLEUS (Bernhardt and Stemberger 1998: 370).

## 2.3.4.2 Phonotactics from an acquisition point of view

I assume that in the initial stages of phonological development complex consonant sequences are not allowed by *COMPLEX-CODA and NoSequence constraints. Theoretically syllable level and phonotactics can be connected, for example, at first a syllable level constraint *COMPLEX-CODA prevents sequences entirely in that position and thus the feature content is irrelevant. In the course of development complex codas become possible but perhaps at first only for some sequences of consonants. In time NoSequence constraints become relevant for defining the features of consonant sequences. Similarly, if word level

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[17]　　　Karlsson (1983: 119) has described the phonotactical constraints preventing sequences not belonging to Finnish grammar.

constraints prevent the production of a whole syllable, the syllable's internal content is not relevant. (see Bernhardt & Stemberger 1998: 498 for discussion.)

With the NoSequence constraints in this study I will mainly make use of place features and assume that children have a tendency to articulate consonant sequences in the same place, as a result of which assimilations take place resulting in geminate consonants. In addition, compensatory lengthening is possible: in this instance a consonant is deleted but its timing unit is preserved and the empty slot is filled by the adjacent vowel resulting in a long vowel. Substitutions within a sequence may also occur, but those may not result in violation of the NoSequence constraint on place, but may result in violation of the NoSequence constraint on manner. Other solutions for not violating certain NoSequence constraints would be the deletion of a segment entirely or inserting another segment between the two consonants so that they are no longer adjacent (see Bernhardt & Stemberger 1998: 2394240).

In a more general sense these solutions could be expressed as follows (Bernhardt & Stemberger 1998: 237): "A violation of this constraint can be repaired:

a) by deleting one of the two elements (A or B), or a higher element that contains A or B, or
b) by separating A and B so that they are no longer adjacent, or
c) by re-ordering the elements so that they are no longer in the prohibited sequence (metathesis)."

Deletion of a segment is perhaps not a common solution, since in a stressed position in CC-sequences it would violate syllable level constraint Heavy(Stressed) although it would satisfy No-Coda. On the other hand, assimilation would keep a heavy syllable stressed but violate No-Coda, which however, seems to be low ranked in Finnish acquisition from an early point due to the (C)VCCV word type in first words. In the examples by boy E at the age of 2;8, assimilation was a common strategy to overcome NoSequence constraints, e.g. *vello* 'verho' 'curtain', *tommi* 'sormi' 'finger' (Iivonen 1994: 71). In the case of complex codas and trimoraic syllables deletion may be more common as, for example, in *paama* 'paarma' 'horsefly' by boy E at age 2;8 (Iivonen 1994: 71). In such cases the stressed syllable remains heavy. The following pictures with association lines as used in nonlinear phonology illustrate an assimilation in which a feature spreads from an adjacent consonant as a solution for the highly ranked NoSequence constraint (modified from Bernhardt & Stemberger 1998: 240 for Finnish context, example from boy E at age 2;8 from Iivonen (1994: 71):

(a)   Place   Place      (b)   Place   Place

dental   labial              labial
      /rm/                    /mm/

*sormi*          ⇓       *tommi*   'finger'
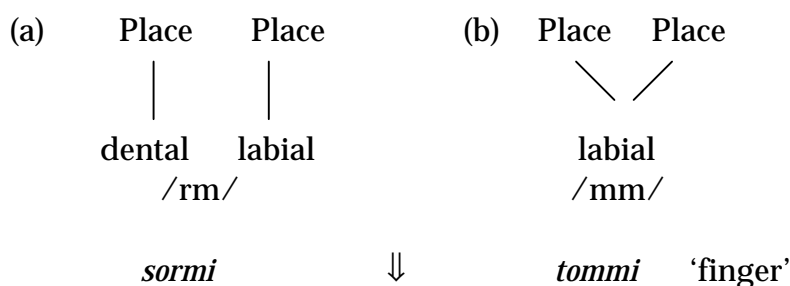
In (a) there is a consonant sequence of dental and labial and in (b), an assimilation has occurred and the place feature labial has spread. Constraint NoSequence(Dental...Labial) may have motivated the assimilation process.

In compensatory lengthening a deleted consonant leaves a "trace" which is filled by the spread of another segment (Broselow 1995: 183). In other words, the segment is deleted but not its timing unit. The following pictures (a) and (b) illustrate how the prosodic structure remains the same despite changes in phonemes, whether due to assimilation or compensatory lengthening (Finnish example by boy E at age 2;8, Iivonen 1994: 71):

(a)   ω  ω            (b)   ω  ω
      ⋀  |                  ⋀  |
      σσ  σ                 σσ  σ
      | |  |                | |  |
     *mär  kä*      ⇓      *mää  kä*    'wet'
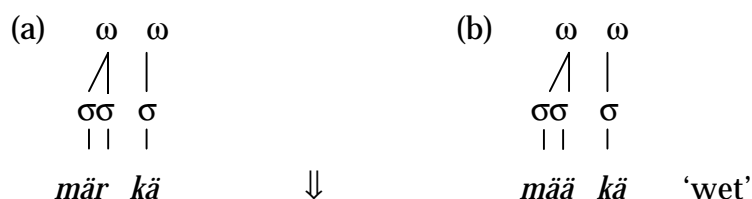
Compensatory lengthening in fact violates *COMPLEX-NUCLEUS since it has a long vowel in peak position, however, in this case it is considered to be lower ranked than NoSequence(Dental…Velar).

It is of interest when the NoSequence constraint is overcome by assimilation and when by compensatory lengthening, for example, why boy E produced *tommi* instead of *toomi.* On the contrary Sini produced Ψbb` Xβ *sormet* 'fingers' at age 2;3 (Savinainen-Makkonen 1996: 102). It may be that the sonority of consonants involved plays a role in these changes, for example in the production Ψkkeeβ *itkee* 'cries' by Sini at age 2;4 (Savinainen-Makkonen 1996: 101) low sonority of the coda consonant may result in assimilation rather than compensatory lengthening (*iikee*).

In some cases, after these solutions, a child may produce sequences in which constraints on place still occur, for example, among the first sequences in the speech of boy J was homorganic /ξk/ in *koξke* for *kolme* 'three' (Iivonen 1994: 71). When sequences of different place appear, manner constraints may still not be violated, for example at age 2;7 boy E produced *putku* for *puskuri* 'bumber' in which the sequence of a dental and velar consonant is produced but in terms of manner, fricative /s/ is substituted by stop consonant /t/. In this study I will emphasise that by producing a heterorganic sequence of different place the child has progressed in his/her phonology inspite of possible limitations in manner of articulation.

There is evidence for which sequence constraints are first violated in the phonological development of Finnish children; these sequences can be assumed to be the most unmarked and thus easiest for a Finnish child. According to Iivonen (1994: 70) correct sequences started to appear in the speech of boy E at age 2;5 and examples show that in these sequences both segments are pronounced in the same place. This indicates that the child starts off with homorganic sequences:

| | | | |
|---|---|---|---|
| *hinta* | *hinta* | 'price' | (dental+dental) |
| *kampa* | *kampa* | 'comb' | (labial+labial) |
| *täŋki* | *säŋky* | 'bed' | (velar+velar) |

Concerning the manner of articulation these examples also show Iivonen's (1994: 71) conclusion that the nasal+stop sequence was easiest for E. The other subject, boy J, started to produce consonant sequences earlier, at age 2;0, e.g. *kakf* for *kaksi* 'two', *koŋke* for *kolme* 'three', *kintti* for *kiltti* 'nice' (2;2), *oŋkakko* for *lompakko* 'wallet' (2;2) (Iivonen 1994: 71). Most of the examples include sequences of same place and although in some cases there were substitutions of segments, homorganic place was retained, e.g. /mp/ (labial+labial) became /ŋk/ (velar +velar) (Iivonen 1994: 71).

Based on Iivonen's examples of first realisations of sequences, /h/ was included in several of them, but it is phonetically problematic (see Karlsson 1983: 61) and it is not included in the target words of this study. According to Iivonen (1994: 70), the first sequences pronounced with different place (other than those with /h/) were /tk/ *putku* for *puskuri* 'bumber' (dental+velar) at age 2;7, /ps/ *kypsä* 'ripe' (labial+dental) at age 2;10 and *kylpy* 'bath' (dental–labial) at age 3;0. Another case study likewise shows that most of the first sequences include those of same place. The first realisations of sequences in Sini's speech were (Savinainen-Makkonen 1996: 100):

| | | | | |
|---|---|---|---|---|
| [kantaa]˘ | *kantaa* | 'to carry' | (1;6) | (dental+dental) |
| [kakχ] | *kaksi* | 'two' | (1;7) | (velar+dental) |
| [kampa] | *kampa* | 'comb' | (1;7) | (labial+labial) |
| [alkaa]˘ | *]T_^TTa* | 'foot' (Illative) | (1;7) | (dental+velar) |
| [ehmä] | *lehmä* | 'cow' | (1;7) | |
| [paleltaa] | *paleltaa* | 'to freeze' | (1;7) | (dental+dental) |
| [käleχtä] | *kädestä* | 'hand' (Elative) | (1;7) | (dental+dental) |
| [keŋkä] | *keŋkä* | 'shoe' | (1;8) | (velar+velar) |

The examples also include consonant sequences of different place and in some of these (e.g. in *kädestä*) manner also plays a role.

Once the child has acquired sequences, both heter- and homorganic, and when only manner constraints occasionally play a role, NoSequence constraints may be no longer relevant. The question remains, however, about paradigmatic constraints on certain phonemes despite the freeing up of the syntagmatic environment. For example, the child's phonological system may be adult-like apart from correct production of /r/ or /s/ phoneme.

Thus far in this chapter I have dealt with consonant sequences but diphthongs are also investigated from the word structures in this study. A solution for the constraint preventing diphthongs (*COMPLEX-NUCLEUS) would be a deletion of one vowel from the diphthong, which seems to be possible in Finnish 4as well as in English (see Bernhardt and Stemberger 1998: 410). For example, boy E produced *löty* for *löytyi* 'was found' (colloquial form is *löyty*) at 2;6 although in most cases he produced diphthongs (Iivonen 1994: 59). Epenthesis is an unlikely solution since that would break the nucleus into two

syllables (Bernhardt and Stemberger 1998: 411). Perhaps the most common solution to avoid diphthongs is to produce a long vowel instead, in such cases the timing unit is preserved but complexity is decreased at the segment level. A long vowel, however, still forms a complex nucleus at the level of timing units. In this study, concerning the complexity of the nucleus I will focus on complexity at a segment level rather than on the moraic timing unit level and assume, according to Bernhardt and Stemberger (1998: 409), that a long vowel is not as complex as a diphthong since it has a single Root node. I assume that the constraint *COMPLEX-NUCLEUS is highly ranked when a long vowel is produced instead of a diphthong even though in such cases it is not completely satisfied at the timing unit level.

Production of a long vowel instead of a diphthong can be illustrated as in (a) below. In the example, Sini produced [kiiku] ~ [kiikuu] for *kiekuu* 'crows' at age 1;2–1;3) (Savinainen-Makkonen 1998: 59). Sini preserved the required heaviness of a syllable by producing a long vowel. In (b), a hypothetical example illustrates how a deletion of a segment would violate the moraic syllable level.

a)          target              child

              ω   ω                  ω  ω
             ∕∖  ∕∖               ∕∖ ∕∖
             σσ  σσ               σσ  σσ
             | |  | |               | |  | |
             kiekuu               kiikuu


b)         ω    ω                 ω   ω
          ∕∖   ∕∖                ∕   ∕∖
          σσ   σ σ               σ   σσ
          | |   | |               |    | |
          kiekuu               *ki kuu

Similarly to consonant sequences, in this study I will look at the complexity of diphthongs in the sense that the child may first be able to produce a diphthong but with changes at the segment level. Such productions, however, are more faithful to the input than productions without a diphthong at all. For example in the early stages of Sini's (1;2–1;3) phonological development she produced both ʉitiβ and ʉitiβ for *äiti* 'mother' (Savinainen-Makkonen 1996: 58).

Compared to consonants, acquisition of vowels is in general less studied (Vihman 1996: 112). Iivonen (1994: 59) has however reported on how diphthongs were acquired by boy E. They appeared in babbling but the first target-like diphthongs started to appear at age 1;8, e.g. *aita* 'fence', *vuovu* for *vuohi* 'goat' (1;9), and at age 2;0–2;4, e.g. *laiva* 'boat', *ruoka* 'food', *kauppa* 'shop',

*veitsi* 'knife'. Inter-individual variation in acquisition is known to be high, and perhaps at age 2;6 some children still have difficulties in producing them.

In this study I will also investigate possible conspiracies of constraints in sequences and diphthongs, productions of the words *aurinko* 'the sun' and *polkupyörä* 'bike' providing data for investigating how the children produce words containing both. There may be a stage in a child's phonology when only one of them is possible in the output.

## PHONOTACTICAL LEVEL RESEARCH QUESTIONS AND HYPOTHESES

### *Research questions*

1. To what extent are children able to produce consonant sequences and diphthongs at age 2;6?
2. Which are the most common strategies to overcome the constraints preventing consonant sequences and diphthongs?
3. Do at-risk children have more problems with consonant sequences and diphthongs than controls?
4. Do late talkers have more problems with consonant sequences and diphthongs than others?

### *Hypotheses*

1. At the age of 2;6 there are several children who do not yet produce consonant sequences. Diphthongs on the other hand may be easier and most children produce them.
2. Assimilation and compensatory lengthening in sequences and a long vowel in diphthongs are the most common strategies to overcome the constraints preventing them.
3. At-risk children have more difficulties in the production of consonant sequences and diphthongs than control children, because they have more problems in the accurate identification of complex word structures. This deficit may be manifested through simpler word structures produced by at-risk children than by children without a genetic risk for dyslexia.
4. Late talkers have got more problems in the production of consonant sequences and diphthongs than others, because assimilation and compensatory lengthening are typical to earlier stage in phonological development.

## 2.3.5 Phoneme level

In this study word structures are investigated as wholes and the analysis attempts to take into account the phonological environment of elements. As noted by Iivonen (1994: 65), syntagmatic acquisition is more complex compared to paradigmatic acquisition of phonemes. In this study the phoneme level is touched upon in the context of phonotactics and also quantitative analyses will

be reported on the production of /r/ and /s/ in chapter 5. /r/ and /s/ were chosen for the analysis since they are usually among the last phonemes to be acquired.

Constraints concerning individual segments are expressed as Not-constraints of which Not(Dorsal), Not(Labial) and Not(Coronal) rule out all features. A satisfaction of these constraints requires a null output which is phonetically realised as silence. Only a higher ranked Faithfulness constraint causes the feature to be present in the output. (Bernhardt and Stemberger 1998: 170.) Besides constraints on place, manner of articulation may affect the production of an individual segment.

When a segment is entirely omitted it may be due to higher level constraint, for example, Light(Unstressed) may cause omissions of segments in order to achieve a CV-syllable. Also, NO-CODA may cause a deletion of a segment. Constraint ONSET is interesting since it seems to be typical for Finnish children to omit word initial onsets. In this study phoneme level is the focus only after the higher levels in the hierarchy have been acquired. This includes word level, in terms of number of syllables, syllable level in terms of syllable heaviness and phonotactics in terms of consonant sequences and diphthongs. I assume that the paradigmatic finishing comes after these structures are present in the output.

Segmental constraints become relevant when a segment is present, that is, the production is Faithful to the target at the moraic level. During this stage, substitutions become more visible than earlier when syntagmatic constraints dominate. A common substitution for /s/ is probably the stop consonant /t/ as in ˈtæξkyβ *sänky* 'bed' (Sini 1;9) (Savinainen-Makkonen 1996: 105). Here the constraint preventing /s/ may be Not(+continuant) (see Bernhardt and Stemberger 1998: 322). In /r/, as Bernhardt and Stemberger point out (1998: 334), a common substitution is /l/ where only manner of articulation changes and not place as in ˈkiljaaβ *kirjaa* 'book' (Partitive) (Sini 2;4) (Savinainen-Makkonen 1996: 84). It is problematic to define the feature constraints preventing /r/ (see discussion in Bernhardt and Stemberger 1998: 335); in this study, however, featural constraints on individual segments are not the focus.

Savinainen-Makkonen (1996: 136) has compared the developmental acquisition patterns of consonants in the case studies of Sini (Savinainen-Makkonen 1996), boys E and J (Iivonen 1986: 41) and Eero (Toivainen 1990: 64). The consonants were explored based on their first realisations in meaningful words. According to these studies, the first consonants were stops and nasals. Out of thirteen consonants, /s/ was realised as the 5th (Sini), 6th (boy J), 8th (boy E) and 11th (Eero) respectively and /r/ among the latest consonants of the total 13 as the 8th (Eero) 11th (boy E, boy J) and 12th (Sini). The final consonant to appear was /d/, which usually do not appear in dialects (see Karlsson 1983: 57–58 for discussion).

Sini produced a phonetic variant of /s/ at the age of 1;2 (Savinainen-Makkonen 1996: 94). Boy E produced /s/ at age 2;1 and boy J at age 1;3

(Iivonen 1994: 65467), but it was typical for boys E and J that /s/ was not phonetically adult-like before school age.

Sini (Savinainen-Makkonen 1996: 83) produced trilled /r/ for the first time at the age of 2;5 but it was often substituted by /l/ until the age of 3;6. Boy E produced a phonetically correct /r/ at the age of 3;6 and J at the age of 4;0 (Iivonen 1994: 66467). Phonetically the acquisition of these consonants seems to be on a continuum (see Itkonen 1977) which causes problems for the quantitative analysis in this study. In transcription the variants of these phonemes were coded as /s/, /r/, as another phoneme or as an unclear production with notes. In the quantitative analyses the phonemes were coded as realisations or nonrealisations of the segments; it may be that children with an emerging /s/ or /r/ may have suffered through this type of straightforward coding which is necessary for the quantitative purposes of a large dataset.

To conclude, the paradigmatic acquisition of /r/ and /s/ in this study is seen as the final stage in the acquisition of word structures. Based on previous developmental case studies it is predicted that most of the children at the age of 2;6 have not yet acquired /s/ and this is even more likely for the phoneme /r/.

## RESEARCH QUESTIONS AND HYPOTHESES AT THE PHONEME LEVEL

### Research questions

1. What is the proportion of children who have not yet acquired /s/ and /r/ at the age of 2;6?
2. Do at-risk children have more problems in the production of /s/ and /r/?
3. Do late talkers have more problems in the production of /s/ and /r/?

### Hypotheses

1. Most children have not yet acquired /r/; there is more of those who have acquired /s/.
2. At-risk children have got more problems with /r/ and /s/ than controls, because they have more problems in the accurate identification of complex word structures. This deficit may be manifested through simpler word structures produced by at-risk children than by children without a genetic risk for dyslexia.
3. Late talkers have got more problems with /r/ and /s/ than others, because substitutions of these consonants are typical to earlier stage in phonological development.

# 3    SUBJECTS AND DATA COLLECTION

In this chapter I will report on the selection criteria of the at-risk and control subjects as well as late talker subgroup which was selected according to results of measures at the age of 2;0. The selection of another late talker group based on results from age 5;0 as well as groups of poor, middle and good readers will be reported in chapter 5. In addition to subject selection, I will describe the method of data collection (a naming task) in this chapter. The same data was used in in word analyses in chapter 4 and the phonological scoring in chapter 5 where the method for that scoring is also reported.

The selection of at-risk and control children in the JLD-project was based on dyslexia's heritable nature. The parents of the at-risk children have reported a history of reading or writing difficulties themselves and in their close relatives, and correspondingly, control children's parents did not report any reading or writing difficulties. The reported difficulties of the dyslexic parents, (and for the control subjects, the lack of them), were verified in a series of tests. A subgroup of late talkers was selected from the at-risk and control children based on tests administered to them at age 2;0. The naming task was conducted when the children were 2 years and 6 months old.

## 3.1  Selection of subjects

### At-risk and control subjects: selection of dyslexic and nondyslexic parents

The selection of subjects for this study is fully dependent upon the selection criteria of the JLD-project. A three-stage process was conducted for families visiting maternity clinics between 1993 and 1996 in the Province of Central Finland, in order to find the dyslexic families for the study. This description is solely based on a report by Leinonen et al. (2001) (for a more detailed description of the selection procedure see also Lyytinen et al. 1995; Richardson 1998: 86492).

In the first stage, a questionnaire concerning difficulties in learning to read and spell was administered to more than 9000 parents. In the second stage, a more detailed questionnaire was mailed to approximately 5400 parents out of whom 3130 returned the questionnaire. The questions concerned demographic information and the occurrence of reading and writing problems both in childhood and adulthood and among relatives.

In the third stage, for the selection of at-risk children, 190 parents fulfilling the criteria in the first and second stages were invited for an interview and for an assessment of their reading or writing skills: The dyslexic parents were then selected according to self-reported childhood and adulthood history of reading or writing difficulties. Those with sensory or neurological abnormalities or a low IQ and those who did not report occurrence of reading or writing difficulties among close relatives were excluded. Criteria for performance in diagnostic tasks for the dyslexic sample were as follows: they had low scores either in accuracy or speed of oral text reading or alternatively in spelling accuracy, and additionally in at least two out of four computer-aided single word tests measuring phonological recoding and orthographic processing.

Some parents who reported reading and writing problems at school and as an adult and who also had relatives with literacy difficulties, did not score enough below the norm to meet the inclusion criteria for the dyslexic group. These individuals were, however, included into the dyslexic group as compensated dyslexics. Their children were included in this study as at-risk children due to the reported positive history of reading and writing difficulties in themselves and in their families.

The following description of the selection of control parents is adapted from Richardson (1998: 91492). They were selected along the same principles as the dyslexic subjects but the inclusion criteria were the opposite conditions. Control subjects completed the first and second stages similarly to dyslexic subjects. The information provided by subjects about themselves and about their close relatives included disclosure of any indications of reading or writing difficulties. An exclusionary criteria for this group was also that subjects with sensory or neurological abnormalities were not included in the study.

At the third stage, the criteria for inclusion in the control group were z-scores at or above –0.9 in all of the variables except one in the following tasks: nonsense word reading, orthographic reading (accuracy), accuracy and speed in oral text reading, accuracy in spelling both actual and nonsense words.

### *At-risk and control children*

The children for this study were the children of the carefully selected dyslexic and nondyslexic parents. According to the dyslexia status of their parents the children were divided into an at-risk and control group. The children of compensated parents were included into the at-risk group due to a reported positive history of reading and writing difficulties in the parents and in their families.

The data for this study is from a naming task conducted at the children's homes when they were 2;6 year old (mean age 30 months 3 days). Altogether the task was administered to 105 at-risk subjects (54 boys and 51 girls) and to 91 control subjects (51 boys and 40 girls).

Individual children are referred by invented names. In addition, "RG" after child's name refers to an at-risk girl, e.g. Anna (RG), and "RB" to an at-risk boy. Correspondingly, "CG" refers to a control girl and "CB" to a control boy.

In the JLD-project the children are followed from birth until school age. The follow-up assessments after neonatal assessment are conducted at ages 6, 14 and 18 months and at ages 2;0, 2;6, 3;6, 4;6, 5;0, 5;6, 6;6.[18] The follow-up continues to first, second and third grade. In october 2001 all the children had reached 4;6 year assessment. Practically all who participated in the neonatal assessment also attended the 4;6-year assessment. (Lyytinen, H. et al. 2001.)

### *Late talkers*

So-called late talkers in this study were selected on the basis of tests carried out with children in the JLD-project at the age of 2;0. These children were analysed in at-risk and control groups and then reanalysed as late talkers. They were selected from both groups as those who scored one standard deviation below the mean in the following tests.

The measures used for selection were the Finnish version of the MacArthur Communicative Development Inventories, which provided information on vocabulary production and maximum sentence length, and Bayley's expressive score in which the child's naming of pictures and objects was examined (Lyytinen, P. et al. 2001; Bayley 1993). The MCDI is based on parental report. Lyytinen (1999) has investigated the correlation between parental report and child's perfomances on language tests and found that they correlate well, although there are some risks in a parent's estimation of their child's linguistic skills, e.g. over- or underestimation. Similarly with Thal et al. (2000) Lyytinen has found that the MCDI can be used as an indicator of a child's linguistic skills especially before and after the age of 2;0.

Of the selected children, the naming task was administered to 20 of the at-risk group and 12 of the control group.[19] In the results of the word analyses no division is made between at-risk and control late talkers due to relatively low number of productions.

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[18]     For a description of the follow-up assessment program of JLD from birth to five years see Lyytinen, H. et al. (2001: 540-541).

[19]     The naming task was also attempted with one at-risk late talker and one control late talker but they were not able to produce the target words.

## 3.2  Naming task

***Target words***

The data were collected using a naming task with 33 pictures, which the children named twice. Of these words, 19 were chosen for the transcription and analyses of this study. Productions of 16 target words are analysed in chapter 4 and all 19 were used in phonological scoring reported in chapter 5. The target words (Appendix 1) included a variety of Finnish word structures. The number of syllables varied from two to four (one five syllable compound target word was not included in the specific word analyses but was taken into account in the phonological scoring in chapter 5). Also the length and position of syllables varied so that short and long syllables occurred both in stressed and in unstressed positions. Phonotactically the words included a range of  consonant sequences typical to Finnish and also some diphthongs (/yö/, /öy/, /iu/).

In the selection of stimulus words for the task some issues had to be taken into account as the research was being administered to young children. First of all, the words were selected to be content words in order for them to be easily picturable for a 2;6 year old child. Also, the words had to belong to the every day vocabulary of the child, thus the pictures included familiar objects for the children, such as food or clothing.

The pictures were presented within a story frame and in a picture book. The basic storyline was about three friends who spent a day together. They played, ate and went to sleep. During the day they saw different objects which the children named. The experimenter explained to the children that she/he was going to say what the friends saw. In order for the child to name each picture twice, the same pictures were also presented in a form of stickers that the child glued onto a board. The board presented the friends' house and the yard. The children were asked to name the picture before gluing it in place.

***Procedure***

The naming task took place in the children's homes. The child and the experimenter sat by a table. A microphone (Super uni-directional electric condenser microphone) was placed on the table in front of the child, it was connected to a video recorder (Canon UC8Hi) as well as to a tape recorder (Sony Walkman Professional).

First the child read a picture book with an experimenter and named the pictures he saw on the pages. The experimenter pursued to encourage the child to name the picture without giving a model. If the child for some reason did not produce the target word, the experimenter produced the word him/herself which usually caused the child to repeat the word. These productions were later coded as imitated productions and were not used in quantitative analyses.

After reading the book, the second productions of the words were collected as the children glued the stickers onto the board. This procedure was

conducted to ensure that as many children as possible would produce each target word at least once.

If the child repeated a word several times, only the first two productions on both naming rounds were taken into account. In the word analyses, the production which was phonologically most advanced was analysed. The number of productions of different targets varied due to several reasons. Most often the child had refused to name the picture, or the production was whispered or otherwise so unclear that the structure of the word could not be defined. The child may also have produced another word instead of the intended target.[20] Whatever the reason was, since the aim was to examine the children's phonological skills based on the same target words, these productions were not included. In other words, only those productions which could be interpreted as attempts of the intended target word were included in the results; if the child did not produce the target word, he/she was not included in the analysis of that word.

## 3.3  Transcription

First the whole naming task (33 words named twice) was transcribed for 60 children (30 at-risk and 30 control). The transcription was done both with a tape recorder and with the video recordings. This data was checked throughout by another linguist and again rechecked by the author. Since they also discussed about unclear productions, reliability score was not counted for these transcriptions.

After the transcription of the productions of these 60 children, a smaller number of target words for the rest of the children were chosen in order to decrease the amount of transcription from such a large number of children. These words (19 words named twice) similarly included a variety of word structures (Appendix 1). For the rest of the children (altogether N=136) only these words were transcribed.

Transcription was done with orthographic graphemes and with some diacritics applicable for the present study (see Appendix 2). An emphasis was on the number of syllables, the heaviness of syllables and in the quality and length of segments. The phonetic realisation of /s/ and /r/ varied but for the purposes of this study these phonemes were marked only as /s/ and /r/ based on their classification as allophones of those phonemes. It was attempted to transcribe /r/ based on the presence/absence of a trill. If the production could

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[20]  The child may have produced for example a synonym e.g. *puukko*4*veitsi* 'a knife', or a semantically correct but categorically different word, e.g. *hedelmä-appelsiini* 'a fruit4an orange', or *karkki*4*suklaa* 'candy4chocolate'. In addition, a misinterpretation of the picture may have occurred, though these were often semantically close e.g. *kettu*4*pupu*4*orava* 'a fox4a bunny4a squirrel', or *helikopteri*4*lentokone* 'a helicopter4an aeroplane'. The words may also have had some other semantic connection, e.g. *apina*4*banaani* 'a monkey4a banana' or *leipä*4 *veitsi* 'a bread4a knife'.

not be classified as /s/ or /r/ (or another phoneme in case of substitution) it was marked in brackets as unclear. These were later counted as nonrealisations of the segment.

Following Finnish orthography, a long quantity was marked with two letters in the case of geminates and long vowels. In other cases it was marked with "ˑ" Also phonetically half-long segments were marked.

An unexpected stress placement (other than word initial main stress) and naming register with a rising intonation (ä) were coded. A word-initial main stress was also coded if it was stronger than usually. Notes were also taken, for example, on whispering or pauses within a word. It was also coded whether the production was imitated or spontaneous. If the child imitated the word in the first round of naming (book reading) but produced the target word spontaneously in the second naming (stickers), it was taken into account as a spontaneous production in the results. Imitated productions were not included in the analyses since by imitation the child may be able to produce more target-like word forms than she/he would be able to produce spontaneously (Iivonen 1994: 46).

Since the tests for 60 children were checked by another linguist and again rechecked by the researcher no additional reliability analysis was carried out for this part of the data. For the rest of the data (N=136) the reliability was ascertained for 10 % of the data, that is, the word productions of 14 children were transcribed separately by another linguist and the two transcriptions were compared, concentrating on the relevant features for the present study (see Table 1). The reliability was highest in the number of syllables (94 %) and in vowels (93 %). It was lowest in consonants (82 %) and in the heaviness of unstressed syllables in words (82 %).

In consonants and in vowels a disagreement was marked if one or more of the phonemes in a word was transcribed to be qualitatively different (e.g. *rʒl*), or, if there was a disagreement in the existence of the phoneme. In this, durational differences (e.g. *kʒkl*) and slight qualitative differences were not taken into account, e.g. voiceless vowels in the end of the word or slight openness of a round vowel.

Disagreements of stress were counted only if there were differences in the marking of the stress later in the word, that is, if the production had an unpredictable stress pattern. Disagreement was also taken into account if there were differences in the marking of the specific naming register. This register includes a rising intonation and is deviant from the standard pronunciation. In the transcription it was often difficult to define whether the question was about rising intonation due to naming register and/or stress shift to the word final syllable. The reliability score for stress also includes markings of phonetic traces of syllabification, in other words, marking of a slight temporal demarcation between syllables.

The reliability for quantity was counted for the words *mato–matto* 'worm – carpet', which are phonologically differentiated by a quantity distinction only.

TABLE 1    Reliability scores.

| Feature | Reliability score (%) |
|---|---|
| Number of syllables | 94 |
| Diphthong | 91 |
| Consonant sequences | 90 |
| Vowels | 93 |
| Consonants | 82 |
| Stress placement | 91 |
| Length of unstressed syllable | 82 |
| Quantity  (*mato–matto*) | 96 |
| Average | 89,9 |

# 4    ANALYSES OF WORD PRODUCTIONS

The aim of word specific analyses is to explore the variety of production types from simple truncated forms to complete target-like forms and to provide normative information on typical word forms at this age in control and at-risk groups as well as in the subgroup of late talkers which includes children from both the control and at-risk group.

The classification of children's productions is based on the hierarchical and implicatory model presented in chapter 2. It is noteworthy that although the model hypothesises how word structures are developmentally acquired, the data in this study is cross-sectional and thus the evidence for an actual developmental path is only tentative. However, in spite of the nature of the data, the hierarchical model serves to define the degree of complexity of a word structure, and thus, if one assumes that phonological complexity increases in the course of development, the results also shed light  on the developmental aspect. Theoretically an increase of complexity is an increase of marked structures, which in Optimality Theory is expressed by a promotion of Faithfulness to input forms. The productions of late talkers are used to verify the developmental aspect of the hierarhical model; their productions, although spoken at the same age, will illustrate what may be the structure of the target words at an earlier age.

The word level analysis focuses on longer three and four syllable words: both the frequency and the structure of truncated forms are analysed. At syllable level I will focus on heavy unstressed syllables especially in bisyllabic target words. Analysis of phonotactical elements concentrates on the production of consonant sequences and diphthongs. Production of individual phonemes is seen as the final stage of the acquisition of word structure. A special focus is on word initial /r/ and /s/ consonants due to their expected difficulty at age 2;6. As phonemes are always produced in a certain phonological context, they are prone to assimilation and harmony processes; these issues are also touched on in the word analyses. Word and syllable level, as well as phonotactics and the phoneme level are more specifically defined in relation to each target word, for example, if the word lacks diphthongs and

consonant sequences then this aspect of phonotactics is naturally left out. The core idea is to define the phonologically complex features of each level of word structure and to examine the children's productions according to the hypothesised developmental stages.

The results are presented from bisyllabic to three and four syllable words. In the results the most advanced production of the target words from each child is taken into account, with the number of produced words and the number of subjects remaining the same. The numbers vary from word to word due to the different number of namings. Since the quantitative results are based on single words in this section, statistical analyses were not conducted. Comparisons of groups will, however, shed light on a more general application of the word analyses in chapter 5 in which statistical comparisons are also conducted. Besides giving preliminary information on group comparisons, the quantitative results will in the first place give information on variation and on the normative aspect of Finnish children's phonological skills at age 2;6.

## 4.1   Bisyllabic target words

### 4.1.1 Productions of the word *rattaat*

The prosodic structure of *rattaat,* 'strollers' is an example of a rare word structure in Finnish due to a heavy trimoraic, or superheavy, unstressed syllable which is diachronically developed via consonant deletion: *rattahat>rattaat.* This process changed the word prosodically from a tri- to a bisyllabic form and it may be that a drive towards binary footing without extrametrical syllables motivated the process. The process, however, led to a less optimal trochaic foot form compared to the word initial foot in the diachronically earlier form. Since main stress in Finnish is fixed to the word initial syllable in Finnish, the heavy second syllable remained unstressed. What follows is that Light(Unstressed) has to be low ranked in Finnish in order to allow such forms, but this may not be the case in a developing grammar of a child: a solution for this conflict would be a shortening of the heavy syllable by deleting segments, which would result in the form *(r)atta.* This form would satisfy the constraints requiring trochaic rhythmic pattern as well as Light(Unstressed).

I assume that the child will first acquire a target-like prosodic form, and only after that the phonotactical and phoneme level characteristics will be specified. In the word *rattaat* another complex element besides the heavy unstressed syllable is the initial phoneme /r/ which is often typically either deleted or substituted in syllable initial position. A hypothetical path in the acquisition of *rattaat* would thus be:

> *(l)atta*          Satisfies Light(Unstressed)
>                        Violates Faithfulness at syllable and at phoneme level

| *(l)attaa* | Violates Light(Unstressed), |
| | Violates Faithfulness at syllable and at phoneme level |
| *(l)attaat* | Violates Light(Unstressed), |
| | Violates Faithfulness at phoneme level |
| *rattaat* | Violates Light(Unstressed), |
| | Satisfies Faithfulness at all levels |

Since the second syllable is trimoraic, there may be stages in development from the fully shortened CV -syllable to a bimoraic CVV- or CVC-syllable before the complete CVVC-syllable is mastered.

### Syllable level

The total number of *rattaat*-productions was fairly low compared to other target words, for example, due to the synonym *kärryt* that was quite often produced by children. However, a total of 117 children produced *rattaat* in the naming task. Table 2 shows the distribution of shortened forms to forms with similar heaviness to the target word.

At-risk and control groups had almost the same number of unmarked CV-structures in the unstressed syllable: at-risk group 11,9 % and control group 13,8%. However, the results show that there was indeed a continuum in the length of the second syllable in terms of moras, from monomoraic to bimoraic to trimoraic syllables. When the syllable types of the productions were examined more carefully, the at-risk group had less prosodically target-like trimoraic syllables (67,8 %) than controls (74,1 %) (see Table 2). This means that they had more (20,3 %) intermediate CVV- and CVC-structures than controls (13,8 %).

Also the late talkers had less CV-syllables than expected: only 2 out of 14 late talker's *rattaat*-productions included a fully shortened second syllable (see Table 2). Four out of 14 were bimoraic CVV- or CVC-syllables and 8 produced a target-like trimoraic CVVC-syllable.

In general the number of fully shortened CV-syllables was quite low: a total of 15 productions out of 117 (12,8 %). It was, however, a clear tendency and perhaps more typical of an earlier age. Productions by Aino (CG) illustrate hesitation and variation in mastering the prosodic structure of the word: At first she produced ᴪ‑ taattaβ with correct geminate quantity and a monomoraic unstressed syllable. After that she produced ᴪu- tatAAtβ with a correct trimoraic unstressed syllable but this time there was no control on correct quantity in the geminate.

TABLE 2      Production of the heavy unstressd syllable in *rattaat.* Proportions (%) of light (CV) and heavy (CVV, CVC, CVVC) syllables in the control group, at-risk group and late talkers (including both at-risk and control children).

| Type of the second syllable: | -CV e.g. (r)atta | -CVV/CVC e.g (r)attaa,[21] (r)attat | -CVVC e.g. (r)attaat |
|---|---|---|---|
| Control (N=58) | 13,8 (8) | 13,8 (8) | 72,4 (42) |
| At-risk (N=59) | 11,9 (7) | 20,3 (12) | 67,8 (40) |
| Late talkers (N=14) | 14,3 (2) | 28,6 (4) | 57,1 (8) |

In this word morphological issues may have affected the children's processing of the word since *rattaat* is in fact a plural form. It may be that the children formed their own single form *\*ratta.* Although this may be a possibility, I would assume that they aimed to produce a plural form because the input is *rattaat,* and that they produced CV's because of a highly ranked constraints that disallow heavy unstressed syllables. However, morphology may still play a role since the stem varies in inflection, e.g. *rattaat:rattaita:rattaisiin* (Nominative, Partitive, Illative). These morphological processes may cause hesitation on nominative forms. There were three children who produced a trisyllabic form of the word:

[ˈɪ- n- lattaita]      Taija (RG)
[ˈattaita]      Tiina (RG
[ˈattaja] [ˈattoja]      Jesse (CB)

Perhaps this is a strategy to avoid the conflict of stress and length since these forms have CVV or CV syllables instead of a trimoraic CVVC syllable later in the word. But it is more likely that these productions resemble partitive forms due to high frequency utterances such as *työntää rattaita* 'push strollers'.

Another example is a trisyllabic partitive form [ˈtaaˈtaitaˌ] (Noora CG) in which clash of stresses violates an undominated \*CLASH –constraint in Finnish. It may be, that instead of one bisyllabic foot and an extrametrical syllable, the output could in fact be divided into two feet: [(ˈtaat).(tai.ta)] The production pattern was noteworthy since after overemphasising the initial syllable, the last two syllables were produced relatively quickly which may indicate that the word was indeed divided into two separate phases (similarly to compound words). The same child also produced [ˈattaˌ] with a light and unstressed second syllable. There was also a bisyllabic production in which both syllables were stressed: [ˈtatˌtaat] Ismo (RB). It may be that occasionally \*CLASH is violated in the developing phonology of Finnish in order to have stress on heavy syllables. The question may also be about temporal spacing, which by definition refers to a non-adultlike production with a slight temporal demarcation between the syllables (see Nettelbladt 1983: 68). This would support the view that actually \*CLASH is not violated in [ˈtatˌtaat] but the question may be about a sequence of two bimoraic, word-like productions.

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[21]      The form [ˈat'taa(t)] by VT 064 was counted as CVV due to the unclear final /t/.

There were also a few bisyllabic cases in the data with a stress shift to a heavier second syllable:[22]

    ˈɑtˌɟaatβ   Pinja (RG), Asko (CB)
    ˈɑtˌɟaatβ   Uolevi (CB)
    ˈɑtˌɟaatβ   Tuovi (RG)

Stress shift also has to do with naming register in which intonation rises towards the end of the word. In transcription it was sometimes difficult to separate rising intonation and stress. The following example may indicate that stress shift is used as a strategy to produce the trimoraic syllable. At first Maria (RG) produced the final /t/ effortfully and separately: ˈɦaltha-thβ then she repeated the word twice with stress on second syllable and succeeded in the correct production of that syllable: ˈɦat'taatβ In such cases the productions do not follow trochaic pattern. It may be that in the naming register in Finnish an iambic pattern may occur although in general a trochaic rhythmic type with stress on the initial syllable dominates.

To sum up, a clear strategy to overcome the conflict between the stress and heaviness of a syllable was shortening of the second trimoraic syllable into a bi- or monomoraic syllable, the latter of which does not violate Light(Unstressed). The other strategies were questionable, because there were only few cases. First of all, trisyllabic productions were probably due to partitive input rather than avoiding a trimoraic syllable and secondly, stress shift to the latter syllable may be due to the naming register rather than stressing the trimoraic syllable instead of the initial syllable. Finally, a few cases in which stress occurred on adjacent syllables violate *CLASH which is unexpected in Finnish.

### *Phoneme level*

In the phoneme level analysis of the word *rattaat* I focused on the realisation of the consonant /r/. The word initial position is interesting since in Finnish children the deletion of word initial consonants is a normal developmental process but it is defined as a deviant process in some other languages (Savinainen-Makkonen 2000c).

Production of /r/ was analysed from two points of view. First of all, it was examined in relation to the word's prosodic structure. According to the hierarchical model one could assume that if prosodic structure is not completed, neither is the phoneme level, in other words, /r/ is more often produced in forms with a trimoraic second syllable than in forms with a

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[22]    In the quantitative results the realisations of the target's trimoraic syllable were viewed only on a moraic level by not taking the stress placement in the actual output into account, although in some outputs that syllable was stressed. In other words, the focus was on how the target's trimoraic unstressed syllable was realised in the moras of children's productions.

shortened CV-syllable. Secondly, the number of deletions as well as number and type of substitutions were studied.

The results in Table 3 show that for prosodically complete forms /r/ was realised in 33,3 % in the control and 22,5 % in the at-risk group, altogether in 28,0 % (23/82) of the cases. There were fewer productions with a second CVV, CVC and CV syllable. Within those productions /r/ was produced in 25 % (4/16) in the control group, 15,8 % (3/19) in the at-risk group and altogether in 20,0 % (7/35) of cases. Thus the proportions of /r/ were lower in productions with a shortened second syllable which supports the view that the phoneme level is not completed before prosodic structure. This relationship between prosodic and phonemic structure may be clearer in cases in which the prosodic and phoneme level complexities are located in the same syllable. Late talkers had only one realised /r/ phoneme which means that they as a group are developmentally late compared to the others.

TABLE 3    Proportions (N) of correct word initial /r/ in *rattaat* in forms with different realisations of the second unstressed syllable in the control group, at-risk groups and late talkers  (including both at-risk and control children).

| Type of the second syllable: | -CV e.g. ratta | -CVV, CVC e.g. rattat, rattaa | -CVVC e.g. rattaat[23] |
|---|---|---|---|
| Control  (N=58) | 2/8 | 2/8 | 14/42 (33,3 %) |
| At-risk  (N=59) | 3/7 | 0/12 | 9/40 (22,5 %) |

To summarise for the proportion of realised word initial /r/-phonemes, irrespective of syllable level, controls produced /r/ more often than at-risk children (see Table 4 and Figure 3). The phoneme was realised in 31,0 % of control productions but only 20,3 % of at-risk productions. And as seen earlier, only one of the fourteen late talkers produced an /r/, which in percentages is clearly less compared to all other groups (late talkers include both at-risk and control children).

Types of substitutions of /r/ varied extensively, and there were also deletions of the initial consonant. In the study by Savinainen-Makkonen (2000c) on six Finnish speaking children, all underwent the process of word initial consonant deletion from the first words onwards, for six months, and usually the omissions became infrequent by the age of two. She also reports that in stops the omissions were rare but /h/ and liquids were more prone to being omitted. The following examples illustrate the variation including deletion of /r/ and various substitutions with different realisations of syllable length:

CV–syllable

[rattaβ          Minna (RG)
ʔattaβ          Katja (RG), Liisa (CG)

---

[23]    The forms in the CVVC-category vary in realisation of /r/ but otherwise represent fully complete forms besides one exception: ʔattaanβ (Otso RB), which is included in this category due to the CVVC-unstressed syllable, although the final consonant is not correct.

Ɣrattaβ               Marjo (RG), Ronja (CG

CVC- and CVV-syllables

Ɣrattatä β           Olga (CG)
Ɣhattatä β           Sampsa (CB)
Ɣrattatβ             Santtu (CB)
ƔrattaAβ             Henri (RB)
Ɣattaaβ              Olli (RB)

CVVC-syllable

Ɣrattaatβ            Lauri (CB) and others
Ɣrattaatβ            Martta (RG)
Ɣrattaatβ            Aleksi (RB), Markus (RB)  and others
Ɣhrattaatβ           Kyösti (CB), Tatu (CB) and others
Ɣrattaatβ            Janne (CB), Sanni (RG) and others
Ɣrattaatβ            Janna (RG)

Quantitative results show that there were differences in the realisations of initial consonants between the groups, not only in number of correct /r/-phonemes but also in types of substitution and deletion (Table 4, Figure 4). Besides having more correct /r/-phonemes, the control group's most frequent substitutions were /h/ and /l/ whereas the at-risk group favoured /l/ and deletions. Developmentally word initial consonant omissions tend to occur at an earlier stage in phonological development than substitutions. The main type of substitution among the fourteen late talkers was /h/, but there were also cases of /t/, /l/ and well as deletions, so no clear deletion or substitution tendency was found in this group. Production of word initial /r/ was thus characterised by different substitution processes as well as deletions. Systematic substitution patterns for /r/ could probably be found in the individual phonological systems of the children.

TABLE 4    Production of the word initial /r/ in *rattaat.* Proportions (%) of word initial /r/ and its' deletions and substitutions in the control group, at-risk group and late talkers (including both at-risk and control children).

|          | Control group (N=58) | At-risk group (N=59) | Late talkers (N=14) |
|----------|----------------------|----------------------|---------------------|
| /r/      | 31,0 (18)            | 20,3 (12)            | 7,1 (1)             |
| /h/      | 20,7 (12)            | 8,5 (5)              | 35,7 (5)            |
| /l/      | 20,7 (12)            | 28,8 (17)            | 14,3 (2)            |
| /j/      | 1,7 (1)              | 3,4 (2)              | -                   |
| /t/      | 3,4 (2)              | 8,5 (5)              | 14,3 (2)            |
| /k/      | 1,7 (1)              | -                    | -                   |
| /n/      | 1,7 (1)              | -                    | -                   |
| /v/      | -                    | 1,7 (1)              | -                   |
| deletion | 12,1 (7)             | 23,7 (14)            | 21,4 (3)            |
| unclear  | 6,9 (4)              | 5,1 (3)              | 7,1 (1)             |
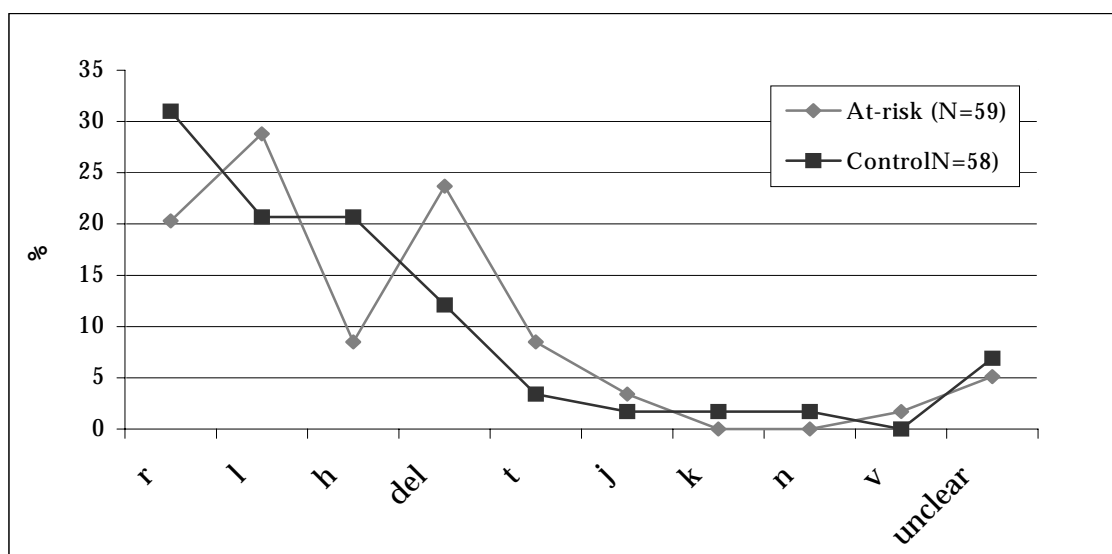
FIGURE 3   Production of the word initial /r/ in *rattaat*. Proportions (%) of word initial /r/, deletions and substitutions in the control and at-risk group.

## 4.1.2 Productions of the word *avain*

Word *avain* 'key' is another extreme example of the conflict between stress and length within the bisyllabic words of Finnish. The second unstressed syllable has the same length in segments and in moras as *rattaat*. It is, however, an even more extreme example of the conflict of stress and length since the initial syllable is light, violating Heavy(Stressed). In Finnish, the constraint requiring stress on the initial syllable (RHTYPE=T) is undominated even if the word structure violates both Light(Unstressed) and Heavy(Stressed). Diachronically the word structure has been explained by a contraction from a trisyllabic form *avaḣin* (Länsimäki 1987: 133).

Again, a solution for a child to balance the syllable weights may be a shortening of the second syllable due to the constraint Light(Unstressed), which at this stage of development could be ranked relatively high. In such cases the children would rather violate Faithfulness than the structural constraint requiring light unstressed syllables. Since the second syllable is trimoraic, a similar continuum could be hypothesised for this word as for *rattaat*. The word phonotactically includes the diphthong /ai/ in the second syllable, thus a constraint causing shortening of the trimoraic syllables may also be *COMPLEX-NUCLEUS which prevents diphthongs. I will here, however, examine the productions in terms of the moraic structure of the heavy unstressed syllable.

| | |
|---|---|
| *ava* | Satisfies Light(Unstressed) |
| | Violates Faithfulness at syllable and at phoneme level |
| | (Satisfies *COMPLEX-NUCLEUS) |
| *avai* | Violates Light(Unstressed) |
| | (Violates *COMPLEX-NUCLEUS) |
| | Violates Faithfulness at syllable and at phoneme level |

*avain*      Violates Light(Unstressed)
              (Violates *COMPLEX-NUCLEUS)
              Satisfies Faithfulness at all levels

### Syllable level

There were 166 productions of the word *avain* altogether but it turned out that 49 of these were trisyllabic productions which in most cases was due to inflection of the word: *avaimen* (Genetive), *avaimet* (Plural). These inflected forms also have heavy, bimoraic unstressed syllables. The proportion of bisyllabic forms was higher in the control group (76,6 %) than in the at-risk group (65,2 %) which may be explained by a better knowledge about the unusual inflection paradigm of the word in the controls. In the following quantitative results only bisyllabic forms (N=117) are included, but examples of trisyllabic forms will also be presented.

At-risk children had more fully shortened syllables in their bisyllabic productions and thus less trimoraic syllables than control children. The proportion of light second syllables was 11,8 % in the control and 24,1 % in the at-risk group (Table 5). In general, when all of the children were included, the proportion of monomoraic second syllables was higher (17,9 %) in *avain* than in *rattaat* (12,8 %). Altogether 25 late talkers produced the word and 76 % (19) of them were bisyllabic. In this group the proportion of CV-syllables in bisyllabic productions was highest, 57,9 % (11).

TABLE 5    Production of the heavy unstressed syllable in *avain.* Proportions (%) of light (CV) and heavy (CVV, CVC, CVVC) syllables in the control group, at-risk group and late talkers (including both at-risk and control children).

| Type of the second syllable: | -CV e.g. ava | -CVC/CVV e.g. avai | -CVVC e.g. avain |
|---|---|---|---|
| Control % (N=59) | 11,8 (7) | 37,3 (22) | 50,8 (30) |
| At-risk % (N=58) | 24,1 (14) | 31,0 (18) | 44,8 (26) |
| Late talkers (N=19) | 57,9 (11) | 21,1 (4) | 21,1 (4) |

Most of the forms with a light unstressed syllable were, as expected, the type *ava* (e.g. Liisa CG, Anna RG) but there were also some deviant forms as seen in the examples below (/m/ and /p/ in some of the following productions may be due to inaccurate pronunciation of labial /v/):

CV-syllable

Ψɑmiβ        Ulpu (CG)
Ψɑijɷβ      Janna (RG), Onni (CB)
Ψɑpiβ        Elisa (RG)
Ψɑ2vaβ(v~m)  Asser (CB)
Ψɑðeβ        Uolevi (CB)[24]

---

[24]    If the production is very exceptional one has to consider whether the child actually even attempts to produce the target word. In this case Uolevi (CB) repeated the word form and his mother verified that the child meant *avain* in his naming. From this evidence the production was accepted as an attempt of *avain*.

Besides shortening the syllable into a monomoraic CV-syllable, a typical strategy was to delete the word final /n/ which results in a bimoraic syllable. There were also forms in which the final /n/ survived but the vowel /i/ of the diphthong was deleted, or there were some other kinds of changes in the phonemes:

CVV- or CVC -syllable

| | |
|---|---|
| ˈʔavaiβ | Noora (CG) (and others) |
| ˈʔpaiä β | Ninni (CG) |
| ˈʔjãß | Henri (RB) |
| ˈʔveß | Atso (RB) |
| ˈʔkavaiä β | Pyry (RB) |
| ˈʔleiä β | Joel (CB) (twice) |
| ˈʔome3nβ | Juho (RB) (also ˈʔha(j)iß) |
| ˈʔjamä β | Niilo (RB) (high intonation) |

In forms with adult-like syllable structure there were not many changes at phoneme level. Exceptional cases were ˈʔpa- avˈvainβ (Jyri RB) which includes a gemination of the /v/-consonant, a pattern typical to some dialects, and ˈʔv-ainβ (Elsa RG) in which the child had a slight demarcation between the syllables which were syllabified differently from the target form. These processes may be due to balancing of the syllable weights and thus Heavy(Stressed) is not violated in these outputs, unlike in the target form.

Many children produced a trisyllabic form in an adult-like plural form *avaimet* or a plural form with a shortened third syllable e.g. ˈʔvaimeβ (m~p) (Miira CG), or a trisyllabic form with changes at phoneme level. Perhaps most of the trisyllabic forms were influenced by inflection, but forms with a V.CV.CV-structure in particular may show a strategy to avoid a heavy unstressed syllable. In those cases, there is one unparsed syllable but they do not violate Light(Unstressed), e.g. in the form ˈʔvaniβ (Miro RG), in which there are no changes in the actual quality of the phonemes but the child produced CV-syllables only through metathesis.

Examples of trisyllabic productions with light final syllable

| | |
|---|---|
| ˈʔpeˑmiˇei katoβ | Iiro (CB) ('a keyˇdon't watch') |
| ˈʔvavˑviβ | Severi (CB) |

Examples of trisyllabic V.CV.CV structures

| | |
|---|---|
| ˈʔjameβ | Ossi (CB), Olivia (CG) |
| ˈʔvaneβ | Iivari (CB) |
| ˈʔvaneβ | Leeni (RG) |
| ˈʔvameβ | Juuso (RB) |

Hesitation on a word form is shown below in the productions by Maija (RG) whose word endings were unclearly produced. Plural forms probably affected the attempts to produce a singular nominative form:

Ψảmeβ
Ψảme-β            (unclear ending and speech after the word)
Ψảmeni oliβ       'there was a key'
Ψảva-β            (unclear ending)

The following examples from naming situations illustrate further the variation of the forms in the speech of an individual child, especially regarding uncertainty over the nominative singular form. In example (1) Panu (CB) first produced the word  correctly but on the second naming he declared not to know what the word was. In example (2) Johanna (CG) likewise produced the word correctly at first but variation into a trisyllabic form came at the second naming. AlsoPyry (RB), in example (3), first produced a bisyllabic singular form but used a plural form at the second naming. The experimenter's genitive form of the word then confused him and he finally produced an incorrect trisyllabic singular form. This example shows the effect of the input in a conversation with an experimenter.

(1) Panu (CB)

First naming:      Ψtoi on ˌavainβ *toi on avain* 'that is a key'
Second naming:     Ψảv- en tätä tiä] *av- en tätä tiä* '- -  I don't know this one'

(2) Johanna (CG)

First naming:      Ψảvainβ *avain* 'a key'
Second naming:     Ψảvaine - - sillä aukastaan oviβ *avain - - sillä aukastaan ovi*
                   'a key - - you open the door with it'

(3) Pyry (RB)

First naming:      Ψảavaiä β *avain* 'a key'

Conversation during second naming:

Pyry:              Ψồξko siinäki avaimetβ *onko siinäki avaimet*
                   'are the keys there also?'

Experimenter:      *avain, tuosta saat avaimen*
                   'a key, here is a key for you'

Pyry:              Ψảmissä se avaimi onβ *missä se avain on*
                   'where is that key?'

Besides shortening the second syllable and tentatively producing the word in trisyllabic form with light unstressed syllables, stress shift to the heavy syllable may be a way to master the syllable length. The following examples of stress shift may also be due to the naming register:
Stress on second syllable:

Ψảꭕai β        Toni (RB), Helka (RG)  (twice)
Ψảꭕainä β      Mira (CG)

Forms with equal stress on both syllables violate *CLASH. But if this constraint was also undominated in child phonology, it may be that in the cases below the syllables are in fact separated. In the trisyllabic form *avani,* the heavy syllable was divided into two light syllables and in the following cases the word is tentatively divided into two separate sequences, but this is against the minimum of two moras in a foot.

Stress on both syllables:

ˈɑˌɣaiβ    Oskari (CB) (also produced ˈɑvaiβ with trochaic stress pattern)
ˈɑˌɣaɪhβ   Minna (RG)

### 4.1.3 Productions of the word *suklaa*

The word *suklaa* is complex at least in two aspects: prosodically it has a bimoraic unstressed syllable and phonotactically a heterorganic consonant sequence. In addition, the phoneme /s/ may at this stage still be prone to substitutions or deletions. If the prosodic constraint which requires light unstressed syllables and NoSequence constraint which prevents velar–dental combinations are not violated, the output for the child would hypothetically be *sukka,* and even *ukka* if word initial consonant deletion still takes place in this word, as it did in *rattaat.* If prosodic overall structure was acquired before phonotactical elements, one would expect that the *(s)ukkaa-*form would precede forms with a consonant sequence. This interplay between prosody and phonotactics is examined below.

*(t)ukka*     Satisfies Light(Unstressed)
             Satisfies NoSequence(Velar...Dental)
             Violates Faithfulness at syllable, phonotactical and at phoneme level

*(t)ukkaa*    Violates Light(Unstressed)
             Satisfies NoSequence(Velar...Dental)
             Violates Faithfulness at phonotactical and at phoneme level

*(t)uklaa*    Violates Light(Unstressed)
             Violates NoSequence(Velar...Dental)
             Violates Faithfulness at phoneme level

*suklaa*      Violates Light(Unstressed)
             Violates NoSequence(Velar...Dental)
             Satisfies Faithfulness at all levels

Again, morphology, e.g. *suklaata* (Partitive), affected the production of the word in nominative singular form: out of a total of 143 productions 81 (56,6 %) were trisyllabic. Since the partitive form does not cause changes in the stem, the same analyses were conducted separately for both bi- and trisyllabic productions.

### Syllable level

Although the number of bisyllabic productions was fairly low, the results indicate that the at-risk group was more likely to produce CV-syllables instead of the target's CVV-syllable. The same tendency came up in trisyllabic words. In general the number of monomoraic second syllables was low, only 12,6 % (18/143) (Tables 6 and 7) of all the bi- and trisyllabic productions, which is approximately the same as with *rattaat*. In this sense, *avain* violating both Heavy(Stressed) and Light(Unstressed) is the more difficult word form at syllable level.

TABLE 6    Production of the heavy unstressed syllable in *suklaa*. Proportions (%) of light (CV) and heavy (CVV) syllables in the control and at-risk groups.

| Type of the second syllable: | -CV e.g. (s)ukka, (s)ukla | -CVV e.g. (s)ukkaa, (s)uklaa |
|---|---|---|
| Control (N=30) | 10,0 % (3) | 90,0 % (27) |
| At-risk (N=32) | 25,0 % (8) | 75,0 % (24) |

TABLE 7    Production of the  heavy unstressed syllable in *suklaata* (Partitive). Proportions (%) of light (CV) and heavy (CVV) syllables in the control and at-risk groups.

| Type of the second syllable: | -CV e.g. (s)ukkata, (s)uklata | -CVV e.g. (s)ukkaata, (s)uklaata |
|---|---|---|
| Control (N=36) | 2,8 (1) | 97,2 (35) |
| At-risk (N=45) | 13,3 (6) | 86,7 (39) |

There were 16 late talkers who produced the word. Out of nine bisyllabic productions five included a CV-syllable instead of the target's heavy unstressed syllable and three out of seven in trisyllabic productions (Table 8).

TABLE 8    Production of the heavy unstressed syllables in *suklaa* and *suklaata* (Partitive). Proportions (N) of light (CV) and heavy (CVV) syllables in the late talkers (including both at-risk and control children).

| Type of the second syllable | -CV e.g. (s)ukka(ta) | -CVV e.g. (s)ukkaa(ta) |
|---|---|---|
| Late talkers bisyllabic (N=9) | 5 | 4 |
| Late talkers trisyllabic (N=7) | 3 | 4 |

### Phonotactics

The realisations of the consonant sequence were examined both regardless of syllable length and in relation to it. In bisyllabic productions the groups had the same amount of complete /kl/ sequences (53 %) (Table 9). Assimilation of the heterorganic sequence occured in 43,3 % of the control's and 40,6 % of the at-risk children's productions. The class of inaccurate sequences includes forms with sequences other than /kl/, e.g. metathetical cases such as ʔkuskaaβ (Henri RB). Assimilation was also a clear tendency in late talkers' productions: seven out of nine bisyllabic productions included an assimilation of the sequence (Table 11).

In trisyllabic forms the frequency of target-like /kl/ sequences was slightly higher than in bisyllabic forms: control group 58,3 % and at-risk group 55,6 %. Correspondingly, the proportion of assimilated forms (including a few single consonants) was lower than in bisyllabic productions (see Tables 9 and 10). Out of seven trisyllabic productions by late talkers only one included a /kl/-sequence (Table 11).

TABLE 9 Production of the consonant sequence in *suklaa* regardless of syllable length. Proportions (%) of assimilated sequences, inaccurate sequences and target-like sequences in the control and at-risk groups.

|  | Assimilation[25] e.g.sukka(a). | Inaccurate sequence e.g. kuskaa | Target-like /kl/-sequence e.g. sukla(a) |
|---|---|---|---|
| Control (N=30) | 43,3 (13) | 3,3 (1) | 53,3 (16) |
| At-risk (N=32) | 40,6 (13) | 6,3 (2) | 53,1 (17) |

TABLE 10 Production of the consonant sequence in *suklaata* (Partitive) regardless of syllable length. Proportions (%) of assimilated sequences, inaccurate sequences and target-like sequences in the control and at-risk groups.

|  | Assimilation[26] e.g.sukka(a). | Inaccurate sequence e.g. sutkaata | Target-like /kl/-sequence e.g. sukla(a)ta |
|---|---|---|---|
| Control (N=36) | 30,6 (11) | 11,1 (4) | 58,3 (21) |
| At-risk (N=45) | 35,6 (16) | 8,9 (4) | 55,6 (25) |

TABLE 11 Production of the consonant sequence in *suklaa* and *suklaata* (Partitive). Proportions (N) of assimilated sequences, inaccurate sequences and target-like sequences in the late talkers (including both at-risk and control children).

|  | Assimilation[27] e.g.sukka(a). | Inaccurate sequence e.g. kuskaa | Target-like /kl/-sequence e.g. sukla(a) |
|---|---|---|---|
| Late talkers, *suklaa* (N=9) | 7 | - | 2 |
| Late talker *suklaata* (N=7) | 6 | - | 1 |

When the heaviness of the second syllable is taken into account, one could predict that the forms with a light unstressed syllable do not have a sequence. In bisyllabic productions the number of forms with a light unstressed syllable was low. Out of 11 forms, 4 included a /kl/ sequence, one an /hj/ sequence and 6 were assimilated (one had a single consonant instead of a sequence and thus had changes in moraic structure) (Table 12). These bisyllabic productions do not yet confirm that a sequence is not produced if the prosodical structure is not complete. The number of bisyllabic forms with heavy unstressed syllables was higher, and the sequence was realised more often than it was assimilated in these productions (see Table 13).

---

[25]    Includes two forms with a single consonant and one unclear sequence

[26]    Includes three forms with a single consonant and one with a half-long consonant

[27]    Includes three forms with a single consonant

TABLE 12  Production of the consonant sequence in *suklaa* with light second syllables. Proportions (N) of assimilated sequences a accurate or inaccurate sequences in the control and at-risk groups.

|  | Assimilation[28] e.g. sukka | Accurate or inaccurate sequence (/kl/ or other), e.g. sukla |
|---|---|---|
| Control (N=3) | 2 | 1 |
| At-risk (N=8) | 4 | 4 |

TABLE 13  Production of the consonant sequence in *suklaa* with heavy second syllables. Proportions (%) of assimilated sequences and accurate or inaccurate sequences in the control and at-risk groups.

|  | Assimilation[29] e.g. sukka | Accurate or inaccurate sequence (/kl/ or other), e.g. sukla |
|---|---|---|
| Control (N=27) | 40,7 (11) | 59,3 (16) |
| At-risk (N=24) | 37,5 (9) | 62,5 (15) |

The following examples illustrate the variation in realisations of the heavy second syllable as well as the consonant sequence:

Bisyllabic forms with a light unstressed syllable:

<u>Assimilation</u>
Ψɦuukkaβ        Tommi (RB)
Ψʃukkaβ         Anna (RG)
Ψkᵘ- ka- kukkaβ    Minttu (CG)
Ψʃukkuβ         Panu (CB)
Ψɦuutiβ         Maija (RG)

<u>Other sequence</u>
Ψɨ hjapaloaβ     Verneri (RB) (*suklaapaloja* 'chocolate pieces')

<u>/kl/</u>
Ψʃuklaβ         Otto (RB), Esa (CB)
Ψʃukɬaβ         Kirsi RG)
Ψɨklaβ          Leeni (RG)

Bisyllabic forms with a heavy unstressed syllable:

<u>Assimilation</u>
Ψʃukkaaβ        Katja (CG) and others
Ψɦukkaaβ        Mirva (CG), Martta (RG)
Ψɦuhhaaä β       Sanni (RG), Inkeri (RG)
Ψkutɟaaβ        Risto (RB)
Ψɨkkaaβ         Olli (RB)
Ψɨkkeeβ         Onni (CB)
Ψɡuukkaaβ       Aaro (CB)

<u>Other sequence</u>
Ψʃuskaaβ        Henri (RB)

---

[28]    Includes one form with a single consonant.

[29]    Includes one form with a single consonant.and one with an unclear sequence

/kl/
Ɣʃuklaaβ          Reetta (CG) and others
Ψɪuklaaβ          Sini (RG) and others


Similarly to bisyllabic forms, the number of light unstressed second syllables was low in trisyllabic partitive productions (N=7), but unlike in the case of bisyllabic productions none of these forms included a sequence, which supports the hypothesis that prosodic overall structure precedes the specification of the phonotactical elements:

Trisyllabic forms with a light second syllable:

Assimilation (or single consonant)
Ɣʃukkulaβ          Elisa (RG)
Ψɪukkataβ          Sara (RG
ΨɪhukkAiβ          Visa (CB)
Ɣʃukkiaβ          Jussi (RB)
ƔKuk2A2Aβ          Eero (RB)
ΨɪuulatAAβ(t weak)  Daniel (RB)
Ψɪɪkanaβ          Otso (RB)


On the contrary to trisyllabic productions with a light second syllable, out of trisyllabic productions with a heavy second syllable over 70 percent in both groups included a consonant sequence (Table 14).

TABLE 14   Production of the consonant sequence in *suklaata* with heavy second syllables. Proportions (N) of assimilated, inaccurate and accurate consonant sequences in the control and at-risk groups.

|         | *Assimilation*[30] *e.g. sukka* | *Accurate or inaccurate sequence (/kl/ or other), e.g. sukla* |
|---------|------------------|--------------------------------------|
| Control | 28,6 (10)        | 71,4 (25)                            |
| At-risk | 25,6 (10)        | 74,4 (29)                            |

As seen in the examples below, assimilation of the sequence was typically /kk/, but there were a few cases of /hh/, /ss/ and dental /tt/ which may be progressive from the word initial dental/s/, especially in the form *tuttaata*. As in this form, sometimes assimilation concerned the whole word, e.g. *huhhaa* and *guukkaa* with velar consonants. In addition to target-like /kl/ sequences, there were several metathetical forms, e.g. *kuskaa, sutkaata, uksaata*.

Trisyllabic forms with a heavy second syllable:

/kl/
Ɣʃuklaataβ          Aleksi (CB)  and others
Ψɪuklaataβ          Jarkko (RB)

Other sequence
Ɣʃuksaɫaβ          Jeppe (CB)
Ψʃuhlaataβ          Jenni (RG), Tanja (RG)

---
[30]   Includes one halflong medial consonant

ˈʃutkaataβ     Kaisla (RG)
ˈʃuksaataβ     Senja (CG)
ˈʌksaataβ     Olivia (CG)
ˈʃukjaataβ     Heini (CG)
ˈʌska4ltaβ     Niilo (RB)

<u>Assimilation</u>
ˈʌukkaakaβ[31]     Mikko (RB)
ˈʌukkaataβ     Jyri (RB)
ˈʃukkaaltaβ     Arvo (RB)
ˈʃuttaataβ[32]     Masa (RB)
ˈʌkkaataβ     Arsi (RB)
ˈʌssaataβ     Janne (CB)
ˈʌuttaataβ     Ossi (CB)
ˈʌkkallaä β     Ari (CB)
ˈkukka ɬaβ     Minna (RG)
ˈʃuk ɬltaβ     Emilia (CG)

### *Phoneme level*

It was hypothesised that the phoneme level is completed after prosodic and phonotactical specification. Tables 15 shows the results of analysis in which the realisation of /s/ was examined in those bi-and trisyllabic forms which included the target /kl/ sequence and those with assimilation of the sequence (forms with inaccurate sequence were not included in the results here). Although there were form types such as *sukla(ta), ukla(ta), sukkaa(ta)* and *ukkaa(ta),* quantitative results show the same tendency in both groups: if the production of /kl/ was correct, the production also included correct word initial /s/ more often than the productions including an assimilation of the sequence. In assimilated forms at-risk children had less realisations of word-initial /s/. Thus the development of the word regarding the sequence and /s/ could be *ukkaa(ta), uklaa(ta), suklaa(ta)*.

TABLE 15   Proportions (%) of correct word initial /s/ in *suklaa* and *suklaata* with assimilation of consonant sequences and with target-like /kl/-sequences in the control and at-risk groups.

| | *Assimilation*[33] *e.g. sukkaa(ta)* | *Target-like sequence e.g. suklaa(ta)* |
| --- | --- | --- |
| Control (N=59) | 45,5 (10/22) | 73,0 (27/37) |
| At-risk (N=71) | 34,5 (10/29) | 73,8 (31/42) |

An analysis of substitution types for the word initial /s/ is seen in Table 16 and in Figure 4. At-risk children had less realisations of word-initial /s/ regardless of other elements. If compared to the production of /r/ in the word *rattaat* it can be that at this age /r/ is less often produced in word-initial position than

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[31]     According to mother, the child may attempt to say target word *suklaakalenteri* "a chocolate calendar"

[32]     The child also produced ˈʃutˌʃaaˌʃaβ with equally stressed syllables

[33]     Two forms with word-medial /s/ were excluded form these results.

/s/. The word initial consonant was also more often deleted in *rattaat* than in *suklaa*. As expected, /s/ was typically substituted by dental /t/ which has the same place of articulation.

Similarly to substitutions of word initial /r/ in *rattaat,* the productions of late talkers did not show any clear tendency in the production of word initial /s/. Rather, the sixteen productions (bi- and trisyllabic included) were characterised by extensive variation in substitution types: there were forms with /s/, /t/, /k/ and its voiced variant /g/, /h/ as well as /l/ and deletions.

TABLE 16   Production of the word initial /s/ in *suklaa.* Proportions (%) of word initial /s/, its' deletions and substitutions for the control group, at-risk group and late talkers (including children from control and at-risk groups).[34]

|  | Control group (N=63) | At-risk group (N=75) | Late talkers (N=16) |
|---|---|---|---|
| /s/ | 65,1 (41) | 58,7 (44) | 18,8 (3) |
| /t/ | 17,5 (11) | 22,7 (17) | 25,0 (4) |
| /k/ | 3,2 (2) | 4,0 (3) | 18,8 (3) |
| /l/ | 3,2 (2) | 1,3 (1) | 6,3 (1) |
| /h/ | 4,8 (3) | 4,0 (3) | 6,3 (1) |
| /n/ | 1,6 (1) | - | - |
| deletion | 4,8 (3) | 8,0 (6) | 25,0 (4) |
| unclear | - | 1,3 (1) | - |
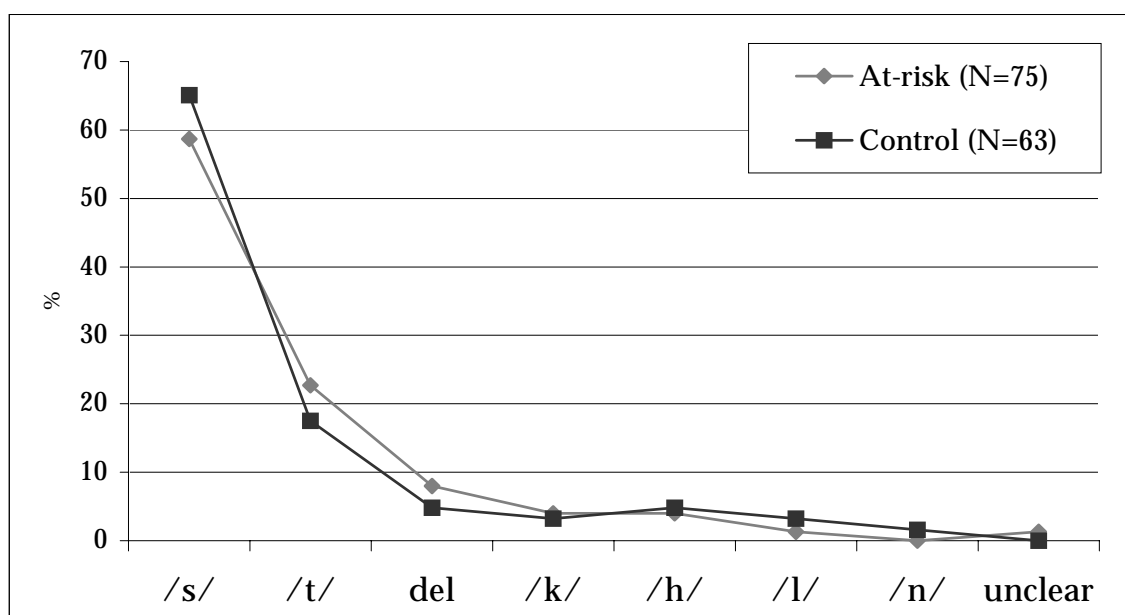


FIGURE 4 Proportions (%) of correct word initial /s/, its deletion and different types of substitutions in *suklaa* for the control and at-risk group.

Variation in the realisation of /s/ is due to a complex interplay of constraints. Some of them may include paradigmatic processes motivated by constraints

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[34]   Forms Ψkuskaaβ (Henri RB), Ψuso`β (Laura CG), Ψuskaltaβ (Niilo RB), Ψussaataβ (Petteri CB), Ψuksaataβ (Olivia CG) are excluded from these results since phoneme /s/ is produced but not in word initial position.

which concern the features of single consonants, e.g. in /t/ the place of articulation is target-like but the manner feature has changed from fricative to a stop. Some substitutions are caused by assimilatory processes, probably due to NoSequence constraint across segments, for example in the case of /k/. The interplay is even more complex in forms including processes that resemble metathesis, that is, the place of the phoneme is different than in the target form e.g. ꞌꞰuskaaβ (Henri RB) or ꞌꞰuksaataβ (Olivia CG). This type of examples show that in investigating the paradigmatic aspect of children's phoneme productions, syntagmatic aspect should not go unnoted.

### 4.1.4 Productions of the word *sakset*

The moraic structure of *sakset* 'scissors' equates to the moraic structure of *suklaa*: both have two bimoraic syllables. They also share the same complex elements in phonotactics, namely a consonant sequence, and at the phoneme level, the /s/-consonant. Morphology may again affect productions because the word is plural, but in naming the children may produce their own singular forms. The possible development from an unmarked to more marked target-like structures illustrated by constraint ranking is thus similar to that of *suklaa*.

> *(t)akke*  Satisfies Light(Unstressed)
> Satisfies NoSequence(Velar...Dental).
> Violates Faithfulness at syllable, phonotactical and at phoneme level
>
> *(t)akket*  Violates Light(Unstressed)
> Satisfies NoSequence(Velar...Dental).
> Violates Faithfulness at phonotactical and at phoneme level
>
> *(t)aktet*  Violates Light(Unstressed)
> Violates NoSequence(Velar...Dental).
> Violates Faithfulness at phoneme level
>
> *sakset*  Violates Light(Unstressed)
> Violates NoSequence(Velar...Dental).
> Satisfies Faithfulness at all levels

In the analysis I will concentrate on the production of the heavy syllable in the target, consonant sequence, word-initial phoneme /s/ and in interplay between the levels.

### *Syllable level*

Some children produced a trisyllabic partitive form *sak.si.a* in which both of the unstressed syllables are light, unlike in partitive form *suk.laa.ta*. These forms were thus not considered in the results. If the child had both a bisyllabic and a trisyllabic production, the bisyllabic one was analysed.

Of all bisyllabic forms 19,8 % of at-risk children's productions had a light second syllable (see Table 17). In the control group the proportion was lower, 15,1 %. In the group of late talkers, a tendency to produce a CV-syllable was

clearer since 56,0 % (14) of the total 25 productions were of the type (C)VCCV, with a light second syllable. In general, the proportion of fully shortened CV-syllables was relatively high: 17,5 %, which is close to the proportion in *avain*.

Typically the forms with a light second syllable were of the type *(s)akke,* with deletion of the final consonant, but there were also forms ending with /i/, e.g. Чhakkiä β (Ari CB), and also with /a/, as in Чakkaβ (Pia CG). Forms ending with /i/may indicate a hypothetical singular form *saksi.* Even though the singular form is not used with this word, the child may find it easier due to the second CV syllable.

In the following section I will examine the interplay between syllable length and the consonant sequence and present examples of forms with both a light and heavy syllable. Despite the tendency to shorten the syllable, the majority of productions included a CVC second syllable (Table 17). If the acquisition of prosody precedes phonotactics, one could expect that in forms with a redused light second syllable less consonant sequences would be produced. In other words, forms with incomplete prosody have incomplete phonotactics, which in this word would mean assimilation in the sequence.

TABLE 17   Production of the heavy unstressed syllable in *sakset.* Proportions (%) of light (CV) and heavy (CVC) syllables in the control group, at-risk group and late talkers (including at-risk and control children).

| Type of the second syllable: | -CV e.g. sakke | -CVC e.g. sakset |
|---|---|---|
| Control (N=86) | 15,1 (13) | 84,9 (73) |
| At-risk (N=91) | 19,8 (18) | 80,2 (73) |
| Late talkers (N=25) | 56,0 (14) | 44,0 (11) |

### *Phonotactics*

The sequence /ks/ was correct in 55,8 % of the productions in the control group and 49,5 % in the at-risk group (Table 18). Controls thus had slightly less assimilated forms than at-risk children. Assimilation was more typical for late talkers since 60,0 % (15) of their productions were assimilated. There were also forms with a sequence other than target-like. Examples of variation in assimilation and sequences are presented below.

The number of productions with a light second syllable was not very high, but if we look at realisations of the consonant sequence one can see that the proportion of accurate /ks/ sequences was lower in forms with a CV-syllable (25,8 %) than with a CVC-syllable (58,2 %) when both at-risk and control children's productions were considered (Tables 19 and 20).

TABLE 18  Production of the consonant sequence in *sakset* regardless of syllable length. Proportions (%) of assimilated sequences, inaccurate sequences and target-like sequences in the control group, at-risk group and late talkers (including both at-risk and control children).

|  | Assimilation e.g. sakke(t)[35] | Inaccurate sequence e.g. satse(t) | Target-like /ks/-sequence e.g. sakse(t) |
|---|---|---|---|
| Control (N=86) | 34,9 (30) | 9,3 (8) | 55,8 (48) |
| At-risk (N=91) | 37,4 (34) | 13,2 (12) | 49,5 (45) |
| Late talkers (N=25) | 60,0 (15) | 8,0 (2) | 32,0 (8) |

TABLE 19  Production of the consonant sequence in *sakset* with light second syllables. Proportions (N) of assimilated sequences, inaccurate sequences and target-like sequences in the control and at-risk groups.

|  | Assimilation e.g. sakke | Inaccurate sequence e.g. satse | Target-like /ks/-sequence e.g. sakse |
|---|---|---|---|
| Control (N=13) | 6 | 1 | 6 |
| At-risk (N=18) | 14 | 2 | 2 |
| TOTAL (N=31) | 20 (64,5 %) | 3 (9,7 %) | 8 (25,8 %) |

TABLE 20  Production of the consonant sequence in *sakset* with heavy second syllables. Proportions (%) of assimilated sequences, inaccurate sequences and target-like sequences in the control and at-risk groups.

|  | Assimilation e.g. sakket | Inaccurate sequence e.g. satset | Target-like /ks/-sequence e.g. sakset |
|---|---|---|---|
| Control (N=73) | 32,9 (24) | 9,6 (7) | 57,5 (42) |
| At-risk (N=73) | 27,4 (20) | 13,7 (10) | 58,9 (43) |
| TOTAL (N=146) | 30,1 (44) | 11,6 (17) | 58,2 (85) |

Assimilation concerned either the sequence or all of the consonants in the word as for example in [sasse] (Saku CB), [katti] (Katja CG) and [kakke] (Eero RB). This type of consonant production refers to strong constraints on place of articulation for consonants in a word. In addition to consonant harmony, Minna (RG) also had assimilation in vowels: [sassa]

The geminate in assimilated forms was most often /kk/, e.g. [kakket] (Toni CB and several others). This could be expected since /k/ as a stop consonant would rather spread into the position of /s/ than vice versa. There were, however, cases with /ss/, e.g. [asset] (Janne CB and Katja CG), or its propable substituted form /tt/, e.g. [attet] (Jyri RB and Niilo RB). /t/ could be a substitute for /s/ due to same place of articulation. It may be, that word initial dental /s/ affects the assimilation type in the sequence. Of the forms without any kind of sequence, an exceptional production was [avee] (Juho RB) in which the child may have extracted the vowels and ignored the quality of consonants. This strategy violates Faithfulness at the phoneme level although not the moraic structure of the syllables.

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[35]  Includes [ah(s)iä] (Severi CB) in which the consonant sequence is unclear.

In eleven forms with a light unstressed syllable and with a sequence, three included a sequence other than /ks/. These were ˈatkiβ (Ossi CB), with metathesis and /t/ substitution for /s/, ˈastiβ (Annika RG), with fronting of /k/, as well as in ˈks- satseβ (Risto RB). Forms with a target /ks/ sequence had variation in the final vowel and in the initial consonant:

| | |
|---|---|
| ˈkh- sakseβ | Sakari (CB) |
| ˈkakseβ | Mari (CG) |
| ˈaksiβ | Julius (CB) |
| ˈhaksiβ | Ulpu (CG) |
| ˈsaksiβ | Silja (CG), Satu (RG) |
| ˈaksiβ | Leo (RB) |
| ˈakse(t)β | Birgitta (CG) |

In forms with target-like prosodic structure but an incomplete consonant sequence, the quality of the sequence varied as well. There were however only four forms with /kt/ in the productions with complete syllable structure: ˈaktetβ (Anniina RG, Liisi RG, Heini CG, Lassi CB). Perhaps the expected form developmentally before a target /ks/ sequence would be /kt/, in which /s/ is substituted by /t/; in this kind of form the place of articulation in the sequence is the same.

It turned out that instead of substituting /s/, some children fronted the velar /k/ into dental /t/ in order to produce an easier sequence in which the phonemes are articulated in the same place. These productions do not violate the place constraint NoSequence(Velar...Dental):

| | |
|---|---|
| ˈatsetβ | Kristian (RB), Marjo (RG) |
| ˈatsitβ | Tuuli (CG) |
| ˈatsetβ | Minttu (CG) |
| ˈtˌsetä β | Leeni (RG) |

Metathesis was also found. In seven productions the child produced /sk/ rather than /ks/. Also /tk/ is considered a metathetical form in which /s/ is substituted by /t/:

| | |
|---|---|
| ˈsasketβ | Leo (RB), Anu (RG) |
| ˈasketβ | Arsi (RB) |
| ˈastetβ | Kuisma (RB) |
| ˈasketβ | Ronja (CG), Petri (CB) |
| ˈkatˌketβ | Jarkko (RB) |

### *Phoneme level*

As the realisation of the sequence was examined in different prosodical environments, /s/ is examined in different phonotactical environments as well as in a general sense. It was hypothesised that the phoneme level is completed after prosodic and phonotactic levels. Here it means, that word initial /s/ is perhaps not produced so often with an assimilated consonant sequence as it is

in forms with a target sequence. The developmental path would thus be *(s)akke, (s)akket, (s)aktet, (s)akset, sakset.*

If we look at the realisation of /s/ in forms with assimilation of a sequence and with a /ks/ sequence, one can see that the proportion of word initial /s/ is indeed higher in forms with /ks/ (76,3 %) than in forms with an assimilation (32,8 %) (Table 21). This means that if a sequence is assimilated, then the word initial consonant is also most likely either substituted or deleted.

TABLE 21   Proportions (%) of correct word initial /s/ in forms with an assimilation of the consonant sequence, an inaccurate sequence and with a target-like sequence for the control and at-risk groups.

|  | *Assimilation*[36] *e.g. sakke(t)* | *Inaccurate sequence e.g. satse(t)* | *Target-like /ks/- sequence e.g. sakse(t)* |
|---|---|---|---|
| Control (N=86) | 36,7 (11/30) | 0 (0/8) | 75,0 (36/48) |
| At-risk (N=91) | 29,4 (10/34) | 41,7 (5/12) | 77,8 (35/45) |
| TOTAL | 32,8 (21/64) | 25,0 (5/20) | 76,3 (71/93) |

Table 22 and Figure 4 show the numbers of realised word initial /s/, its substitutions as well as the number of omissions in different groups more generally. /s/ was produced in approximately 55 % of the productions for both at-risk and control groups. It was substituted by /t/ in 23,1 % of at-risk and 20,9 % of control group productions. The result was nearly same for both groups, with at-risk children having slightly less substitutions with /k/. Late talkers again showed variation in the production of word initial /s/. Instead of /t/, a typical substitution for them was /h/.

TABLE 22   Production of word-initial /s/ in *sakset*. Proportions (%) of correct word initial /s/, its deletion and substitution for the control group, at-risk group and late talkers (including both at-risk and control children).

|  | Control group (N=86) | At-risk group (N=91) | Late talkers (N=25) |
|---|---|---|---|
| /s/ | 54,7 (47) | 54,9 (50) | 24,0 (6) |
| /t/ | 20,9 (18) | 23,1 (21) | 16,0 (4) |
| /k/ | 8,1 (7) | 3,3 (3) | 12,0 (3) |
| /l/ | 1,2 (1) | 3,3 (3) | 8,0 (2) |
| /h/ | 8,1 (7) | 7,7 (7) | 28,0 (7) |
| /n/ | - | 1,1 (1) | - |
| deletion | 7,0 (6) | 6,6 (6) | 12,0 (3) |
| unclear |  |  |  |

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[36]   Includes two forms with a single consonant and one unclear sequence
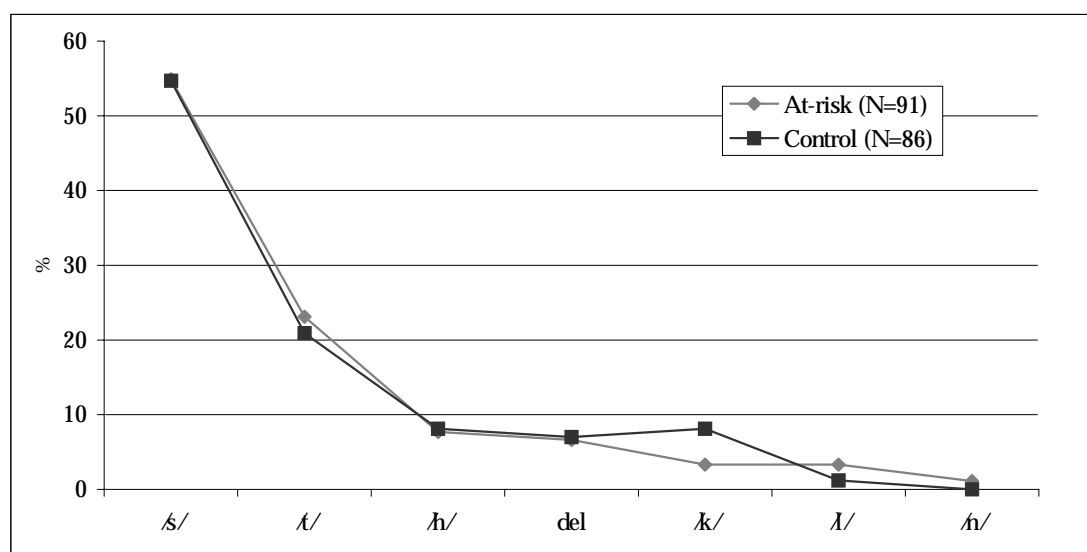
FIGURE 5   Proportions (%) of correct word initial /s/, its deletion and substitution in *sakset* for the control and at-risk groups.

### 4.1.5 Productions of the word *pöytä*

In the word *pöytä* 'table' it may be hypothesised that in the early stages of development, diphthongs are prohibited by *COMPLEX-NUCLEUS. Also, if constraint concerning place of articulation in consonants is also highly ranked, an early productions of this word could be *pööpä*. When Faithfulness become more highly ranked and the structure constraints are ranked lower, output becomes more complex, resulting in *pöötä* and finally *pöytä*. Vowels in the word *pöytä* typically follow Finnish vowel harmony: all the vowels in the word are front vowels. In this analysis I will focus mainly on the production of the diphthong.

### *Phonotactics*

Results in Table 23 indicate that the majority of the productions included a complete diphthong, approximately 80 % of the children produced it correctly. Although the differences between the at-risk and control children were not big, the at-risk children had slightly more forms with an inaccurate diphthong. The results also indicate, that although the majority of the late talkers (60,7 %) were also able to produce the correct diphthong in this word, there were relatively more of those who produced an inaccurate diphthong or no diphthong at all.

TABLE 23   Production of diphthong in *pöytä*. Proportions (%) of forms with no diphthong and with inaccurate and target-like diphthongs for the control group, at-risk group and the late talkers (including both at-risk and control children.)

|  | No diphthong | Inaccurate diphthong | Target-like diphthong |
|---|---|---|---|
| Control (N=82) | 8,5 (7) | 9,8 (8) | 81,7 (67) |
| At-risk (N=100) | 7,0 (7) | 14,0 (14) | 79,0 (79) |
| Late talkers (N=28) | 17,9 (5) | 21,4 (6) | 60,7 (17) |

If the diphthong was not produced, compensatory lengthening of the vowel took place in order to keep the syllable heavy. Only in two cases was the timing slot filled by a consonant: Ψbe- beppʰaβ (Kuisma RB) and Ψbohtaβ (Essi RG). A difficulty producing the word is apparent in Essi's second naming, in which she actually first produced an inaccurate diphthong but was not able to produce any kind of diphthong in a word: Ψtoo pyö to to pö tata pääpäβ (*too~to* probably refers to *tuo* 'that').

In compensatory lengthening, typically the first component of the vowel was preserved, which in this word is the round vowel /ö/, e.g. Ψböötäβ (Miro RB and several others). In some cases back vowels were produced instead of front vowels, e.g. ΨPootaβ (Elisa RG).

Backing of vowels also occurred in the case of diphthongs, e.g. Ψbuotaβ (Vilja RG). Typically /y/ was inaccurately produced, e.g. Ψbäijäβ (Pia RG) or Ψböipäβ (Minna RG and others). The latter production is also an example with constraint on the place of articulation in the consonants.

Sometimes it was difficult to define the backness or frontness of the vowels; it seemed as if the production was in between the two counterparts (/o/–/ö/, /a/–/ä/) as for example in forms Ψbö5ytäβ (Joonas RB) and Ψbo4o4tä5β (Onni CB). Although the word structure in *pöytä* is fairly simple, it seemed that the diphthong /öy/, perhaps due to frontness and roundness of the vowels caused problems for some children.

An interesting case was Ψbö-i5ɟäβ Otso (RB) produced the word with a slight temporal demarcation between the segments in diphthong. Such a process actually leads to a trisyllabic production. It may be, that this child was in the process of learning the diphthong in this word.

### 4.1.6 Productions of the word *pyörä*

There were two possible ways to name the picture of a bicycle, either as the colloquial form *pyörä* or as the four syllable compound word *polkupyörä.* The bisyllabic productions are analysed here and the four syllable productions in chapter 4.3. This is why the total amount (N=139) of *pyörä* productions is less than the total amount of productions of other target words.

Complex elements analysed here were the opening diphthong /yö/ and the phoneme /r/. Based on the results from *pöytä* one could expect that most children would produce the diphthong correctly. In word initial position consonants are often deleted in early phonology of Finnish children. Thus, unlike in *rattaat*, /r/ in this word is not in word initial position thus there may be less deletions of this consonant. If neither diphthong nor /r/ is produced, an initial form for the word could be *pöölä*. Then, if phonotactics precedes a target-like phoneme level, the form *pyölä* would precede the adult form *pyörä*.

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### *Phonotactics*

Contraty to the expectations, in the at-risk group the proportion of complete diphthongs was higher (89,3 %) than in the control group (81,3 %) (see Table 24). When the production of the opening diphthong /yö/ and a closing diphthong /öy/ were compared, the proportion of target-like diphthongs was nearly the same in both types in the control group, but in the at-risk group the proportion of /öy/ diphthongs was less (79,0 %) than /yö/ diphthong (89,3 %). Also late talkers had a higher proportion of target-like /öy/-diphthongs. This pattern may be explained by the fact that in Finnish the diphthongs usually end with a closed rather than with a more open vowel as in *pyörä* (see Karlsson 1983: 83). Productions with the diphthong /yä/ were accepted as target-like forms as it is typical in some dialects. It may be that the openness may spread from word final /ä/.

TABLE 24    Production of diphthong in *pyörä*. Proportions (%) of forms with no diphthong and with inaccurate and target-like diphthongs for the control group, at-risk group and the late talkers (including both at-risk and control children.)

|  | *No diphthong* | *Inaccurate diphthong* | *Accurate diphthong* |
|---|---|---|---|
| Control (N=64) | 10,9 (7) | 7,8 (5) | 81,3 (52) |
| At-risk (N=75) | 4,0 (3) | 6,7 (5) | 89,3 (67) |
| Late talkers (N=22) | 31,8 (7) | 13,6 (3) | 54,5 (12) |

In forms without a diphthong, compensatory lengthening was common as in *pöytä*. An exception was ʻpöjaʼ (Ulpu CG), which violates both Heavy(Stressed) and vowel harmony. There were forms with /yy/, e.g. ʻpyyräʼ (r weak) (Leevi CB), but mostly it was the second component, which was lengthened, e.g. ʻpööläʼ (Joni CB and others). In *pöytä* the spreading vowel was mostly /ö/ (or in some cases it was back counterpart). Besides compensatory lengthening in vowels, some forms had assimilation in the consonants, e.g. ʻpyyɟpyʼ (Maija RG), which indicates strong harmony (or sequence) constraints and thus developmentally less advanced forms of production.

Typically an inaccurate diphthong had back vowels either in the diphthong or in the whole word, e.g. ʻpuolääʼ Tuovi (RG), ʻpualaʼ (Vilja RG), but also one form with /i/ occurred: ʻpyiɟaʼ (Risto RB). The following utterances during the naming of *pyörä* by Tuovi reveal uncertainty concerning vowel harmony. She first produced ʻpuoɟäʼ and after this she talked about the two bikes in the picture and imitates:

Namings of *pyörä* by Tuovi:

(1)     ʻpuoɟäʼ *pyörä* 'bike'

(2)     ʻnäitä on momeõnia pyölɟä oli tä-ʼ (imitates)
        *näitä on molempia pyöriä (~pyörä) oli tä-*
        'here is both bike(s) were he(re)'

(3)      Ψ-näitä om kat puaɟa4a4 -- on kat pualaa tättaβ
        *-- näitä on kaks pyörää -- on kaks pyörää tässä*
        '--here are two bikes -- two bikes are here'

At first, vowel harmony is violated in naming (1), but then in an imitated utterance (2) vowel harmony is correct and all vowels are front. After imitation in (3), she produced unclear vowels with regard to frontness and finally produced the word with back vowels. Note that in example (3) vowel harmony is also violated in word *tässä* 'here".

Out of the ten forms without any kind of diphthong only two included a weak /r/-phoneme which indicates that in most cases phonotactically incomplete forms are not yet accurate at the phoneme level either.

### *Phoneme level*

Results for word-medial /r/ show that the phoneme was more often realised than in word-initial position: in *rattaat,* /r/ was produced in 31,0 % in the control and 20,3 % in the at-risk group whereas in *pyörä,* as many as 46,9 % of controls produced the phoneme and 36,0% of the at-risk group (Table 25, Figure 5). The at-risk group produced /r/ less often than controls in both of these words. The same tendency was found in late talkers who produced /r/ more often in word medial (22,7 %) than in word initial position (7,1 %).

Entire deletion of the phoneme in the medial position was a rarer process in word-medial than in word-initial position. There were, however, some productions with deletion, for example Ψøyyäβ (Eero RB) and Ψøyö-äβ (Minttu CG). These productions do not violate the moraic structure although the constraint requiring an onset (ONSET) is violated. A more advanced form would satisfy this constraint and have and onset consonant, perhaps at first in a substituted form.

The substitution types also varied between *rattaat* and *pyörä*: in *pyörä* there were no substitutions by /h/ but in *rattaat* the proportion of word initial /h/ was 8,5 % in the at-risk and as much as 20,7 % in the control group. It seems to be obvious that not only the position in a word but also other phonemes affect the production of /r/. For example, in *rattaat,* word initial /t/ was possibly caused by regressive assimilation from the geminate /tt/, for which reason in *pyörä* there were no substitutions by /t/. Moreover, /r/ was never substituted by /p/ in *rattaat,* but in some cases of *pyörä* progressive assimilation caused /p/ to be produced in the place of /r/. Constraints on place and manner of articulation are behind these processes.

TABLE 25  Production of word-medial /r/ in *pyörä*. Proportions (%) of word-medial /r/ and its deletions and substitutions for the control group, at-risk group and late talkers (including children from control and at-risk groups).

|  | Control group (N=64) | At-risk group (N=75) | Late talkers (N=22) |
|---|---|---|---|
| /r/ | 46,9 (30) | 36,0 (27) | 22,7 (5) |
| /l/ | 40,6 (26) | 50,7 (38) | 40,9 (9) |
| /j/ | 4,7 (3) | 1,3 (1) | 13,6 (3) |
| /v/ | 1,6 (1) | 2,7 (2) | - |
| /p/ | 1,6 (1 | 1,3 (1) | 4,5 (1) |
| deletion | 1,6 (1) | 4,0 (3) | 9,1 (2) |
| unclear | 3,1 (2) | 4,0 (3) | 4,5 (1) |
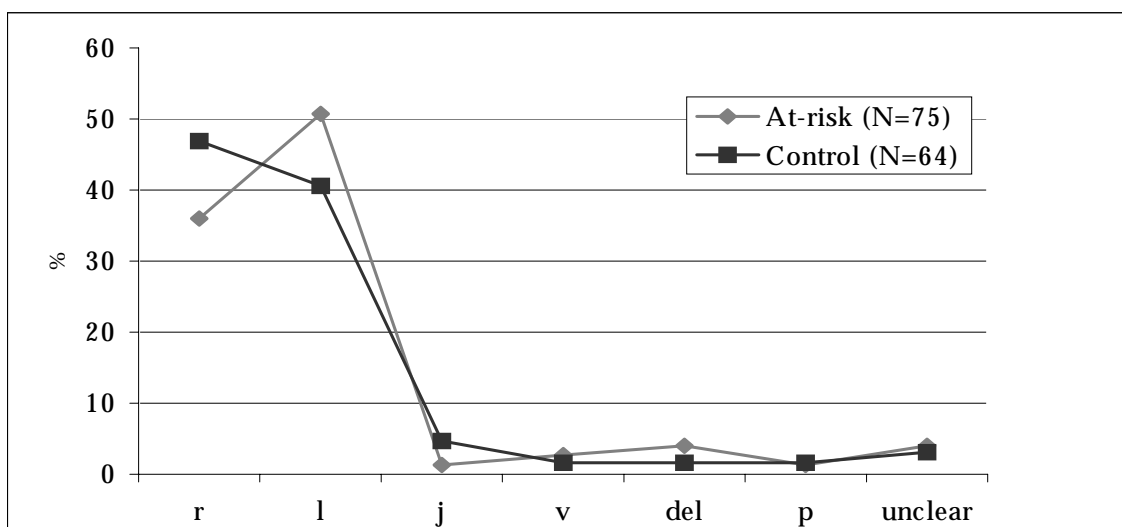


FIGURE 6  Production of word-medial /r/ in *pyörä*. Proportions (%) of word-medial /r/ and its deletions and substitutions for the control and at-risk groups.

### 4.1.7 Conclusion

Children's productions of bisyllabic words showed high inter-individual variation in word structures. In the analyses, structurally the most advanced form was taken into account for each child. In order to quantify large amounts of data relevant elements from syllable level to phonotactics and phoneme level were specified for each target word and it was attempted to explain these elements by constraints requiring unmarked structures.

The syllable level constraint Light(Unstressed) was suggested to prevent heavy unstressed syllables. A common strategy to satisfy the constraint was to shorten the syllables, e.g. *(r)atta* for *rattaat* and *ava* for *avain*, although most of the children produced target heavy syllables as heavy. In addition to fully shortened monomoraic syllables, there were also intermediate bimoraic syllables from trimoraic target syllables. In bisyllabic target words proportions of fully shortened syllables varied from 10 to 25 percent depending on the target. Conversely, the proportion of target-like second unstressed syllables in bisyllabic forms varied from 45 to 90 percent. Productions of word *avain* had the lowest proportion of target-like syllables at the moraic level. The word structure

is an extreme example of conflict between stress and length in Finnish as main stress is fixed on the initial syllable regardless of the fact that the word form violates both Heavy(Stressed) and Light(Unstressed). Inspite of these phonological reasons which support children's production strategies of the word, morphological reasons such as the unusual inflection paradigm may weaken children's knowledge of the nominative form, especially because the word in input is probably usually heard in an inflected form.

However, it seemed to be a clear tendency for some children to shorten heavy unstressed syllables in the target. At-risk children had more monomoraic syllables in three target words, *avain, sakset* and *suklaa*, and in *rattaat*, they had more intermediate bimoraic forms for which the number of target-like trimoraic syllables was lower.

In the analysis at the phonotactical level, I concentrated on the production of consonant sequences and diphthongs. Sequences are tentatively prevented by NoSequence constraints on place of articulation but also constraints on manner of articulation may prevent the production of completely target-like sequences. For example, the constraint NoSequence(Velar...Dental) may prevent sequences in the words *suklaa* and *sakset*. At the age of 2;6 approximately 53 % of the children produced a target-like /kl/-sequence in the word *suklaa*. The /ks/-sequence in *sakset* was realised approximately among half of the children; in this word control children had more target sequences (55,8 %) than at-risk children (49,5 %). A typical strategy to satisfy a sequence constraint on place was to produce geminates. It was also found that some children produced a sequence at the same place of articulation, for example by fronting /k/ in *sakset*, which results in the form *satset*. Phonotactically a more advanced form was *taktet* due to the consonant sequence featuring different place of articulation. However, in this form manner constraints still prevent a fully target-like sequence from appearing as the stop consonant /t/ in this position is substituted for fricative /s/.

The analysis of the interplay between syllable length and consonant sequences in these words revealed that there was a tendency for a target sequence to appear more often in forms with a heavy unstressed syllable than with prosodically inaccurate forms. For example, in *sakset*, altogether 25,8 % (N=8) of the forms with a light second syllable included /ks/ whereas the proportion was higher, 58,2 % (N=85) in forms with bimoraic second syllable. These kind of results reveal the interplay of phonological elements in a word and possibly show developmental trends in phonological acquisition; in this case one would suggest that prosody, more specifically a correct moraic structure of syllables, precedes the production of phonotactical elements such as consonant sequences. If so, acquisition of *sakset* would thus proceed from *sakket* to *sakset*.

Diphthongs are probably prevented by *COMPLEX-NUCLEUS requiring a simple nucleus. However, deletion of a segment was not a solution for children who did not produce a diphthong in the target word *pöytä* or *pyörä*. Instead, their productions included compensatory lengthening which still satisfies

Heavy(Stressed) by preserving the moraic structure of the initial syllable (e.g. *pöötä* for *pöytä*). It is, however, not clear whether this kind of production actually satisfies *COMPLEX-NUCLEUS since the nucleus in this form is still complex at the level of timing unit. At-risk children did not prove to be less advanced in the production of diphthongs in the two target words *pöytä* and *pyörä*. In fact, controls had less (81,3 %) target-like diphthongs than at-risks (89,3 %) in *pyörä*. In general, diphthongs do not seem to problematic at this age since also in *pöytä* correct diphthong was produced in approximately 80 % of the cases. As in syllable length and in consonant sequences, there were intermediate forms, which in the case of diphthongs were more advanced than forms with compensatory lengthening but were not yet completely target-like (e.g. *pöitä* for *pöytä)*. At the phonotactical level, this kind of form can be considered complex, in the sense that a diphthong is realised in the production. It also turned out that some children had problems with Finnish vowel harmony, which should be more systematically investigated in further studies.

The phoneme level focused on /r/- and /s/-phonemes of which the realisation of /r/was investigated both in word-initial as well as in word-medial position. In *rattaat*, /r/ was produced accurately more often in the control group (31,0 %) than in the at-risk group (20,3 %). The low number of realised /r/-phonemes indicates, as expected, that it may be among the last phonological elements to be acquired in a child's phonological system in Finnish. It should be noted though, that the question at age 2;6 is not yet about purely paradigmatic acquisition but also about the effects of phonological context on the production of phonemes. This is evident when the production of /r/ in *rattaat* is compared to the production in the word-medial position in *pyörä*: In the latter, /r/ was realised more often, in 46,9 % of the control group's and 36,0 % of the at-risk group's productions. Moreover, not only the proportion of realised /r/-phonemes but also the substitution types and the proportion of deletions differed. In these instances, sequence constraints on place and manner of articulation played a role across consonants. For example, in *rattaat*, there were cases in which /r/ was substituted by /t/, probably regressively due to the word-medial /tt/. These results emphasise the importance of the syntagmatic aspect even when individual phonemes are investigated in phonological production.

The difference between the at-risk and control children in the productions of word initial /s/ was not clear although the at-risk group had less realisations (58,7 %) of /s/ in *suklaa* than the control group (65,1 %). In sakset, however, the proportion of word-initial /s/ was 55 % for both groups. Proportions of correct word-initial /s/ revealed that more than half of Finnish children produce the consonant in word-initial position at age 2;6.

Investigation of the interplay between the phoneme level and syllable level supported the view that overall structure of a word is acquired before the phoneme level is completed: analysis of *rattaat* showed that /r/ was produced more often in forms with target-like syllable structure at a moraic level. Phoneme level was also examined in relation to phonotactics: analysis of *suklaa*

showed that /s/ was more often realised in forms with a target-like consonant sequence than in assimilated forms. The same tendency was also found  for *sakset*.

Group comparisons showed that there was a tendency for at-risk children to be less advanced in the production of several word-specific phonological elements when each child's most advanced productions were considered. The groups are further compared in the analyses of three and four syllable words as well as in a more general quantitative application of the hierarchical model in chapter 5.

In addition to the comparison of at-risk and control children, productions of a subgroup of late talkers were analysed. This group included children from both the at-risk and control groups and they were selected on the basis of linguistic measures at the age of 2;0. At the age of 2;6, they proved to be less advanced than others in all of the investigated elements in bisyllabic words. Their productions indicated more highly ranked prosodic and phonotactic constraints than in other groups and supported the view that the constraint based account used in this study is suitable for developmental analysis; constraint re-ranking would gradually result in more complex and target-like productions in the speech of these children.

## 4.2   Trisyllabic target words

### 4.2.1 Productions of the word *porkkana*

The word *porkkana* is complex in three aspects. Trisyllabicity may cause trouble for those children who have difficulties with the production of longer words at this age. A typical strategy for such children would be a truncation into a bisyllabic form. Secondly, the consonant sequence /rkk/ may cause trouble in production. The sequence in this word is in coda position and thus it violates the constraint *COMPLEX-CODA. I assume, however, that this constraint is still fairly high ranked and that the children have a tendency to avoid producing the sequence. They may produce either a shortened, but still heavy, initial syllable *pok-* or a syllable with compensatory lengthening of a vowel, resulting in target-like heaviness in the moras (*pook-*). At the syllable level the target word satisfies the constraints requiring stressed syllables to be heavy and instressed syllables light. This will probably be true  in children's productions also, since heavy syllables in stressed position were rarely shortened in bisyllabic words.

When trisyllabic words are allowed into a child's phonological system along with complex codas, the production of the sequence may not at first be complete at the phoneme level although the segments are produced in the same place of articulation as in the target form. At this stage, in the /rkk/-sequence /r/ is most likely to be substituted by dental /l/. At a final stage, the child proceeds to the productions of phonetically correct /r/. In the following section

it is attempted to quantitatively analyse variation in children's forms according to the hypothetical hierarchical path.

| | |
|---|---|
| *pokka* | Satisfies PARSE-SYL |
| | Satisfies *COMPLEX-CODA |
| | Violates Faithfulness at word level, phonotactical and at phoneme level |
| | |
| *po(o)kkana* | Violates PARSE-SYL |
| | Satisfies *COMPLEX-CODA |
| | Violates Faithfulness at phonotactical and at phoneme level |
| | |
| *polkkana* | Violates PARSE-SYL |
| | Violates *COMPLEX-CODA |
| | Violates Faithfulness at phoneme level |
| | |
| *porkkana* | Violates PARSE-SYL |
| | Violates *COMPLEX-CODA |
| | Satisfies Faithfulness at all levels |

The overall quantitative results according to these hypothesised levels are presented in Table 26. Each level with production examples is more specifically explained below.

TABLE 26  Proportions (%) of different types of productions of *porkkana* in the control group, at-risk group and the late talkers (including children from both control and at-risk groups).

| | Control (N=77) | At-risk (N=89) | Late Talkers (N=25) |
|---|---|---|---|
| 1. Word level not complete e.g. *pokka* | 11,7 (9) | 6,7 (6) | 44,0 (11) |
| 2. Phonotactics not complete e.g. *pokkana* | 28,6 (22) | 32,6 (29) | 40,0 (10) |
| 3. Phonotactics partially complete e.g. *poξkkana* | - | 12,4 (11) | - |
| 4. Phoneme level not complete e.g. *polkkana* | 15,6 (12) | 20,2 (18) | 4,0 (1) |
| 5. Target-like forms *porkkana* | 44,2 (34) | 28,1 (25) | 12,0 (3) |

### *Word level*

The proportion of truncated forms was fairly low, as expected based on earlier reports in which the bisyllabic stage is reported to be over by the age of two. 11,7 % of the most advanced productions in the control group were truncated and against expectations, the proportion was less in the at-risk group 6,7 %. Truncation was typical for 25 late talkers as 11 (44,0 %) produced a bisyllabic form of the word.

Besides the proportion of truncations the quality of truncated structures is of interest in this study. It was expected that Finnish children –unlike English speaking children4 preserve the first two syllables of the target word. A typical bisyllabic form of *porkkana* would thus be *pokka* or *pookka* if the constraint

preventing complex codas is satisfied. This would be the case if one assumes that prosodical features precede more exact phonotactics, in other words, *pok-* would precede the trimoraic initial syllable *pook-* which would precede the syllables *polk-* and *pork-* with a complex coda.

The results showed, as expected, the truncated productions typically included the first two syllables, which in the target word form the initial foot, e.g. ʃpokkaβ (Kuisma RB) and ʃpookkaβ (Mirva CG). The unparsed final syllable was thus omitted. There was only one exception in which the extracted syllables could not be clearly detected: ʃpovaβ (v weak) (Maija RG). Analysis of the form of the initial syllable showed that typically the productions already had the trimoraic initial syllable, only in four out of fifteen bisyllabic forms was the syllable bimoraic and the only one with a monomoraic initial syllable was the above mentioned exceptional production by Maija. Others did not violate Heavy(Stressed).

It was also typical for the productions not to include the complex coda: 10 out of 15 truncated forms were of the type *pokka* or *pookka* . Some of these forms had changes in phonemes but it was still typical to preserve the geminate and not produce the sequence, e.g. in ʃpooppAβ (Lasse CB) the geminate is assimilated into /pp/ by the constraint requiring same place of articulation for consonants.

There were, however, four truncated productions against the hypothesis that sequences do not appear before complete trisyllabic prosodic structure, for example ʃporkkaβ (Panu CB), in which the sequence is complete also at the phoneme level. Interestingly, among the most advanced forms included in the quantitative analysis, there were no truncated forms with the consonant sequence /lkk/. Such examples were however found outside the most advanced productions. For example, Henri (RB) produced ʃpolkkAβ but he also produced ʃpoikkaliβ which, on the basis of trisyllabicity, was defined to be his most advanced production despite the lack of a sequence. In terms of constraints these two outputs from the same child are quite revealing about the interplay of constraints preventing complex codas and extrametrical syllables, in the sense that only one of them may be realised in the output but not both. Moreover, this variation in outputs shows an unstable ranking of constraints which indicates development in the phonological system towards Faithfulness.

### *Phonotactics*

After the bisyllabic forms the child starts producing trisyllabic forms, first perhaps without the target-like trimoraic initial syllable and coda: *pokkana*. The truncated forms however show that the trimoraic syllable is typically preserved already in these forms. This is in line with the low proportion of *pokkana* (N=6) compared to *pookkana* (N=45). These forms are included into the same category in the overall quantitative results in Table 26. Following example of word processing may reflect hesitation about the syllable which is at first produced in parts: ʃm- po- oko- pookkanaβ (Iiro CB).

The results show that out of all the productions the proportion of *pokkana~pokkana* forms was 28,6 % in the control and 32,6 % in the at-risk group, thus there is a tendency for the children to produce trisyllabic forms without a sequence at this age. This was even more typical for late talkers of whom 40,0 % (10) produced a trisyllabic form without a sequence. Based on this word, we may hypothesise that late talkers at this age typically produce either truncated bisyllabic forms or phonotactically simple trisyllabic forms.

There was variation at the phoneme level but all of the forms in this category are trisyllabic though do not yet have the sequence. Variation occurred both in vowels and in consonants:

Ψɸuukkanaβ(n~l)  Liisi (RG)
Ψɸookkalaβ       Anniina (RG), Inkeri (RG), Otto (RB)
Ψɸookkavaβ       Eero (RB)
Ψɸookkamaβ       Mari (CG)

Interestingly, the four productions presented below included a diphthong. Since the complex consonant sequence of the target was on focus here, these forms do not fill the requirements of the phonotactic level. It may be that especially *poikkana* indicates a progressive form towards the consonant sequence: *pookkana > poikkana > polkkana*.

Ψɸoikkaliβ       Henri (RB)
Ψɸoikkanaβ       Kimmo (RB)
Ψɸuokkanaβ       Jeppe (CB)
Ψɸoukkanaβ(n~l)  Hanna (RG)

It was assumed that after the prosodic structure in terms of syllable numbers and syllable length is acquired, the child moves towards more exact phonotactics and segmental specification. He/she can thus produce the heterorganic consonant sequence /lkk/ in which /r/ is substituted resulting in *polkkana*. It appeared that there were forms that could be placed between *pookkana* and *polkkana* in terms of their complexity. They are the forms with a simpler consonant sequence regarding the articulatory place of the components. In the form *poξkkana* the place of articulation is velar in the sequence and in *polttana* it is dental. Out of the 11 forms of this kind, four included an /ltt/ sequence and seven an /ξkk/ sequence. In these forms complex codas are allowed by violation of *COMPLEX-CODA, but Sequence-constraints still prevent target-like heterorganic sequences.

Group comparison revealed that *poξkkana* or *polttana* was produced only in the at-risk group by eleven children (12,4 %). If the categories *pokkana-pookkana* and *poξkkana/polttana* were combined, 28,6 % of the control group's productions belonged to these categories whereas the proportion was as much as 44,9 % in the at-risk group. This indicates that even though at-risk children did not differ from control children in the production of trisyllabicity, in this word they had more problems in production of the consonant sequence.

### Phoneme level

When the heterorganic sequence /lkk/ has emerged in the production of *porkkana* the element to be acquired is the phoneme /r/. The proportion of these forms was 15,6 % in the control and 20,2 % in the at-risk group. Since late talkers produced structurally simpler forms, there was only one production of this kind.

Again, there was some variation in phonemes but in all of the forms in this category the preceding elements were realised, namely number of syllables, syllable length and heterorganic consonant sequence. A typical production of this kind was [polkkana] (Suvi RG and several others).

Two forms had assimilatory changes, in ʹkolkkanaʹ Hannu (RB) uses a regressive assimilation from the stop geminate to initial consonant and in ʹpelkkolaʹ Oskari (CB) shows a progressive assimilation of /l/. It may be that behind these processes are phonotactic constraints concerning either place or manner of articulation. The form ʹponkkanaʹ (Silja CG) is interesting since it includes a consonant sequence not allowed in Finnish: /nk/. According to Karlsson (1983: 119) a nasal can not form a sequence with an obstruent of different place in Finnish. In addition, there are phoneme level changes for consonants in ʹpolkkajaʹ (j~n) (Janna RG) and in ʹpolkkajaʹ (Joni CB, Toni CB). These also include a heterorganic sequence.

### Target-like forms

The proportion of target-like forms was lower in at-risk (28,1 %) than in the control groups (44,2%). Although most of the late talkers produced simpler structures, there was three (12,0 %) of them who produced the target form.

Production of the /r/ varied phonetically. A few /r/-phonemes which were produced more posterially than the phonetically correct /r/ were accepted as complete forms, although the typical heterorganic dental-velar – sequence is not actually realised in these productions. Some produced an /r/ which sounded weaker, often due to whispering. If the phoneme was categorised as an /r/-phoneme in an otherwise target-like form, it was accepted in this category despite the phonetic variation in /r/.

There was one accepted and exceptional production, namely ʹporkkakaʹ in which the velar /k/ has spread progressively. The child also produced ʹpolkkanaʹ thus the concentration put into the production of /r/ may have caused the assimilation.

To sum up, the hypothetical developmental forms of *porkkana* were classified into five stages based on their structural complexity in order to compare the phonological skills of the control, at-risk group and late talkers. The analysis showed that this type of categorisation is possible although some truncated bisyllabic forms were against the developmental hypothesis since they already included a heterorganic sequence. The analysis also showed, that even more discrete categories could be found. The complete developmental

continuum of the word could be as follows: *pokka – pokkana – pookkana – poikkana/ poξkkana/polttana – polkkana – porkkana.*

## 4.2.2 Productions of the word *aurinko*

Similarly to *porkkana*, the number and quality of truncated productions were examined for the word *aurinko*. The second unstressed syllable is heavy, violating Light(Unstressed), which in children's productions may be satisfied through a VV.CV.CV word structure. Production of the second syllable is connected to an interplay of constraints concerning phonotactics: the diphthong /au/ may be prevented by *COMPLEX-NUCLEUS and sequence /ξk/ by NoSequence(Nasal...Stop). It is of interest to see how these elements are realised; constraint conspiracy may prevent both of them appearing in the same output. Phoneme level difficulty again concerns the productions of /r/. Since the word structure is quite complex, in the quantitative results some types are included into same category although some developmental hierarchy could be detected. Overall quantitative results are presented in table 27 and each category is more specifically explained below.

| | |
|---|---|
| *aali* | Satisfies PARSE-SYL<br>Satisfies Light(Unstressed)<br>Satisfies *COMPLEX-NUCLEUS, Satisfies NoSequence(Nasal...Stop)<br>Violates Faithfulness at word, syllable, phonotactical and at phoneme level |
| *a(a)liko* | Violates PARSE-SYL<br>Satisfies Light(Unstressed)<br>Satisfies *COMPLEX-NUCLEUS, Satisfies NoSequence(Nasal...Stop)<br>Violates Faithfulness at syllable, phonotactical and at phoneme level |
| *auliko* | Violates PARSE-SYL<br>Satisfies Light(Unstressed)<br>Violates *COMPLEX-NUCLEUS, Satisfies NoSequence(Nasal...Stop)<br>Violates Faithfulness at syllable, phonotactical and at phoneme level |
| *a(a)liξko* | Violates PARSE-SYL<br>Violates Light(Unstressed)<br>Satisfies *COMPLEX-NUCLEUS, Violates NoSequence(Nasal...Stop)<br>Violates Faithfulness at phonotactical and at phoneme level |
| *auliξko* | Violates PARSE-SYL<br>Violates Light(Unstressed)<br>Violates *COMPLEX-NUCLEUS, Violates NoSequence(Nasal...Stop)<br>Violates Faithfulness at phoneme level |
| *auriξko* | Violates PARSE-SYL<br>Violates Light(Unstressed)<br>Violates *COMPLEX-NUCLEUS, Violates NoSequence(Nasal...Stop)<br>Satisfies Faithfulness at all levels |

TABLE 27  Proportions (%) of different types of productions of *aurinko* in the control group, at-risk group and the late talkers (including children from both control and at-risk groups).

|  | Control (N=80) | At-risk (N=87) | Late Talkers (N=20) |
|---|---|---|---|
| 1. Word level not complete e.g. *auli* | 18,8 (15) | 18,4 (16) | 55,0 (11) |
| 2. Phonotactics not complete e.g *aliko* | 2,5 (2) | 5,7 (5) | 10,0 (2) |
| *3.* Phonotactics partially complete e.g. *auliko, aliξ́ko* | 28,7 (23) | 31,0 (27) | 20,0 (4) |
| 4. Phoneme level not complete e.g *auliξ́ko* | 25,0 (20) | 27,6 (24) | 10,0 (2) |
| 5. Target-like form *auriξ́ko* | 25,0 (20) | 17,2 (15) | 5,0 (1) |

### Word level

The proportion of bisyllabic forms was the same in both the at-risk (18,4 %) and the control group (18,8 %) (Table 27). In the late talker subgroup roughly half of the productions were bisyllabic (55,0 %) which indicates that bisyllabic forms precede trisyllabic forms developmentally. The variation in the quality of truncated productions was high. Against the assumption that phonotactical elements, the diphthong and consonant sequence, and the phoneme /r/ have not yet emerged, there were truncated productions in the data which included these features. In the overall quantitative results all the truncated forms were included in the first category. The interplay of phonotactical elements was more closely examined in the quantitative analysis of trisyllabic forms.

The beginning form for *aurinko* could be the very unmarked production Ψakaβ (Maija RG) with a trochaic foot and with simple phonotactical and phonemic structure. Of the more complex truncated forms, it was difficult to categorise the different types because many productions were a mixture of elements of all the syllables in a target word (so called conflation effect). A main type of truncation was, however, a preservation of the first and second syllable: 15 out of 31 truncated productions were of this type (48,4 %). Three of these were the type *auri* and others included substitutions or deletion of /r/, e.g. *auli* by several children. Also the forms Ψuðuβ (Into CB) and Ψaniβ (Anna RG) have elements from the first and second syllable only but the order of segments differs from the target form (/n/ is probably fronted from /ξ/).

There was only one production with just the first and third syllable: Ψaʉko3äβ (Siiri RG), but also Ψakkoäβ (Arja CG) and the above mentioned Ψakaβ (Maija RG) may be interpreted as having the first and third syllable. Perhaps an easy onset consonant in the third syllable compared to /r/ in the second syllable caused many children to preserve the final syllable or its onset instead of the second syllable.

Several forms included elements from all the target's syllables, for example, several forms included the vowel /i/ from the second syllable along with a stop consonant /k/ from the third syllable, as in Ψukiβ (Tommi RB,

Julius CB) and in ʮikoβ (Lasse CB, Olga CG). Form *auki* is opposite to Pater's (1997) suggestion that (English-speaking) children may preserve the third syllable rhyme and second syllable onset.

The consonant sequence was also sometimes produced as in ʮɑξkoβ (Mira CG and three others). Conflation also takes place in these forms since the first syllable includes elements from the first and second syllable in the target. The form ʮiξkoβ (Jussi RB) is already quite close to the target the word but is bisyllabic. The bisyllabic forms could also be analysed as a conspiracy between constraints preventing a diphthong and sequence. This type of interplay of constraints is seen in the two productions of Ninni (CG) in which the output depends on the dominating constraint ("\>>" reads as "dominates"):

(a) *COMPLEX-NUCLEUS >> Faithfulness>> NoSequence(Nasal...Stop)

ʮɑξkaβ

(b) NoSequence(Nasal...Stop) >> Faithfulness >> *COMPLEX-NUCLEUS

ʮikoβ

A possible example of progressive processing of the word structure in the following is by Alisa (CG) who in both naming occasions first produced a bisyllabic form of the word but then continued to a more advanced trisyllabic form:

First naming:       ʮja auleξkoβ
Second naming:      ʮaji aulekkoβ

The trisyllabic form in the first naming is much more advanced compared to truncated forms as it has only substitutions at phoneme level (/l/ for /r/ and /e/ for /i/).

To summarise, children truncated *aurinko* by preserving the two initial syllables or first and third syllables, with conflation and sonority effects as well as a conspiracy effect between the diphthong and consonant sequence.

### *Syllable level and Phonotactics*

Syllable length and phonotactics also form a complex interplay of elements in trisyllabic productions. There were various forms in the data showing an interplay. In the main quantitative results in Table 27 syllable level is not considered since the categorisation would be quite scattered if all the output possibilities were taken into account. Syllable level with respect to the heavy unstressed syllable is, however, more carefully examined here.

Production of the /ξk/-sequence as well as production of the /au/-diphthong is related to syllable length in the sense that a bimoraic syllable has to precede the phonotactical elements. The most simple trisyllabic form of *aurinko* would include only (C)V-syllables resulting in the form such as *aliko.*

However, the constraint requiring stressed syllables to be heavy may prevent *aliko*, instead, the children may produce *aaliko*. This is more likely since the truncated bisyllabic forms also preserve the heavy word initial syllable. In *aaliko* Light(Unstressed) is satisfied but when heavy syllables also emerge in unstressed position violating LightUnstressed, the output form could be *aalikko*.

There were only seven productions in the data which were trisyllabic without the diphthong and consonant sequence completely. These forms had substitutions at the phoneme level but if we look at the heaviness of syllables, the following patterns were found.

a) V.CV.CV *aliko* (Without heavy syllables)

| | |
|---|---|
| ˈal- alituβ | Pauli (RB) |
| ˈarikoβ | Osmo (RB) |

b) VV.CV.CV *aaliko* (Heavy syllables in stressed position)

| | |
|---|---|
| ˈaalikoβ | Mikael (RB) |
| ˈaaʔlikoä β | Taru (CG) |
| ˈaakukiβ | Onni (CB) |

c) VV.CVC.CV *alikko* (Heavy syllables in stressed and unstressed position)

| | |
|---|---|
| ˈaalikʰbβ | Sara (RG)[37] |
| ˈaarikkoβ (r weak) | Outi (RG) |

Since stressed syllables are more prominent, the diphthong may appear before the consonant sequence and a possible conspiracy may prevent them from appearing in the same output. The third category in Table 27 refers to forms of this type and the results show that there were many productions with either diphthong or sequence but not both. The number of these productions was approximately the same in both groups: in controls 28,7 % and in the at-risk group 31,0 %. Also 20 % of the productions by late talkers were of this type. In general there were almost equal number of forms including either the diphthong (*auliko*) (N=23) or the consonant sequence (*aliξko*) (N=27) so no preference for conspiracy type was found.

It is essential to point out that in the analysis of phonotactical elements, a completely target-like realisation of phonemes was not required, for example in diphthongs /ai/ was also accepted as in ˈaijiikaä β (Reetta CG). Similarly, a consonant sequence with another place of articulation was also accepted, e.g. ˈaaintoβ (Sauli CB) (dental instead of velar). In addition, there were also some other phonemic changes in the forms classified into this category although they included the required elements with respect to syllable length and phonotactics. For example, the phoneme /r/ was not produced in most cases. There were deletions, e.g. ˈaaiξkoβ (Olivia CG), substitutions, e.g. ˈaajiξKoβ (Asko CB) and regressive assimilations, e.g. ˈaukikoβ (Jaakko CB). Also some insertions of an

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[37] A half-long consonant is here syllabified similarly to a geminate (*aa.lik.ko*).

initial consonant appeared, e.g. ˈɦaaniξkoβ (Oskari CB), ˈɦaaʔlikoä β (Taru CG). As well as productions following the prototypical types, the following examples further illustrate the variation in children's forms regarding syllable length, phonotactics and phoneme level:

   a) Diphthong and a light second syllable, type *auliko*

        ˈɦuriko4β        Elina (RG)

   b) Diphthong and a heavy second syllable, type *aulikko*

        ˈɦauiikoβ        Marja (RG)
        ˈɦuiitaβ         Tuukka (RB)
        ˈɦurikkoβ        Emilia (CG)
        ˈɦijiikaä β      Reetta (CG)

   c) Consonant sequence and a light first syllable, type *alξko*

        ˈɦ-iξkoβ (syllable border) (Mikko RB)

   d) Consonant sequence and a heavy first syllable, type *aalξko*

        ˈɦaiξkoβ         Heini (CG)
        ˈɦaviξkoβ        Hanna (RG)
        ˈɦajiξkoβ        Marjo (RG)
        ˈɦaruξkoä β      Joel (CB)

The examples below illustrate phonotactical processings of the word. Annina (RG) produced the diphthong separately first before succeeding in producing it in a complete form. Taija (RG) also produced the first syllable but without the diphthong before producing the phonotactically correct form.

        ˈɦ- ala- au- auriξk ɓβ Anniina (RG)
        ˈɦa- ˌauliξkoä β        Taija (RG)

### *Phoneme level*

I hypothesised that /r/ would be the last element to be mastered, that is, it would appear after the elements at word, syllable and phonotactic levels were acquired. The data above shows that this was not always the case and /r/ was present in some forms in which the hypothetical previous stages were not acquired, e.g. *ariko, aarikko*. The forms in the category 4 (table 27) were, however, types in which the prosodic and phonotactical structures were acquired but changes at phoneme level remained to be made. The proportion of the forms in this category was approximately the same in both the control (25,0 %) and the at-risk group (27,6 %) and only two out of twenty late talkers produced a form of this category.

Despite the variation, most of the forms in this category were *aulξko*, (N=12 in control and N=15 in at-risk group). Some forms had phoneme level

substitutions in the diphthong or consonant sequence although the forms were prosodically and phonotactically advanced:

    ʮaʉlinto3β        Emma (RG), Paavo (RB)
    ʮiliξkoβ          Kasperi (RB), Miira (CG), Janne (CB)
    ʮidiξkoβ        Akseli (CB)

Other exceptions included target-like diphthong and sequence but had substitutions in other phonemes:

    ʮuleξko2äβ      Sini (RG), Alisa (CG)
    ʮuviξkoβ        Vilma (RG), Katja (CG), Petri (CB)
    ʮuiξko2β         Anu (RG), Joonas (RB), Nuutti (RB), Irene (RG), Minttu (CG)
    ʮuaξko2β        Valma (CG)

### *Target-like forms*

The proportion of fully target-like forms reached 25,0 % in the control and 17,2 % in the at-risk group[38]. This gap is due to the slightly higher number of trisyllabic forms with inaccurate phonotactics or phoneme level in the at-risk group. Only one late talker produced a target-like form.

    The productions of *aurinko* were characterised by extensive variation in forms. Complex phonotactics and an interplay of constraints resulted in several types of outputs. Variation was seen already in the truncated bisyllabic forms which showed that it is not only prosodical reasons which play a role in truncations, but also sonority of consonants affects the outputs.

### 4.2.3 Productions of the word *orava*

The word *orava,* 'squirrel' is fairly simple in structure; it does not have heavy unstressed syllables, diphthongs nor complex consonant sequences. The extra unparsed syllable can be deleted as in other trisyllabic words, but the number of truncated productions may be lower than, for example, in *aurinko,* due to the simple phonotactic structure. Previous analyses of phonotactics have mainly dealt with diphthongs and consonant sequences but in this word I will look at the types of assimilation in consonants. Avoidance of /r/ may cause regressive assimilation of /v/ resulting in the form *ovava.* The NoSequence constraint(Dental...Labial) may cause the assimilation. Overall quantitative results are presented in Table 28 below.

    *ola*        Satisfies PARSE-SYL
               Satisfies NoSequence constraint(Dental...Labial)
               Violates Faithfulness at word level, phonotactics and phoneme level

---

[38]    The form ʮiriξkoβ (Juuso RB) was accepted into the category of complete forms even though it does not have a fully target-like diphthong. It is, however, considered more advanced than the productions in the previous category due to the /r/-phoneme

| | | |
|---|---|---|
| *ovava/* | Violates P<small>ARSE</small>-S<small>YL</small> | |
| *olala* | Satisfies NoSequence(Dental...Labial) | |
| | Violates Faithfulness at phonotactics and phoneme level | |
| | | |
| *olava* | Violates P<small>ARSE</small>-S<small>YL</small> | |
| | Violates NoSequence(Dental...Labial) | |
| | Violates Faithfulness at phoneme level | |
| | | |
| *orava* | Violates P<small>ARSE</small>-S<small>YL</small> | |
| | Violates NoSequence(Dental...Labial) | |
| | Satisfies Faithfulness at all levels | |

TABLE 28  Proportions (%) of different types of productions of *orava* the control group, at-risk group and the late talkers (including children from both control and at-risk groups).

| | | *Control (N=66)* | *At-risk (N=73)* | *Late Talkers (N=21)* |
|---|---|---|---|---|
| *1.* | Word level not complete e.g. *ola* | 7,6 (5) | 12,3 (9) | 38,1 (8) |
| 2. | Phonotactics not complete e.g. *olala* | 13,6 (9) | 11,0 (8) | 28,6 (6) |
| 3. | Phonotactics partially complete (metathesis) e.g. *ovala, ovara* | 21,2 (14) | 34,2 (25) | 19,0 (4) |
| 4. | Phoneme level not complete e.g. *olava* | 28,8 (19) | 27,4 (20) | 9,5 (2) |
| 5. | Target-like form *orava* | 28,8 (19) | 15,1 (11) | 4,8 (1) |

### *Word level*

As seen from the results in Table 28, the number of bisyllabic forms in *orava* was 7,6 % in the control and 12,3 % in the at-risk group which indicates that the majority of productions were trisyllabic. 38,1 % of the productions in the late talker group were bisyllabic, but also in this subgroup the proportion was less than, for example, in the more complex *aurinko* (55,0 %).

It is assumed that children usually preserve the initial stressed syllable and the adjacent second syllable in truncated forms in order to produce a binary foot, thus the most common truncation type would be *ora* with possible substitutional changes in /r/, for example *ola*. This indeed was found in the data, for example:

| Ψʊlaβ | Panu (CB) |
|---|---|
| Ψʊ3laðβ | Kuisma (RB) |
| Ψʊraβ | Pia (RG) |

However, the data shows that this was not always the case since in 8 cases out of a total 14 truncated productions the third syllable was preserved with the initial syllable instead of the second syllable, e.g. Ψʊvaβ (Julius CB and several others). Since the vowel in both the second and third syllable is /a/, the definition of syllable preservation is done only on the basis of onset consonant. The children may have avoided /r/ and rather violated Contiguity than

produced it as an onset consonant. In other words, the requirement to choose an easier onset consonant may have been stronger than satisfaction of Contiguity. In *aurinko* it was concluded that some children chose the less sonorant onset consonant but since both /r/ and /l/ in *orava* are liquids, that conclusion is not as clear here.

Besides *ova* and *ola*, there was one production with the onset /j/ that may have been a substitution for /r/ as well: ˈɤjaˑβ (Sanni RG). In addition, although the binary foot in truncated productions is typically trochaic, there were a few iambic productions: ˈhoˌɣaβ (Otso RB) and ˈɤˌɣaβ (Leeni RG). This may reflect the naming register with rising intonation.

### *Phonotactics*

Constraints on place of articulation in consonants may be ranked high in trisyllabic forms. In *orava* harmonious structures could be caused by NoSequence(Dental...Labial). A solution to satisfy the constraint is assimilation of consonants. The proportion of assimilated forms was 13,6 % in the control and 11,0 % in the at-risk group. Perhaps at an earlier age the proportion of these forms could be higher. Assimilated productions were common in late talkers (28,6 %, N=6) along with truncated forms.

Thirteen out of a total 17 assimilated forms were regressive, resulting in the type *ovava,* probably due to avoidance of /r/. In addition there were forms such as *olala*, *orara* and *ojaja*. Two children also had assimilation in vowels. Although the constraint on place of articulation may have caused the assimilation pattern, reduplication of the syllable /va/ may also be a factor at play:

> ˈɤvaˌɣaβ        Nuutti (RB)
> ˈɤavavaβ (shouts)   Mari (RG)

Reduplication violates Faithfulness because it deletes the syllable /ra/ from the input form. For cases in which a stressed syllable following a prefix or a clitic is reduplicated in English acquisition, Bernhardt and Stemberger (1998: 465–466) propose the explanation that Faithfulness is ranked low in an unstressed syllable, but the timing units of the unstressed syllable survive and these timing unit positions are filled by the spreading of segments from the following stressed syllable. The same might be the case in the *ovava*, although the reduplicative syllable is also unstressed.

When consonants of different articulatory place emerge in a child's output, the production only lacks phoneme level correctness. It was found, however, that the number of metatheses was quite high in the data. For this reason metathesis was more specifically studied and as a special type of phonotactical phenomena a discrete category in the overall results in Table 28 was added. The results show that metathetical forms were more common for at-risk children (34,2 %) than for control children (21,2 %). There were also four cases of

metathesis (19,0 %) in the late talker group, but for them truncated and assimilated forms were the most common.

Bernhardt and Stemberger (1998: 712–713) suggest that Contiguity prevents metathesis, and so if the latter occurs, the constraint is violated:

Contiguity[39]
Elements next to each other (contiguous) in the underlying representation must be contiguous in the surface.

The constraint also prevents insertion of segments. It is, however, not clear whether the question here is about metathesis of consonants or of syllables. Metathetical forms in the data included both forms with /r/ and its substitutions, for example:

|  |  |
|---|---|
| [ovara] | Aleksi (RB) |
| Ḇvalaβ | Oskari (CB) |
| Ḇvaɟaβ | Jukka (RB) |

It may be that for some reason this word is sensitive to metathesis even in adults. A note from the transcription revealed that even the experimenter produced the word with a metathesis when repeating the child's metathetical utterance. The only difference in the experimenter's repetition was the /r/-phoneme, instead of its substitution:

| Riina (RG): | [ovala puussa] *ovara puussa* 'a squirrel in the tree' |
|---|---|
| Experimenter: | [ovara puussa] *ovara puussa* 'a squirrel in the tree' |

The high degree of metathesis in this word may be due to a high frequency derivational ending in Finnish, namely /–ri/, which is used as an affix in abbreviations, e.g. *lenkkari* 'sneaker', *kaivuri* 'digger'. It is also used as an affix in common words indicating a profession, e.g. *lääkäri* 'doctor', *rehtori* 'principal'. Perhaps due to this type of word being used frequently in every day life it is more "natural" to have /r/ in the onset of the third syllable instead of the second syllable.

Interestingly, metathesis (of syllables) is typical for dyslexics in writing (Seymour 1986: 4). In fact, Richardson (1998: 17) mentions just this word as an example of the type of mistakes dyslexics make. This phenomenon could be an example of a process similar in speech production and later in writing.

### *Phoneme level*

In Table 28 the *olava* is placed after metathetical forms in order to indicate that the syntagmatic structure and also the order of segments is correct at this stage and the only remaining feature to acquire is the phoneme /r/. Thus forms with a substitution of a single phoneme, as in *olava*, were considered more advanced than *ovara* with the correct phonemes but violations in the order of segments. In

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[39]    Kager (1999: 251) uses a constraint called Linearity as an "anti-metathesis" constraint.

the control group the proportion of these were 28,8 % and in the at-risk group 27,4 %. Only two of 21 late talkers produced a form lacking only phoneme level specification.

Typically /r/ was substituted by /l/; 34 out of a total of 39 productions in this category included /l/. Thus in this word the variation in substitution types of /r/ was not as high as in the bisyllabic *rattaat,* in which deletions of word initial consonant also occurred. In the word-medial position of *orava* there were no deletions of /r/. The forms other than *olava* were:

| | |
|---|---|
| ßjavaβ | Heini (CG) |
| ßbaɟvaβ | Liisi (RG) |
| ßda2vaβ | Säde (RG) |
| ßlajaβ | Joni (CB) |

Labial /b/ may be resulted from /v/. /d/ perhaps indicates an emerging /r/[40]. Form *olaja* was accepted into the category 4 (Table 28) although there are two substituted segments and others in this class had one substituted segment.

### Target-like forms

Control group had more (28,8 %) complete target-like forms than the at-risk group (15,1 %). Again, late talkers were less advanced compared to other children as only one out of 21 late talkers produced a target-like form.

To sum up, the number of truncated forms was clearly smaller than in more complex words. Due to the /r/-phoneme the proportion of target-like forms was  not very high at the age of 2;6. In addition, the data showed phonotactically interesting phenomena, namely metathesis in trisyllabic forms; its proportion was fairly high in control and at-risk groups, but reached over a third of all the productions in the at-risk group.

### 4.2.4 Productions of the word *lapio*

The word *lapio,* 'shovel' has a simple syllable structure of CV.CV.V. Since it lacks phonotactic complexities I predict that the children produce the word fairly accurately. In the initial stages of phonological development the word might truncate into a bisyllabic form but later there may only be some phonemic changes, for example deletion or substitution of the word initial /l/. In Table 29 the overall quantitative results are presented, and they are more specifically explained below.

*lapi*       Satisfies PARSE-SYL
              Violates Faithfulness at word and at phoneme level

*lapio*     Violates PARSE-SYL
              Satisfies Faithfulness on all hierarchical levels

---

[40]    In addition, there was one form with a flap which in this study is not accepted in the /r/-category. Phonetically it is, however, more similar to the /r/-phoneme.

TABLE 29   Proportions (%) of different types of productions of *lapio* in the control group, at-risk group and the late talkers (including children from both control and at-risk groups).

|  | Control (N=82) | At-risk (N=94) | Late Talkers (N=27) |
|---|---|---|---|
| 1. Word level not complete e.g. *lapi* | 8,5 (7) | 7,4 (7) | 33,3 (9) |
| 2. Phonotactical or phoneme level not complete e.g. *apio* | 26,8 (22) | 23,4 (22) | 29,6 (8) |
| 3. Target-like form *lapio* | 64,6 (53) | 69,1 (65) | 37,0 (10) |

### Word level

The number of truncated forms was low in both the at-risk (7,4 %) and control (8,5 %) group, but made up 33,3 % of the productions in the late talker group (Table 29). It seems that the phonological complexity of the word affects the proportion of truncated forms: extrametrical syllables are produced first in phonotactically simpler words. Again, the hypothetical truncation pattern is a preservation of the first two syllables. In *lapio* this is even more probable than for example in *aurinko* and *orava* due to the stop onset consonant in the second syllable. This was indeed the case in the data as 12 out of 14 truncated forms included the first syllable based on vowel /a/ and an onset consonant /p/. As well as the typical initial consonant deletions and substitutions there was also variation in the vowels. Three forms, for example, ended with /u/, which may be due to inconsistency in vowel harmony: /u/ as a back vowel follows back vowel harmony with /a/, however, in Finnish vowel harmony /i/ is neutral and can be combined both with front and back vowels as in the target form *lapio*. The following examples illustrate the variation in initial consonants as well as in vowels:

|  |  |
|---|---|
| Ψlapiβ | Tommi (RB) and others |
| Ψhapiβ | Ulpu (CG) |
| Ψapi β | Pia (RG) |
| Ψhapuβ | Julius (CB), Samu (CB) |
| Ψapeä β | Ismo (RB) |

Productions by Liisa (RG) reveal hesitation as to exact word form: Ψ- apu β Ψlipeβ Ψlpeφ The trochaic pattern remains but syllable and phoneme level vary, for example, the second form has a heavy initial syllable. There were also a few exceptional truncations that, on the basis of the context were defined as namings of *lapio*:

|  |  |
|---|---|
| Ψlaakkaβ | Siiri (RG) |
| Ψlvaβ | Maija (RG) (repeats several times and points at the picture of shovel) |

Note that Maija produced a form similar to a syllable level truncation from *avain*. This illustrates the fact that strong prosodic constraints may hinder the expansion of vocabulary.

Contrary to prediction based on English truncation patterns (Pater 1997) there were no productions in which the third syllable rhyme survived with the second syllable onset *lapo*.

### Phonotactical and phoneme level

This category in the quantitative results in Table 29 includes mainly two kinds of forms, those with a substitution or with a deletion of word initial /l/. But in addition, a few forms with assimilation of consonants were also included in this category. 23,4 % of the productions of *lapio* in the at-risk group were classified into this category and 26,8 % in the control group. The proportion of this category in late talkers was nearly the same, 29,6 %, but they had more truncated productions. Table 30 shows the distribution in this category of trisyllabic forms with changes in phonotactics (assimilation) or at the phoneme level.

TABLE 30   Proportions (N) of word-initial consonant deletions and substitutions as well as assimilations in trisyllabic forms of *lapio*.

|  | Word-initial cons. deletion e.g. apio | Word-initial cons. substitution e.g. hapio, japio | Other changes e.g. papio |
|---|---|---|---|
| Control (N=22) | 10 | 8 | 4 |
| At-risk (N=22) | 15 | 6 | 1 |
| TOTAL (N=44) | 25 (56,8 %) | 14 (31,8 %) | 5 (11,4 %) |

Word initial consonant deletion was a common process in *lapio*, which might be explained by the type of the consonant. Leiwo suggested (1977) that the liquid /l/ is more prone to deletion than, for example, stop consonants (see also Savinainen-Makkonen 2000c). In the case of liquid consonants, constraint requiring onset is thus violated.

In trisyllabic forms /l/ was most often (9/14) substituted by /h/ resulting in the form *hapio*. Interestingly, /h/ was a common substitutive consonant in the initial position of *rattaat*. In addition, there were a few substitutions by /j/ and a few by stop consonant:

Ψjapioβ          Minttu (CG) (whispers)
Ψtapioβ          Niilo (RB) (produced twice with /t/)
Ψkapioβ          Reetta (CG) (produced twice with /k/)

There were five forms demonstrating processes other than substitution or deletion of the initial consonant. Some had changes in the initial vowel but had additional changes in other phonemes occurred such as productions with regressive assimilation of /p/, e.g. ΨpapIOβ (Henri RB), and the same in the

voiced form e.g. Ψβabioβ (Aaro CB). This is considered to be a satisfaction of the Sequence(Dental...Labial) -constraint preventing consonants of different place.

Some forms included an onset consonant in the final syllable, thus satisfying the constraint requiring onsets: ΨapIlOhβ and ΨapilaΨβ (Ville CB) as well as ΨBaˌkeliβ (Aino CG). Aino also produced the word in a bisyllabic form, ΨþapiΨβ In fact, phonetically the target word may be produced as *lapijo* with an onset in the third syllable. In addition, the form ΨepIOβ (Auli CG) has a front vowel in the initial syllable instead of the back vowel; the substitution may be caused by regressive vowel assimilation of the front vowel /i/.

### *Target-like forms*

The word was  fairly simple in its syllable structure. In the at-risk group the proportion of complete forms was as high as 69,1 % and in the control group 64,6 %. Also late talkers achieved a higher proportion of target forms (37,0 %) than in some other word structures, e.g. in *orava* the percentage of target forms was 4,8 %.

### 4.2.5 Productions of the word *banaani*

In the analysis of *banaani,* 'banana', two problematic issues came up. First of all, the word-initial /p/4/b/ distinction was difficult to perceive. It seemed, however, that the consonant was not voiced in general. This may also be true  in adult colloquial speech, since /b/ occurs only in loanwords and the /p/4/b/ distinction is not used in minimal pairs in Finnish. Also, since Finnish /p/ is not aspirated, the distinction from voiced /b/ was often subtle and difficult to detect. In the analyses below voicing in the word initial consonant was thus not considered.

Secondly, although the target word has an orthographically marked long vowel in the second syllable, it seems that in colloquial speech this long quantity is not always clearly produced and there is a tendency for the syllable to shorten: *banani~banaani* (or *panani~panaani*). This variation may be due to the word position in which minimal pairs of short and long quantity do not occur. Quantity, or second syllable length in moras, was not taken into account in the analysis due to this possible variation in adult colloquial speech. The analysis of this trisyllabic word thus concerns only the truncation patterns and phoneme level changes. Quantitative results are presented in Table 31.

| | |
|---|---|
| *bana* | Satisfies PARSE-SYL |
| | Violates Faithfulness at word and phoneme level |
| | |
| *bana(a)ni* | Violates PARSE-SYL |
| | (Violates Light(Unstressed)) |
| | Satisfies Faithfulness at all levels |

TABLE 31   Proportions (%) of different types of productions of *banaani* in the control group, at-risk group and the late talkers (including children from both control and at-risk groups).

|  | Control (N=72) | At-risk (N=81) | Late Talkers (N=22) |
|---|---|---|---|
| 1. Word level not complete e.g. *bana* | 9,7 (7) | 6,2 (5) | 50,0 (11) |
| 2. Phonotactical or phoneme level not complete e.g. *anani* | 11,1 (8) | 11,1 (9) | 9,1 (2) |
| 3. Complete form *banani~banaani* | 79,2 (57) | 82,7 (67) | 40,9 (9) |

### Word level

The proportion of truncated forms was low in both the at-risk (6,2 %) and the control (9,7 %) group (Table 31). Since the subgroup of late talkers includes children from both the at-risk and control group, one can see from the results in Table 31, that nearly all of them were produced by late talkers, of whose productions half were bisyllabic. If the initial syllable was preserved in truncation, a typical bisyllabic form should be *bana,* but based on the data, the most typical form, seven out of twelve truncations, was *pani* which includes the initial syllable with the final syllable (and a /p/ instead of /b/). Since the onset is /n/ in both the second and third syllable, the conclusion is based on rhymes. The examples below illustrate the two main types of truncations of the word based on rhymes, but again, there was variation in the initial consonant:

| | |
|---|---|
| Ψɓaniβ | Onni (CB) |
| Ψpaniβ | Ulpu (CG), Tommi (RB) |
| Ψʌnaβ | Liisa (RG) |
| Ψɸpanaβ | Panu (CB) |
| Ψʋanaβ | Kuisma (RB) |
| Ψɱnamaβ | Maija (RG) |

The production by Maija shows a reduplication strategy which at this age is rare. In this word, sonority of onsets does not explain the preservation of the final syllable (or its rhyme). It may be, that even though the heaviness of the unstressed second syllable varies in colloquial speech, this very fact causes avoidance of it, i.e. children may rather produce the final, clearly CV-syllable.

   Prosodically the truncated forms were Faithful to the syllable weight in the target in the initial position. Heavy(Stressed) was satisfied in only two cases, namely in Ψɓaaniβ (Juho RB), and in Ψɓaai3β (Aaro CB). Finally, one form had an iambic instead of trochaic foot form: Ψɸaˌniβ (Risto RB).

### Phonotactical and phoneme level

Since the proportion of trisyllabic forms with changes in phonotactics or at the phoneme level was not very high, 11,1 % in both at-risk and control group, all of the trisyllabic forms other than target-like forms were included into same

category. Also, only two late talkers produced an inaccurate trisyllabic form. In this section I will shortly present different types of changes common for *banaani*.

There were some unexpected substitutions (3/17) of consonant /n/. Unexpected in that the sequence of two /n/ consonants is expected to be easier than two different consonants, as for example in ˈpa- pa- palaniβ (Taru CG). Typically for Finnish children, in a few forms the initial consonant was deleted (3/17), e.g. ˈananiβ (Janne CB).

Changes in vowels may be explained by constraints requiring harmony. In 7 out of 17 forms in this category the back vowel /a/ was fronted by the word final front vowel /i/ as in the first two examples below. In contrast, the third example below indicates progressive assimilation in which a back vowel causes the backness of the final front vowel:

> ˈpaniniβ          Joni (CB)
> ˈpaneniβ          Hannu (RB), Outi (RG)
> ˈpunanaβ          Verneri (RB)

It is, however, not always clear whether the question is about phoneme harmony or reduplication of a syllable, c.f. *ovava* for *orava*. There was also a case of nasal assimilation of consonants: ˈmananeβ (Annika RG). Uncertainty as to exact word structure may cause additional behaviours such as shouting, as in the examples below (see also Turunen 1998: 233; 1999: 206):

> ˈpanejaβ          Jesse (CB) (shouts)
> ˈpaðneðiβ         Mari (CG) (shouts)

### Target-like forms

Four syllable productions in the partitive form and with no changes at the phonotactic or phoneme level (*panaania*) were included into the category of target-like forms.

Proportions of target-like forms were similarly high to those for *lapio*: 79,2 % in the control and 82,7 % in the at-risk group. Also 40,9 % of late talkers achieved complete forms although their productions were mostly bisyllabic.

### 4.2.6 Productions of the word *puhelin*

The word *puhelin,* 'telephone', is phonotactically simple. The target form has a heavy final and thus unstressed syllable. However, the realisation of the word final /n/ is problematic, because in colloquial speech and in dialects the word final /n/ is sensitive to deletion. For example, in the passive form *lähetää~lähetään,* the final /n/ does not have grammatical importance since the long quantity in the vowel already marks the passive form. Moreover, final /n/ does not appear in the common inflected forms of the word, e.g. *puhelimessa* (Inessive) 'on the phone', *puhelimeen* (Illative) 'to the phone', which may affect children's understanding of the nominative form. In the quantitative results

(Table 32) *puheli* and *puhelin* forms are thus both included as complete, target-like forms, however, one could expect that in a word final unstressed position the syllable could easily be shortened to a CV–syllable. The analyses concentrated on truncation patterns and phoneme level substitutions in trisyllabic forms.

| | |
|---|---|
| *puhe* | Satisfies PARSE-SYL |
| | Violates Faithfulness at word and phoneme level |
| *puheli(n)* | Violates PARSE-SYL |
| | Satisfies Faithfulness at all hierarchical levels |

TABLE 32   Proportions (%) of different types of productions of *puhelin* in the control group, at-risk group and the late talkers (including children from both control and at-risk groups).

| | Control % (N=77) | At-risk % (N=93) | Late Talkers (N=27) |
|---|---|---|---|
| 1. Word level not complete e.g. *puhe* | 2,6 (2) | 15,1 (14) | 40,7 (11) |
| 2. Phonotactical or phoneme level not complete e.g. *puheji(n)* | 28,6 (22) | 21,5 (20) | 33,3 (9) |
| 3. Target-like form *puheli(n)* | 68,8 (53) | 63,4 (59) | 25,9 (7) |

### Word level

Unlike in other words, the at-risk group had more bisyllabic productions of the word *puhelin* (15,1 %) than the control group (2,6 %). Late talkers again had a higher proportion of bisyllabic forms, 40,7 % (Table 32).

The results show that although there was a preference for the initial foot to survive in truncated forms, there was variability in productions and no other clear patterns were found. Ψpuheβ which was produced by six children, and also ΨPuẽβ (Pia RG) suggest preservation of the initial foot.

There were no forms clearly representing the first and third syllable *puli*. Several forms had the final syllable rhyme either with second or third syllable onset, although these examples also had unexpected changes in their structure. Some even had a heavy initial syllable that is not in the target word:

| | |
|---|---|
| Ψpahiβ | Tommi (RB) |
| Ψaliβ | Taneli (RB) |
| Ψtuliä β | Ismo (RB) |
| Ψpooliä β | Olli (RB) |
| Ψpuuhiβ | Mirva (CG) (whispers) |

The simplest reduplicated production is again by Maija (RG), Ψpupuβ Ψpueloβ (Juho RB) on the other hand is an example of an advanced production at phoneme level with trochaic prosodic structure. In fact, Savinainen-Makkonen (1996: 46) has reported on the same issue, namely nearly target-like trisyllabic words which rhythmically still sound bisyllabic, e.g. Ψlik.kaβ lusikka by Sini at

age 1;641;9. Juho had two other truncated productions of *puhelin*, realised as ʋpailiβ which reveals something about uncertainty as to word structure and variation which does not always show the developmental trend towards more target-like forms.

In *puhelin,* the preferred truncation type was the preservation of the first and second syllables, but most of the productions were conflations of several features, with a preference for the vowel of the third syllable.

### *Phonotactical and phoneme level*

The second category in Table 32 includes forms which were trisyllabic but had changes in phonotactics or at the phoneme level. The variety of these forms indicates that phonotactically this word form was problematic for some children even though it lacks diphthongs and consonant sequences. The proportion of these forms was 21,5 % in the at-risk and 28,6 % in the control group. The lower percentage in the at-risk group is due to the higher number of bisyllabic forms. The proportion was 33,3 % in the late talker group which likewise had more bisyllabic forms.

In some forms trisyllabicity was defined purely on the basis of rhythmic pattern. An extreme example of this kind of production was ʋpuiβ (Eero RB) which propably was rhythmically trisyllabic although it violated the constraint requiring onsets (ONSET). This form is an example on how overall prosodic structure serves as a basis for longer words; in the following stages the phonemic structure should get more advanced. The form ʋpue3iβ (Jesse, CB) likewise has deletions of onset consonants later in the word but the vowels were correctly produced. Several forms had deletions of one onset consonant later in the word but also these cases had the trisyllabic prosodic pattern. It may be that /h/ is more likely to be deleted, but also /l/ was omitted in some cases:

| | |
|---|---|
| ʋpu(h)e-eβ | Aaro (CB) |
| ʋpu(h)eiβ | Asko (CB) |
| ʋpuheinβ | Lasse (CB) |
| ʋpueɭiβ | Arvo (RB) |

None of the productions had deletions of the initial consonant /p/ whereas for example, *lapio* had a total of 25 trisyllabic forms with a deletion of word initial /l/. This indicates that sonority plays a role. /l/ may be more often deleted than a stop consonant.

In addition to deletions of syllable-initial onset consonants in second or third syllable, there were also phonotactical changes in consonants caused by the NoSequence constraint requiring consonants to be articulated in the same place. As a result of this, some cases (7) of regressive assimilation occurred, e.g. ʋpuleliβ by several children. In addition, there was one case of progressive assimilation: ʋpuhehiβ (Ronja CG). Regressive assimilation also took place in vowels: ʋpu(h)iliβ (Pauli RB) and ʋpuhimiβ (Tuovi, RG).

One production had a clear metathesis, ꞈpulɛhiβ (Emilia CG), but several forms had confusions of consonant order, e.g. in ꞈpuleᵈmiβ (Daniel RB) /m/ might be metathetically derived from the word-final nasal /n/. However, it may rather be that the inflected form *puhelimeen* 'to the phone' caused the appearance of /m/ as in ꞈpulimeβ(ku) (Vilja RG and Miira CG).

Besides consonant deletions, assimilations and metatheses, consonant substitutions occured, e.g. ꞈpuheɟinβ (Ossi CB) and ꞈ𝚿uheðviäβ by Pinja (RG). The productions of this word were characterised by variation in structure, some of which might be due to inflection of the word. The variation was not always predictable as seen in the exceptions below. Hierarchical analysis provides tools to categorise these types of forms as even though these productions severely violate phoneme level faithfulness, their word level prosodic structure is target-like (if word-final /n/ is not considered):

| | |
|---|---|
| ꞈpomeᵈnaβ | Arja (CG) |
| ꞈpo2veviβ | Katja (CG) |
| ꞈpöhelɪβ | Hannu (RB) |
| ꞈheluɭneβ | Mikko (RB) |

The variety of forms in the same category in the quantitative results does not show very specifically the type of structures produced within groups. But all of the forms in this category represent trisyllabic forms with changes in the vowel and/or consonants. However, these changes may be assimilations or metatheses reflecting phonotactical constraints, or deletions and substitutions which rather reflect constraints on individual phonemes.

### *Target-like forms*

The proportion of complete target-like forms was highest both in the at-risk (63,4 %) and control group (68,8 %) despite the variety of constraints concerning the phonotactics and phoneme level. In addition, 25,9 % of late talkers produced a target-like form.

### 4.2.7 Conclusion

At the age of 2;6 prosodic constraints at word level still steered some children's productions towards truncations. A summary of the proportions of truncated, bisyllabic productions is presented below in Table 33.[41] Approximately 10 % of the productions of trisyllabic targets were truncated. The comparison of words reveal that the proportion of truncations was highest in the structurally most complex word *aurinko*. This may indicate that a child first learns to produce longer words in phonotactically simpler forms. The results do not support the

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[41]    In Turunen (2000: 115) I have reported the proportions of truncated forms in the control group. However, in that report the first namings (not the most advanced) of each word were analysed and the proportions of truncations of some targets were slightly higher.

hypothesis that at-risk children had more truncated forms except in productions of the word *puhelin*.

TABLE 33   Proportions (%) of truncated forms from trisyllabic targets in the at-risk and control groups. The most advanced production from each child was analysed.

| Target word | Control % | At-Risk % |
|---|---|---|
| *aurinko* 'the sun' | 18,8 (15/80) | 18,4 (16/87) |
| *orava* 'squirrel' | 7,6 (5/66) | 12,3 (9/73) |
| *porkkana* 'carrot' | 11,7 (9/77) | 6,7 (6/89) |
| *banaani* 'banana' | 9,7 (7/72) | 6,2 (5/81) |
| *lapio* 'shovel' | 8,5 (7/82) | 7,4 (7/94) |
| *puhelin* 'telephone' | 2,6 (2/77) | 15,1 (14/93) |
| TOTAL AVERAGE | 9,9 (45/454) | 11,0 (57/517) |

Even though the number of children who still truncated trisyllabic words was low, the proportion of them was clearly higher in the subgroup of late talkers. In this group  the proportions of truncations varied from 55 to 33 percent,  again being highest in *aurinko.* This indicates that the pattern is indeed typical for Finnish children at an earlier age.

Also the types of truncations were studied. The main types of truncation preserved the initial foot as for example in *pokka* 'porkkana'. Although the initial syllable was usually present, other factors such as sonority of onset consonants played a role in extracting the bisyllabic form. For example in *auki,* for *aurinko*, a less sonorant onset consonant is chosen. Also an interplay of phonotactical elements had an impact on truncations, e.g. in *aξko* for *aurinko*, the child produces the consonant sequence instead of the diphthong. Thus, although the production of the word-initial foot was the most preferred type in truncations, it is apparent that the phonological structure of each word has a further effect on the actual realised form. The syntagmatic aspect is of importance. Despite the resulting variety of truncated forms, a reason for truncations is probably to try and achieve productions of a binary foot without unparsed syllables.

This study investigated the proportion of truncations in an experimental situation in which the children were encouraged to name the pictures they saw. It may be that children more easily avoid producing words which they find difficult in spontaneous speech production. In Korhonen's (1998)[42] study on the phonology of two-year-olds there were quite a few truncated forms in spontaneous speech. She also found that there were some children whose trisyllabic forms were unintelligible or unintelligible reduplicated trisyllabic forms, e.g. [polili], which further signals strong structural constraints (Korhonen 1998). They also illustrate the next step towards phonotactically more complex trisyllabic forms.

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[42]   Korhonen, P. 1998. 2;0-vuotiaiden sanarakenteiden muutoksista. Unpublished Master's thesis. Finnish Deparment, University of Jyväskylä..

Individual preferences and strategies were not investigated in this study. However, I will point out a few issues regarding individual patterns in truncations as well as its connection to morphology. Unlike some others, Panu (CB) produced a word initial foot regardless of the sonority of the onsets, e.g. Ψuriβ Ψßlaβ For most of the time he was able to produce the consonant /r/ which is probably the reason for not avoiding it as an onset. Truncation of trisyllabic words was seen in his speech in an unexpected manner; he was able to produce multisyllabic sentences but often the last syllables of trisyllabic forms were deleted. This type of production strategy was not found in Korhonen's (1998) study of 2-year-olds. The following examples are transcribed from his utterances during the naming task. In example (1) he deletes the final syllable from the verb *pudota* 'to fall down' in example (2) from an adverb *alhaalla* 'down' and in (3) from an inessive form *metsässä* 'forest (Inessive)'.

(1)    Ψ-meinas pulo mäβ         *meinas pudota minä* (reversed word order)
                                   'I was about to fall down'

(2)    Ψi alhaβ                   *ei alhaalla*
                                   'not down'

(3)    Ψää paista, metsäβ         *tää paistaa, metsässä*
                                   'this shines, in the forest'

These forms indicate that the child avoids complex prosodic structures and deletes unparsed syllables in spontaneous speech production. He also had a tendency to shorten heavy unstressed syllables as in *paistaa* 'shines' in example (3). The child is an active talker and able to produce multiword sentences. It can therefore be expected that the stage when truncations appear would soon be passed as it was for most of the children in the data. However, it may hinder the development of morphology since for example a case ending often adds a third syllable to a word as in *metsä:metsässä* 'forest: forest' (Inessive).

The relationship between phonology and morphology will be more specifically investigated in further studies. However, preliminary analyses indicate that the truncation pattern does not necessarily block the production of morphology and syntax.

In addition to word level analyses, syllable level and phonotactics were studied word-specifically. I will here discuss some issues which arose from the word analyses. Phonotactical NoSequence-constraints on place and manner of articulation were used to explain the inability to produce target-like consonant sequences. Two intermediate forms between avoidance of the sequence and realisation of the complete sequence were found in the productions of *porkkana*: First of all, productions of some children did not violate constraint NoSequence(Dental...Velar) because they included a sequence of same place of articulation, e.g. *poξkkana*, a phenomena similar to the *satset* example. Secondly, a high number of children produced *polkkana* in which sequence-constraints on manner of articulation played a role.

In *aurinko* an interplay of constraints preventing both a consonant sequence and diphthong formed a conspiracy, which was found also in truncated forms. There were forms in which only one was realised but not both in the same output, e.g. *auliko, alɨko.*

Productions of *orava* included a surprisingly high number of metathetical forms, e.g. *ovala, ovara.* This violates the Contiguity constraint which requires elements next to each other in input to be adjacent also in output.

Overall group comparisons revealed that although at-risk children did not have a stronger tendency for truncated forms, they had less complete, target-like forms. In *aurinko* the at-risk group had 17,2 % target-like forms and the control group 25,0 %. The difference was higher in *porkkana* and *orava.* In *porkkana* 28,1 % of at-risk children and as much as 44,2 % of control children produced a target-like form. More specific analysis on this word revealed that at-risk children had more problems in the production of the heterorganic consonant sequence: none of the eleven intermediate *poɨkkana* or *polttana* –types were produced by controls. Similarly, in *orava* at-risks had less target-like forms (15,1 %) than controls (28,8 %) because they had more forms with a metathesis. Interestingly, at-risk children were not less advanced in phonotactically simpler words, in *lapio* and *banaani*, but in *puhelin* they had more truncations. Since late talkers had a high proportion of truncated forms, the proportions of target-like forms were low.

Most of the data supported the hypothesised developmental stages and thus a quantification of the productions into different categories was conducted. An exception to the hierarchical model was in realisations of the /r/. It was hypothesised that the phoneme is among the final elements to be acquired in word structures. However, some truncated forms already included an /r/, e.g. *porkka.* The analyses showed, however, that children's word forms can be analysed according to hierarchical levels, and moreover, the productions of late talkers indicate that the stages illustrate the possible developmental paths.

## 4.3   Four syllable target words

### 4.3.1 Production of the word *appelsiini*

Four syllable words in Finnish have main stress on initial syllable and secondary stress on third syllable, thus they are comprised of two trochaic feet. Savinainen-Makkonen (1996: 49) provides an example of development of *appelsiini,* 'orange' in the speech of Sini from the age of 1;3 until 1;11. At first she produced a bisyllabic form Ⴤppiβ then the word was produced in a trisyllabic form, or in four syllable partitive form *appelsiinia*, e.g. Ⴤppeχχiβ Ⴤppeχχi.aβ This stage in Sini's word production is theoretically interesting in the sense that the word *appelsiini* comprises two bisyllabic feet and it is suggested that four syllable words may be even easier for a child than trisyllabic words with an extrametrical syllable (Räisänen 1975: 256). Thus, if children try to avoid

extrametrical syllables, truncation of four syllable words into trisyllabic forms should be rare.

Regarding the quality of bisyllabic truncated forms, I expect that the word-initial foot survives instead of the second foot. In trisyllabic truncations I expect that an unstressed syllable will be deleted instead of stressed one. In other words, the unstressed syllable of each foot is more prone to deletion than the foot initial stressed syllable, which results in forms such as *apsiini* or *appelsi*. The number and quality of truncations into bi- or trisyllabic forms is examined at word level.

Syllable level is not quantitatively analysed in this word but the issue is touched upon in the qualitative analyses of some productions. At the level of phonotactics the focus is on the realisation of the consonant sequence. Sini produced a four syllable form but with a geminate at the age of 1;11 ˈappeχχiiniβ (Savinainen-Makkonen 1996: 49), which indicates that four syllable facility appears before the consonant sequence /ls/. The production of the sequence is related to the phoneme level analysis of /s/, which may be difficult for some children at this age. In such cases the /s/ may be substituted with /t/, as in the form *appeltiini*.

The total number of productions was 108 (the most advanced production selected from each child ), which is fairly low compared to some other words. The reason is methodological at least in some cases since some children had difficulties in interpretation of the picture. The overall quantitative results are presented in Table 34.

| | |
|---|---|
| *appi* | Satisfies NotComplex(PrWd)<br>Satisfies PARSE-SYL<br>Satisfies Light(Unstressed)<br>Satisfies NoSequence(Liquid...Fricative)<br>Violates Faithfulness at word, syllable, phonotactical and at phoneme level |
| *appessi/*<br>*apsiini* | Satisfies NotComplex(PrWd)<br>Violates PARSE-SYL<br>Violates Light(Unstressed)<br>Satisfies NoSequence(Liquid...Fricative)<br>Violates Faithfulness at word, syllable, phonotactical and at phoneme level |
| *appeiini* | Violates NotComplex(PrWd)<br>Satisfies PARSE-SYL<br>Satisfies Light(Unstressed)<br>Satisfies NoSequence(Liquid...Fricative)<br>Violates Faithfulness at syllable, phonotactical and at phoneme level |
| *appeltiini* | Violates NotComplex(PrWd)<br>Satisfies PARSE-SYL<br>Violates Light(Unstressed)<br>Satisfies NoSequence(Liquid...Fricative)<br>Violates Faithfulness at phoneme level |

*appelsiini*  Violates NotComplex(PrWd)
Satisfies PARSE-SYL
Violates Light(Unstressed)
Violates NoSequence(Liquid...Fricative)
Satisfies Faithfulness at all levels

TABLE 34  Proportions (%) of different types of productions of *appelsiini* in the control group, at-risk group and the late talkers (including children from both control and at-risk groups).

|  | Control % (N=49) | At-risk % (N=59) | Late Talkers % N=13 |
|---|---|---|---|
| 1.  Word level not complete e.g. *apsiini* | 16,3 (8) | 20,3 (12) | 46,2 (6) |
| 2.  Phonotactics not complete e.g. *appeiini* | 36,7 (18) | 33,9 (20) | 30,8 (4) |
| 3.  Phoneme level not complete e.g. *appeltiini* | 12,2 (6) | 11,9 (7) | 7,7 (1) |
| 4.  Target-like form e.g. *appelsiini* | 34,7 (17) | 33,9 (20) | 15,4 (2) |

## Word level

In the overall quantitative results in Table 34, the truncations into bisyllabic and into trisyllabic forms are combined. The proportion of all truncated forms was 20,3 % in the at-risk and 16,3 % in the control group. Also, nearly half of 13 late talkers (46,2 %) produced a truncated form. Taken together, there were a total of 20 (18,5 %) truncated productions out of 108, which indicates that the ability to produce four syllable words as such is not problematic at the age of 2;6 for most of the children. Out of 20 truncated forms, only four were bisyllabic 4an expected result at the age of 2;6 (Table 35).

TABLE 35  Proportions (N) of bisyllabic, trisyllabic and four syllable productions of *appelsiini* in the control and at-risk groups.

|  | Bisyllabic | Trisyllabic | Four syllable |
|---|---|---|---|
| At-Risk | 4 | 8 | 47 |
| Control | 0 | 8 | 41 |
| TOTAL | 4 (3,7 %) | 16 (14,8 %) | 88 (81,5 %) |

A typical bisyllabic form of this word was drawn from the first foot, but there was variation in the survival of the final syllable coda, which in an optimal trochaic foot would be prevented by the constraint NO-CODA or by Light(Unstressed). In addition, one form had a rhyme /i/ from the final foot, as seen also in Sini's productions above:

ᴪappIβ  Martta (RG)
ᴪappelβ  Elise (RG)
ᴪa4ppesβ  Ismo (RB)
ᴪampɬβ  Anna (RG)

The type *appi* reflects (C)VCCV structure, which is the typical form of the first words in Finnish. In addition there was one form with an unexpected consonant sequence /mp/. Outside the most advanced productions Atso (CB) produced [ap- apsi] in which he extracts the syllables with main and secondary stress from the target word. This violates Contiguity, which requires elements adjacent in input to be adjacent in output; this child also produced a more advanced trisyllabic form [apsissi]

The results showed that there were basically two types of trisyllabic truncations; either the word initial stressed syllable and the second foot were extracted *(apsiini)* or alternatively the first foot and third stressed syllable *(appessi).* If the final foot survives as in *apsiini*, could it be that the initial heavy syllable forms a foot of its own: [(ap.)(sii.ni)]? The problem with this kind of footing is that it violates *CLASH which prevents stress on adjacent syllables. If then the trisyllabic form is footed as a regular trisyllabic word in Finnish, the final foot is not preserved as such but leaves the final syllable unparsed: [(ap.sii).ni] The *appessi*-type, on the other hand, could be parsed as a trisyllabic word with an unparsed syllable: [(ap.pes.)si] These forms violate Light(Unstressed) in the second syllable. In most cases the main stress was on the first syllable following a regular trisyllabic stress pattern, except [ap‚hensi] (Kirsi RG), which is probably parsed as [ap.(hen.si)] Also, Liisa (CG) concentrated on production of the second foot [‚piini] and clearly separated the word initial vowel.

Another deviant form was [apani] (Otso RB). This production satisfies the syllable level constraint Light(Unstressed) as well as the phonotactic constraint preventing consonant sequences.

The truncated forms did not include the target sequence /ls/ except in [appelssi] (Jussi RB). In addition, there was a /ns/ sequence in two productions as seen in an example above. The deletion of the second unstressed syllable, however, caused /ps/ to appear in the productions. In these cases I suppose that the constraint causing the deletion of the syllable (NotComplex (PrWd)) was more highly ranked than the constraint preventing this consonant sequence and the Contiguity constraint.

### *Phonotactics*

Although truncated forms sometimes included a consonant sequence (though mostly not the target sequence), I assume that four syllable words without a target sequence are more advanced, since the overall prosodic structure in terms of syllable number provides the starting point for the more specific phonotactics and phoneme level. The proportion of *appeiini~appessiini*-types from all the productions was 33,9 % in the at-risk group and 36,7 % in the control group. Four out of 13 late talkers produced these forms without the consonant sequence.

At syllable level these forms included those with with a light unstressed syllable (1) and those with a eavy unstressed syllable (2), as in the target form.

Shortening of the heavy unstressed syllable in the target occurs because of the proposed constraint Light(Unstressed). Roughly half of the productions in this category had a light unstressed second syllable and half had a heavy unstressed syllable. Examples of both are presented below:

(1) Light unstressed syllable

| | |
|---|---|
| ˈappeiiniβ | Eero (RB), Susa (CG) |
| ˈatteˌtiiniβ | Into (CB) |
| ˈappeiniä β | Olli (RB) |
| ˈappeliiniβ | Ari (CB) |
| ˈaupeiiniβ | Severi (CB) |
| ˈappesiiniβ | Paula (RG), Pasi (CB), Hanna (RG) |

(2) Heavy unstressed syllable

| | |
|---|---|
| ˈappessiiniβ | Juuso (RB) and several others |
| ˈappenniiniβ | Petri (CB) |
| ˈa- ap- ap- appettiiniβ | Anniina (RG) |

When the consonant sequence was assimilated, the output was typically *appessiini*. Why is the assimilation regressive and not progressive resulting in the form *\*appelliini*? The sonority hierarchy may play a role here. /s/ as a fricative is less sonorant than liquid /l/ and thus it may be more prone to assimilation. However, variation in this word was high which is illustrated by the above examples; the onset of the third syllable was /s/, /t/, /l/, /n/ or it was deleted.

### *Phoneme level*

Those productions that had complete prosodic structure in terms of syllable number, syllable length and the presence of a sequence but were not target-like at phoneme level were included in this category of the quantitative results (e.g. *appeltiini*). There were less productions in this category than in the category without a consonant sequence (e.g. *appeiini*) and in the category of complete, target-like forms (*appelsiini*). The proportions were approximately the same in the at-risk (11,9 %) and control (12,2 %) groups. One late talker also produced this type of form and two late talkers produced the complete form.

I expected there to be more of this type of word structure in which the /s/ is substituted typically with /t/. However, there were only 7 children in the data whose most advanced productions were of this type. In terms of constraints this type of production would mean that in manner of articulation NoSequence (Liquid...Fricative) /ls/ is highly ranked but NoSequence (Liquid...Stop) /lt/ is less highly ranked.

In addition to the *appeltiini,* there were variations, e.g. ˈappestiiniβ (Osmo RB) and ˈappenˈsiiniβ (Kristian RB). A few types with metathesis were accepted into this category although they are problematic at the phonotactical level. In

such cases the word form included a consonant sequence but there was variation in the position of the sequence:

| | |
|---|---|
| ˈʔplelsilliβ | Patrik (CB) |
| ˈʔplelliisiβ | Akseli (CB) |
| ˈʔpselsiiniβ | Ville (CB) |

### *Target-like forms*

The at-risk and control groups had approximately the same number of complete, target-like forms: the at-risk group 33,9 % and control group 34,7 %. Although at-risk children had slightly more truncated forms, the quantitative results based on this rough categorisation of production forms do not indicate that children at-risk for dyslexia have more problems in the production of longer words, at least not the data examined here.

### 4.3.2 Productions of the word *lentokone*

Except for *appelsiini* the rest of the analysed four syllable words were compound words. In the analysis of *lentokone,* 'aeroplane', word level truncations into bi- and trisyllabic forms are similarly analysed. It is again predicted that in the case of bisyllabic truncations the first foot is preserved and in trisyllabic truncations, unstressed syllables are deleted rather than stressed syllables. The syllabic level is not more specifically examined since the target word satisfies Light(Unstressed) and one could expect that the constraint is satisfied from the onset of phonological development. At the phonotactical level realisation of the consonant sequence is studied. At phoneme level the focus was on the realisation of word initial /l/, as well as assimilatory processes. Quantitative results are presented in Table 36 below.

| | |
|---|---|
| *e.g. (l)eeko* | Satisfies NotComplex(PrWd) |
| | Satisfies Parse-Syl |
| | Satisfies NoSequence(Nasal...Stop) |
| | Violates Faithfulness at word, phonotactical and at phoneme level. |
| *(l)eekone* | Satisfies NotComplex(PrWd) |
| | Violates Parse-Syl |
| | Satisfies NoSequence(Nasal...Stop) |
| | Violates Faithfulness at word, phonotactical and at phoneme level |
| *(l)eetokone* | Violates NotCompex(PrWd) |
| | Satisfies Parse-Syl |
| | Satisfies NoSequence(Nasal...Stop) |
| | Violates Faithfulness at phonotactical and at phoneme level |
| *lentokone* | Violates NotCompex(PrWd) |
| | Satisfies Parse-Syl |
| | Violates NoSequence(Nasal...Stop) |
| | Satisfies Faithfulness at all levels |

TABLE 36  Proportions (%) of different types of productions of *lentokone* in the control group, at-risk group and the late talkers (including children from both control and at-risk groups).

|  | Control (N=74) | At-risk (N=88) | Late Talkers N=23 |
|---|---|---|---|
| 1. Word level not complete e.g. *leξkone* | 5,4 (4) | 19,3 (17) | 39,1 (9) |
| 2. Phonotactics not complete e.g. *leetokone* | 8,1 (6) | 2,3 (2) | 8,7 (2) |
| 3. Phoneme level not complete e.g. *entokone* | 33,8 (25) | 34,1 (30) | 43,5 (10) |
| 4. Target-like form e.g. *lentokone* | 52,7 (39) | 44,3 (39) | 8,7 (2) |

## Word level

In *lentokone* truncated bisyllabic productions were difficult to define since the word is a compound. In some cases the child produced either the first (*lento*) or the latter part (*kone*) of the compound. Perhaps these productions reflect the child's bisyllabic pattern, since *lento* at least is not used alone in the meaning of an aeroplane in adult speech. The word *kone* could perhaps be produced in this context to mean 'a machine', but in these cases I have assumed that the children may have shortened the long target word due to inability to produce all the required syllables:

> Ɪɭenteä β        Ismo (RB)
> ꞮɭntoB           Essi (RG)
> ꞀɭeʰtoB          Mikaela (RG)
> ꞀꞎkoneB          Otto (RB)

Consonant sequence /nt/ was produced in the above forms of *lento* although one could predict that the sequence is not yet produced in bisyllabic forms. Clearer truncations were a few productions in the data in which the child's most advanced production was a bisyllabic form with elements from both parts of the compound. In ꞀɭeξkonB (Ilari RB) the stressed syllables are extracted, and perhaps also in Ꞁꞎee-ʝaB (Kuisma RB), in which the child produced the word in two parts by stressing both syllables equally. These forms violate Faithfulness in general. The second example also reflects effortful articulation and violates *CLASH, which prevents stress on adjacent syllables.

The overall results in Table 36 reveal that most of the truncated forms were produced by at-risk children (19,3 %) whereas controls did not have bisyllabic truncations at all and the proportion of truncated trisyllabic forms for them was only 5,4 %. Again, the proportion of truncated forms for the late talkers was as high as 39,1 %. The majority of truncated forms were trisyllabic: 11 in the at-risk and 4 in the control group. The 6 bisyllabic truncations were produced by at-risk children.

The forms of trisyllabic productions indicate that the main type of truncation was  omission of the unstressed second syllable as in ꞀɭeξkoneB (Iiro CB and several others). Prosodically this form is similar to *apsiini* for *appelsiini*:

both have a bimoraic initial syllable and the omission of the second unstressed syllable. The omission of second syllable causes elements not adjacent in input to be adjacent in output – this results in a consonant sequence which is not present in the target. The possible constraint NoSequence(Nasal...Stop) prevents not only /nt/ but also /ξk/. Maybe because this is violated, more syllables could appear in the output. The following productions are deviant, but perhaps extracted from the same target syllables as *leξkone*:

| | |
|---|---|
| ˈheξkonkiβ | Julius (CB) |
| ˈheekoloä β | Pia (RG) |
| ˈheh-noɲneβ | Severi (CB) (demarcation between syllables) |

Severi produced the word three times. The other two productions were ˈheh-no-neβ and ˈheh-ɲno-ɲneβ He separated the syllables and especially in the last example, stressed all of them equally. This type of effortful pronunciation (Nettelbladt 1983) may be a sign of problems in identifying the exact structure of the word. In this case, the child attempted to produce the syllables in which the vowels are correct but consonants are substituted or harmonised.

Also ˈhookkoneβ (Onni CB) may be drawn from the first stressed syllable and of the second foot. The first syllable has the initial consonant of the target but the syllable is affected by regressive back vowel harmony from the deleted syllable and from the latter foot.

The only productions indicating omission of the secondary stressed syllable /ko/ were ˈentoneβ (Maria RG) and the somewhat unclear ˈenton(e)β (Daniel RB). Besides these forms, Inkeri (RG) also produced ˈkune-Eβ in which she extracts the second foot but also attempts to lengthen the word by adding a single vowel at the end of the production. It may be, that this way she aims for a longer word structure.

### *Phonotactics*

The second category in the quantitative results includes those forms which contained four syllables but lacked the consonant sequence. The number of these forms was quite low, perhaps due to the relatively easy homorganic consonant sequence /nt/. 8,1 % of the productions by controls belong to this category and only 2,3 % in the at-risk group. The proportion of these forms was also low in the late talkers: 8,7 %.

An interesting feature in these eight forms was the variation in the first syllable at the syllabic and phonotactical levels. It can be expected that if the consonant sequence is not produced, the vowel will be lengthened in order to keep the syllable heavy. There were three forms of this type:

| | |
|---|---|
| ˈleekoko2neβ | Jeppe (CB) |
| ˈletokoneβ | Taru (CG) |
| ˈletokonEβ | Mikael (RB) |

Syllable length was also preserved in the following three forms through a diphthong. This indicates that the propable constraint preventing diphthongs (*COMPLEX-NUCLEUS) is violated in order to produce a heavy initial syllable.

| | |
|---|---|
| ˈɭito-oneβ | Joni (CB) |
| ˈʎkeikokoneβ | Senja (CG) |
| ˈɭhe3itokoneβ | Katja (CG) |

In addition, there were two cases with a light stressed syllable violating Heavy(Stressed). In these forms all the syllables were unmarked (C)V syllables, even the onsets were deleted. The production by Liisa (CG) especially indicates that the child extracts only the peak vowels from the syllable (final /a/ may be due to progressive back vowel harmony).

| | |
|---|---|
| ˈɛto-onaβ | Liisa (CG) |
| ˈɛtokoneβ(k~kʲ) | Juho (RB) |

### *Phoneme level*

Category 3 in Table 36 included 34,1 % of the at-risk group's and 33,8 % of the control group's productions. These productions were four syllable words including the consonant sequence. Besides their four syllable quality, the consonant sequence was chosen as a criteria for a more complex word form, as compared to four syllable forms without it: *(l)eetokone>(l)entokone*.

Two types of processes were typical for the forms in this category, namely substitution or deletion of the initial consonant and assimilations across consonants. Thus phonotactics also play a role in the forms in this category. Common forms in this category were ˈɭhentokoneβ (Esa CB and several others) in which /l/ is substituted by /h/. Secondly, deletions of the initial consonant as in ˈɭntokoneβ (Arja CG and many others) were common. Rarer substitutions of /l/ occurred in ˈɭjentokoneβ (Ossi CB), ˈɭ鄟entokoneβ (Henri RB and a few others) and in ˈɭkäntokoneβ (Reetta CG), however, the two latter forms are probably due to regressive assimilations.

Regressive assimilation may cause the backing of the consonant sequence in productions like ˈɭeξkokoneβ (Veera RG and many others) which resemble the truncated *leξkone*. On the other hand, the dental consonant sequence sometimes caused the fronting of /k/ as in ˈɭntotoneβ (Sauli CB). Moreover, the following examples from the same child (Sara RG) illustrate the effect of place-constraint: in (1) consonants are velar and in (2) dental:

| | |
|---|---|
| (1) ˈɭeξkʲbkoneβ | |
| (2) ˈɭntotoneβ | |

The following Table 37 shows the number of forms in this category which had phoneme level changes (substitutions or onset consonant omissions) and those which could be phonotactical changes (regressive and progressive assimilation;

mainly fronting or backing of consonants). Although onset consonant omissions are included into the same category as phoneme level changes, they could actually be interpreted as syllable level changes.

Table 37    Proportion (N) of phoneme and phonotactical level change in four syllable words with a consonant sequence in *lentokone* for the control and at-risk groups. (A distribution within category 3 in Table 36).

|  | *Phoneme level change* <br> *e.g. entokone* | *Phonotactic change (Assimilation)* <br> *e.g. leꞌkokone* |
|---|---|---|
| At-risk  (N=30) | 15 (50 %) | 15 (50 %) |
| Control (N=25) | 18 (72 %) | 7 (28 %) |

The results show that in those four syllable forms in which a consonant sequence was produced, the at-risk group had a tendency to assimilate more. In terms of constraints this may mean the constraints on a consonant's articulatory place are more highly ranked in their productions than in the productions of controls.

### Target-like forms

The proportion of target-like productions was as high as 52,7 % in the control and 44,3 % in the at-risk group. Two out of 23 late talkers achieved a complete form; most of their productions were truncated or had assimilatory or phoneme level changes.

### 4.3.3 Productions of the word *liukumäki*

The word *liukumäki,* 'slide'*,* is also a compound word and prosodically identical to *lentokone*. It has main stress on the initial syllable and secondary stress on the third syllable. It also has a heavy first syllable and the rest of the syllables are light. Thus similar prosodic constraints are expected to apply in this word.  Phonotactically there is a difference through the presence of a diphthong instead of a consonant sequence. Overall quantitative results are presented in Table 38.

*e.g. (l)iiku*    Satisfies NotComplex(PrWd)
Satisfies PARSE-SYL
Satisfies *COMPLEX-NUCLEUS
Violates Faithfulness at word, phonotactical and at phoneme level.

*(l)iimäki*    Satisfies NotComplex(PrWd)
Violates PARSE-SYL
Satisfies*COMPLEX-NUCLEUS
Violates Faithfulness at word, phonotactical and at phoneme level

*(l)iikumäki*    Violates NotCompex(PrWd)
Satisfies PARSE-SYL
Satisfies *COMPLEX-NUCLEUS
Violates Faithfulness at phonotactical and at phoneme level

*liukumäki*   Violates NotCompex(PrWd)
Satisfies PARSE-SYL
Violates *COMPLEX-NUCLEUS
Satisfies Faithfulness at all levels

TABLE 38  Proportions (%) of different types of productions of *liukumäki* in the at-risk group, control group and the late talkers (including children from both at-risk and control groups).

|  | *Control %* *(N=73)* | *At-risk %* *(N=83)* | *Late Talkers %* *N=19* |
|---|---|---|---|
| 1. Word level not complete e.g. *liuku* | 12,3 (9) | 13,3 (11) | 47,4 (9) |
| 2. Phonotactics not complete e.g. *iikumäki* | 13,7 (10) | 10,8 (9) | 15,8 (3) |
| 3. Phoneme level not complete e.g. *iukumäki* | 17,8 (13) | 26,5 (22) | 26,3 (5) |
| 4. Target-like form e.g. *liukumäki* | 56,2 (41) | 49,4 (41) | 10,5 (2) |

## Word level

The proportion of truncated productions was 13,3 % in the at-risk and 12,3 % in the control group, and 47,4 % in the late talkers (Table 38). Nearly half the productions of the late talkers were truncated which indicates an inability to produce longer words at their stage of language development.

As in *lentokone,* bisyllabic forms were hard to interpret since the word is a compound word. However, they were taken into account in the quantitative results, since *mäki* 'hill', which was a typical bisyllabic form for this word, is not usually used alone in the context of a 'slide' in adult speech. Yet it may be that the close semantic meaning led some children to produce only the *mäki*-part of the word as in the examples below. Forms ending with /e/ may reflect the inflection of the word: *mäki:mäkeen* (Illative).

Ψɟmäkeβ                      Anna (RG)
Ψmäkeem˘maka β Ψmäke˘iuuǒi β     Maria (RG)

Altogether there were 20 (12,8 %) truncations among the 156 productions of the word. The distribution of bisyllabic and trisyllabic forms was as follows: Control children had 4 bisyllabic and 5 trisyllabic truncations and at-risk children 9 bisyllabic and 2 trisyllabic truncations.

It may be that at-risk children had a tendency to produce bisyllabic forms more often than controls. Trisyllabic forms were mainly of the type in which the unstressed second syllable was deleted, e.g. Ψumäkiβ (Leevi CB and Verneri RB), reflecting the same type of parsing as in *apsiini* for *appelsiini* and *leʂkone* for *lentokone.*

## *Phonotactics*

The second category in Table 38 includes forms which contained four syllables but lacked the diphthong. This division is parallel with the analysis of *appelsiini* (*appeiini)* and *lentokone (leetokone).* The proportion of forms in this category was 10,8 % in the at-risk and 13,7 % in the control group. In the late talkers the proportion was 15,8 %.

Compensatory lengthening was typically used to preserve the moraic length of the initial syllable, with forms prolonging /i/ being the most common type in this category, e.g. ˥hiikumäkiβ (Saku CB). Some sporadic forms included /ee/ or /uu/ as in ˥liukumäkiβ (Heikki CB), which had regressive back vowel harmony. In addition, some forms had fronting with respect to consonantal place as in ˥litumäɗti3ä β (Minna, RG). An example of an unexpected form is the few cases with a velar consonant sequence instead of diphthong, e.g. ˥ɣ̇kuäkeβ (Otso RB).

## *Phoneme level*

The forms in this category (category 4 in Table 38) included those that had four syllables and a diphthong, but had some other differences compared to adult form. Similarly to the analysis of *lentokone* all of the differences were not purely paradigmatic. Out of the at-risk group's productions 26,5 % were of this type but only 17,8 % in the control group. 26,3 % of the late talkers also had productions of this type.

A production was accepted into this category even if the diphthong was not completely target-like at the phoneme level. Some instances are presented below and feature, for example, a metathesis in the diphthong. The final example illustrates successive processing of the diphthong in production:

| | |
|---|---|
| [luitumäki] | Inkeri (RG) |
| [liekumäki] | Visa (CB) |
| [leuɪkumäki] (eu~i3u) | Sara (RG) |
| [ii- iukupakɪä ] | Severi (CB) |

In a few cases paradigmatic difference to target form was seen in the vowels instead of the consonants due to the possible vowel harmony, e.g. [liukɪmäkʰi] (Marja RG). Some forms also had the final /e/as in [liukumäke] (Tommi RB), probably due to inflection (*liukumäkeen* Illative). These forms are close to the target but it was decided to classify them in this category for the quantitative results as the child has not yet acquired the basic nominative form of the word. [liuke-mäki] (Leeni RG) with a pause between the foot indicates problems in producing a long word. However, by rhythmically pausing between the two feet the child manages to produce all syllables, the diphthong and nearly all the target phonemes.

In addition to the changes in vowels, initial consonant deletion was a typical process in this category: in 14 out of all 35 productions. Five of these had

further additional changes, e.g. deletion of other syllable onsets, as in [iukuä5ki] (Liisa CG), which was also typical for this child elsewhere. Deletion of the initial consonant was more common than substituting the /l/ by /h/, also seen in *lentokone.* There were only a few cases with /h/, e.g. [hiukumäki] by four children. In addition, there was one metathetical form [uihkumäki] (Leo RB) and one child, Birgitta (CG), substituted the initial /l/ by stop consonant /t/: [ʄiukumäkʰi] – this is probably due to the sonority hierarchy in which the less sonorant consonant is chosen. Thus the Faithfulness constraint is not violated regarding the existence of onset consonants although on a paradigmatic level the production violate manner of articulation. There were also cases with assimilatory fronting in consonants, e.g. [liuʄumäti] (Paavo RB).

***Target-like forms***

The higher number of lower level productions leaves the proportion of complete forms lower in the at-risk group (49,4 %) than in the control group (56,2 %). There were two late talkers (10,5 %) who produced a target-like form.

### 4.3.4 Productions of the word *polkupyörä*

A four syllable compound *polkupyörä* 'bike' was often produced in a more common colloquial form *pyörä.* Those bisyllabic productions were analysed separately in chapter 4.1. There was, however, a total of 69 productions which indicated that the child attempted the four syllable target rather than the bisyllabic target form of the word. Unlike in the words *lentokone* and *liukumäki,* the bisyllabic productions were not taken into account in the quantitative results or in the analysis here, due to the common bisyllabic colloquial form. However, when produced as a compound, the word is phonotactically interesting because of phonotactics: it has both a consonant sequence as well as a diphthong. Thus it is parallel to trisyllabic *aurinko* 'the sun' in which a conspiracy was seen in some productions: either a consonant sequence or diphthong was produced but not both, e.g . *aiko, aξko.*

Hypothetically the development of *polkupyörä* would start with bisyllabic forms perhaps including either one of the compound's components, e.g. *pokku* or *pöölä*, or a conflated form. One would also expect, based on the analyses of the other four syllable words, that the length of the word would cause dropping of unstressed syllables even though this would result in prosodically less ideal trisyllabic forms such as *polpöölä.* Once the four syllable stage is reached, the forms may not include all phonotactical elements, diphthong or consonant sequence, e.g. *pokkupöölä.* After this, when diphthongs and sequences emerge, a conspiracy of constraints may result in forms such as *pookupyölä* or *polkupöölä.* After the possible conspiracy is released, only constraints concerning individual segments will still affect the production, e.g. *polkupyölä.*

The productions in Table 39 below are classified into four categories similarly to previously presented analyses of four syllable words.

| | | | |
|---|---|---|---|
| *e.g. pokku* | Satisfies NotComplex(PrWd)<br>Satisfies PARSE-SYL<br>Satisfies NoSequence(Dental...Velar)<br>Satisfies *COMPLEX-NUCLEUS<br>Violates Faithfulness at word, phonotactical and phoneme level | | |
| *e.g. polpöölä* | Satisfies NotComplex(PrWd)<br>Violates PARSE-SYL<br>Satisfies NoSequence(Dental...Velar)<br>Satisfies *COMPLEX-NUCLEUS<br>Violates Faithfulness at word, phonotactical and phoneme level | | |
| *pookupyölä* | Violates NotComplex(PrWd)<br>Satisfies PARSE-SYL<br>Satisfies NoSequence(Dental...Velar)<br>Violates*COMPLEX-NUCLEUS<br>Violates Faithfulness at phonotactical and phoneme level | | |

OR

| | |
|---|---|
| *polkupöölä* | Violates NotComplex(PrWd)<br>Satisfies PARSE-SYL<br>Violates NoSequence(Dental...Velar)<br>Satisfies *COMPLEX-NUCLEUS<br>Violates Faithfulness at phonotactical and phoneme level |
| *polkupyölä* | Violates NotComplex(PrWd)<br>Satisfies PARSE-SYL<br>Violates NoSequence(Dental...Velar)<br>Violates *COMPLEX-NUCLEUS<br>Violates Faithfulness at phoneme level |
| *polkupyörä* | Violates NotComplex(PrWd)<br>Satisfies PARSE-SYL<br>Violates NoSequence(Dental...Velar)<br>Violates *COMPLEX-NUCLEUS<br>Satisfies Faithfulness at all levels |

TABLE 39 Proportions (%) of different types of production of *polkupyörä* in the at-risk group, control group and the late talkers (includes children from both at-risk and control groups).

| | *Control %<br>(N=30)* | *At-risk %<br>(N=39)* | *Late<br>Talkers %<br>N=10* |
|---|---|---|---|
| 1. Word level not complete<br>e.g. *polpyörä* | - | 7,7 (3) | 20,0 (2) |
| 2. Phonotactics not complete<br>e.g. *pookupöölä, polkupöölä,<br>pookupyölä* | 33,3 (10) | 33,3 (13) | 70,0 (7) |
| 3. Phoneme level not complete<br>e.g. *polkupyölä* | 13,3 (4) | 30,8 (12) | - |
| 4. Target-like form<br>*polkupyörä* | 53,3 (16) | 28,2 (11) | 10,0 (1) |

### *Word level*

There were only three truncated forms of this word, two bisyllabic and one trisyllabic production (Table 39). The two bisyllabic forms were included in the quantitative results here since they probably were not productions of the *pyörä* part of the compound: In Ѱɓoiɟkoβ (Kimmo RB) the child possibly produces the first part of the compound, namely *polku* which is not used alone for 'bike'. In his production, the phonotactic constraint preventing the sequence is more highly ranked than the constraint preventing diphthongs. Also [ɟpualouɓ (Ismo RB) was taken into account. It may be that the child was not able to handle the four syllable form and extracted this bisyllabic form from the target.

In addition to these forms, there was only one trisyllabic form which was similar to trisyllabic forms of the other four syllable targets (*apsiini, leᶎkone, liumäki*): Ѱɓolpyöläβ (Jenni RG). Although the quantitative data here only had this one trisyllabic form, there were trisyllabic productions outside the most advanced productions, thus it seems also to be a typical process also in this four syllable word.

### *Phonotactics*

Phonotactically the most interesting aspect is the interplay of constraints preventing both the diphthong and consonant sequence occurring simultaneously. Table 40 presents the results of a more specific analysis concerning the number of four syllable words either with no consonant sequence and diphthong or with just one of these, but not the other. In general, the proportion of these types of productions was 33,3 % in both groups, and seven out of ten late talkers produced a word with incomplete phonotactics.

TABLE 40   Proportions (N) of four syllable forms lacking both diphthong and consonant sequence and forms including one of these in the control and at-risk groups.

|  | *- no diphthong*<br>*- no cons.sequence* | *+ diphthong*<br>*- no cons.sequence* | *- no diphthong*<br>*+ cons.sequence* |
|---|---|---|---|
| Control (N= 10) | 3 | 5 | 2 |
| At-risk (N= 13) | 2 | 11 | - |
| TOTAL | 5 | 16 | 2 |

The data shows that in the case of conspiracy the children more frequently produced a form with a diphthong rather than with a consonant sequence; this was seen especially in the at-risk group's productions. Altogether there were four four syllable productions without both diphthong and sequence and one which was somewhat unclear regarding the realisation of the diphthong:

| Ѱɓokkupyyäβ | Leevi (CB) |
|---|---|
| Ѱɓookupuuaβ | Ossi (CB) |
| Ѱɓo- puukkupuulÄβ | Olivia (CG) |
| Ѱɓookkupuuaβ | Joonas (RB) |
| [pookupy-ä] (~pyö-ä) | Eetu (CB) |

These forms lack the consonant sequencer /lk/ and the diphthong /yö/. Compensatory lengthening typically replaced the unrealisation of the consonant sequence. It occurred in vowels (*pooku-*), in consonants (*pokku-*) and in some cases a child produced a trimoraic initial syllable with long quantity in both the vowel and the consonant (*pookku-*)

One would expect that the replacing form would be /öö/ e.g. *pöölä,* as seen in the analysis of colloquial bisyllabic forms of *pyörä.* However, the examples above raise another issue concerning syntagmatic constraints, namely vowel harmony. Usually Finnish words include only either back or front vowels (with the exception of /i/ and /e/ which are neutral) but in compound words vowel harmony is violated – in the target word *polkupyörä*, for example, there are back vowels in first part of the compound and front vowels in the latter part. However, some forms above (Ossi CB, Joonas RB, Olivia CG) indicate that at this phase of phonological development, the harmony constraint influences both parts of the compound. In other words, the backness of the vowels /o/ and /u/ spreads to the latter part causing the backing of front vowels /y/, /ö/ and /ä/ in the latter part of the compound.

It was typical for the children to have a diphthong instead of a sequence in their productions, as in the examples below. In *aurinko*, with more productions, there was approximately the same number of forms favouring sequences, or even slightly more.

| Four syllable forms with a diphthong | |
|---|---|
| [PookupöijÄ] | Ulpu (CG) |
| [pua- pookupyölä] (whispers) | Petri (CB) |
| ʮookupyöläβ | Iikka (RB), Topi (RB) |
| ʮookupyöräβ | Juho (RB), Sanni (RG), Pinja (RG) |
| ʮkkuʑyöläβ | Janne (CB) |
| ʮokkupyöꝺläβ | Severi (CB) |
| ʮoloʑpie2ra4β (r weak) | Tuukka (RB) |

In some cases the diphthong was produced with uncertainty, e.g. ʮokkupyᵒlääβ (Perttu RB). Additionally the processing as well as the whispering of the end of the word in Petri's production indicates the concentration on the diphthong.

The two forms with a sequence were not phonotactically clear; ʮoˡkubööläβ (Into CB) had a very short and weak /l/ and ʮolku-pyyäβ (Julius CB) had a pause between the feet. A pause between the two feet also occurred in ʮkaako-ʑyöläβ with a diphthong by Siiri (RG). It probably indicates an effortful pronunciation of a long word. In addition, an interesting deviant form included a foot-size metathesis, which occurred twice in the namings of Leeni (RG):

ʮyöhäpo(o)kuβ
[pyöhäPauku]

***Phoneme level***

The criteria for the third category was a production of both the diphthong and consonant sequence within a four syllable form. Compared to the target form, these forms had differences only at the phoneme level. The phoneme /r/ caused the phoneme level problems, thus typically the forms at this stage were of the type *polkupyölä*. The proportion of these forms was 13,3 % in the control group and 30,8 % in the at-risk group. Besides several *polkupyölä*-forms, there was some variation in phonemes, e.g. ʸpolkupöijäβ (weak l) (Heini CG).

In addition to paradigmatic, phoneme level changes, some forms could be explained by phonotactical constrains. In ʸpyö- poltupyöräβ (Paavo RB) a place constraint requires the same place of articulation in the sequence and in ʸkolkupyöräβ (weak r) (Hannu RB) the word initial labial /p/ is regressively assimilated into velar /k/.

As in forms without the sequence and diphthong, two forms had problems with vowel harmony: ʸpolkupuora4β (Pasi CB) and ʸpolkupuäräβ (weak r) (Johanna CG). These forms, as well as the assimilated form, were included in this category due to the criteria of having both the sequence and the diphthong in a four syllable form. However, vowel harmony in the first example concerns the syntagmaticity of the word and not only the individual phonemes; all the vowels in the form are back vowels but the final vowel indicates emerging frontness. The latter form has a back-front combination in the diphthong which is contrary to Finnish grammar.

Over half (53,3 %) of the productions of the control group were completely target-like whereas only 28,2 % of the productions in the at-risk group were target-like. Most of the ten productions by late talkers were phonotactically simpler four syllable forms.

### 4.3.5 Conclusion

Word analyses showed that four syllable compound words behave similarly in children's speech as do non-compounds in terms of truncations. This is due to a similar prosodic pattern – a four syllable word in Finnish consists of two trochaic foot. In truncations bisyllabic forms were rare but truncations into trisyllabic forms revealed that usually an unstressed syllable was deleted as in *appessi* or *apsiini* for *appelsiini*, *(l)eξkone* for *lentokone* and *(l)iumäki* for *liukumäki*. The deleted syllable was most often from the word initial foot. The constraint NotComplex(PrWd) may motivate the shortening of a word but in trisyllabic forms with a regular stress pattern the final syllable is left unparsed by the violation of the constraint PARSE-SYL. A solution in which the initial heavy syllable forms a foot of its own, violating the constraint *CLASH, is unexpected in Finnish, however, in such parsing the final foot of the target word would survive as such.

Similarly to trisyllabic target words, the proportions of truncations varied across words (Table 41). *Appelsiini* was more often shortened than the four syllable compound words. Perhaps a heavy unstressed syllable in the word

initial foot increases prosodic complexity and causes a higher number of syllable deletions. The heavy syllable was shortened due to Light(Unstressed) in several cases, e.g. *appeiini*.

TABLE 41   Proportion (%) of bi- and trisyllabic truncated productions of four syllable target words in the control and at-risk groups. (The target *polkupyörä* is excluded due to its common colloquial bisyllabic form).

|  | Control | At-risk |
|---|---|---|
| *Appelsiini* | 16,3 (8/49) | 20,3 (12/59) |
| *Lentokone* | 5,4 (4/74) | 19,3 (17/88) |
| *Liukumäki* | 12,3 (9/73) | 13,3 (11/83) |
| TOTAL AVERAGE | 10,7 (21/196) | 17,4 (40/230) |

The results do not support the suggestion (Räisänen 1975: 256) that four syllable words were easier than trisyllabic words for a Finnish child due to their rhythmic characteristics. In the control group the overall proportion of truncations was approximately the same as in trisyllabic target words. In the at-risk group four syllable words were truncated more often, reaching the overall proportion of 17,4 % whereas the percentage in trisyllabic words was 11,0 %.

Phonotactically an interesting phenomenon was a conspiracy between the diphthong and consonant sequence in *polkupyörä*. There was a preference for the diphthongs to survive rather than the consonant sequence, whereas in the trisyllabic word *aurinko* this kind of preference was not found, both forms occurring with equal probability. Vowel harmony spread across the components of the compound; in a few cases backness of vowels in the initial foot caused backing of vowels in the latter part of the compound, e.g. *pookkupuua*. This indicates that some children at age 2;6 may still have problems in controlling the quality of vowels in Finnish words. Regarding consonants, assimilation of consonants also took place across word boundaries in compounds; there were cases of both fronting and backing of consonants, e.g. *lentotone* or *leξkokone* for *lentokone.*

Group comparisons based on the quantitative results indicate that at-risk children had a tendency to have more forms with incomplete word structure. A smaller proportion of children in the at- risk group thus achieved fully complete, target-like forms than children in the control group. Late talkers were less advanced in all the four syllable target words. Only a few of them achieved a target-like form, with truncations being much more typical.

# 5 PHONOLOGICAL SCORING AND GROUP COMPARISONS

## 5.1 Purpose and research questions

The analysis reported in this chapter is an application of the hierarchical and constraint based approach to the word specific analyses earlier in this study. The purpose is to generalize and further quantify the naming task data in order to investigate the production of phonological elements at different levels from a normative aspect as well as to compare different groups of children statistically. Quantification of the data also enables the comparison of naming task data to other tests and measures done within the JLD-project. An additional goal is to develop methods for testing children's phonological skills.

In the word analyses a developmental aspect was seen in the analyses of word structures produced by late talkers whose selection was based on tests at the age of 2;0. In this chapter these children are studied further. In addition, a second group of late talkers from the same sample is studied retrospectively; these children were selected as late talkers at age 5;0 by another type of selection criteria.

Besides the two groups of late talkers, the production of phonological elements by the at-risk and control children is further compared. Some specific word analyses indicated that the at-risk children might be behind control children in some aspects of word structure; in several words at-risk children had lower proportions of complete target-like forms, which may indicate that they had more problems in producing complex phonotactical elements. Since the children in the JLD-project are not yet diagnosed as dyslexic or non-dyslexic, the connection of early phonology to reading skills is further studied by comparing results from the naming task data to children's success in the ALLU-subtest, a standardized Finnish test measuring reading skills at elementary level. In this analysis, whether or not children belong to control group or at-risk group was not considered. The purpose is rather to investigate the relationship between early phonological skills and later reading skills in a

general sense. If the at-risk children turn out to be less advanced in their phonology than the control children and if a connection is found between the naming task data at age 2;6 and reading test results at age 7, the results will indicate that reading difficulties may indeed manifest in early phonological production. An ultimate goal is the retrospective analysis of at-risk children 4as well as control children4 who will later be diagnosed as dyslexic.

As stated in Chapter 1, researchers mainly agree that a deficit behind dyslexia is phonological although it is suggested that syntactic factors may also play a role (Scarborough 1990; Locke et al. 1997). This study concentrates on the acquisition of phonology. A few studies on early precursors have shown that dyslexic children (or potentially dyslexic) indeed differ from controls in their phonology. Scarborough's (1990) retrospective study showed that dyslexic children were less advanced in their phonological skills at the age of 2;6, specifically in the production of consonants in spontaneous speech production. Likewise, based on spontaneous speech production at the age of 15 months Locke et al. (1997) found that so-called potentially dyslexic (PD) children's utterances included less consonant clusters. The purpose in this study is to go beyond consonant and consonant sequence analysis to whole word analysis in the Finnish and to investigate more specifically which phonological elements are more difficult for at-risk children and for those classified as poor readers in the ALLU-subtest.

In the specific word analyses the aim was to look at the structure of the children word forms from a hierarchical point of view. The phonological scoring presented in this chapter is similarly based on the hierarchical framework and thus production skills of complex elements at word, syllable, phonotactical and phoneme level are analysed. One focus of the word specific analyses was on the interplay of constraints. In the analyses in this chapter elements and their realisations are examined in isolation. However, an implicatory aspect is inherent in the analysis since the same outputs are used for investigating several phonological elements, for example, if a syllable is deleted (word level change) its phonotactical content (e.g. diphthong) is also not realised. From a developmental point of view this means that prosodical elements precede phonotactical and phoneme level elements

Based on this implicatory view, I hypothesise that in general at the age of 2;6 the prosodic elements, namely word length in syllables and syllable heaviness, will be produced correctly more often than phonotactical and phoneme level elements. Furthermore, it is hypothesised that the two late talker groups will be behind the others in the productions of all phonological elements. That is, they will have more problems in producing correct syllable number and heaviness of syllables as well as diphthongs, consonant sequences and individual phonemes. In addition, based on the word specific analyses and results from other language contexts it is hypothesised that at-risk children will be less advanced than controls in the production of some, perhaps prosodic and phonotactical, elements. I also hypothesise that the poor reader group will be less advanced in early phonological skills.

Besides a more focused phonological analysis a difference from Scarborough's (1990) as well as Locke et al.'s (1997) study is that their analysis was based on spontaneous speech production. It may be that in a naming task situation the children are more forced to produce words that they may find difficult in terms of structure, whereas in a spontaneous speech situation they may easily avoid the production of such structures.

It is to be noted here that the primary aim is to study the quality of children's word structures and not the naming process itself. However, in the present quantitative analysis production activity is also examined as it can be expected to be related to the quality of production. It may be that the naming difficulty which may possibly underlie dyslexia (Bowers and Wolf 1993), has an effect on the results even though the reaction times in naming were not studied (children were given the time they needed for naming the pictures). However, besides being slower in naming reading disordered children often demonstrate substitutions or circumlocutions for target words (e.g. German 1982; see Catts 1986: 504). This difficulty may also be shown at an early age and therefore it may affect production activity in the naming task in this study.

RESEARCH QUESTIONS

1. What proportion of children succeed in the production of word, syllable, phonotactical and phoneme level elements at the age of 2;6?

2. How do the children who were late in speech at age 2;0 differ from others at age 2;6? How do those children who were late in speech at age 5;0 differ from others at age 2;6?

3. Are the at-risk children less advanced in their phonology at age 2;6 than control children? If they are, which phonological elements are the most difficult for them?

4. Are the poor readers at age 7 less advanced in their phonology at age 2;6 than middle or good readers? If they are, which phonological elements are the most difficult for them?

## 5.2 Method

### 5.2.1 Selection of subjects

***At-risk and control group***

Description of group selection regarding dyslexia status is presented in chapter 3.
***Late talkers at age 2;0***

The definition of those who were late in talking at age 2;0 is presented in chapter 3. A total of 34 children were selected as late talkers at age 2;0. The group included both at-risk and control children. Because the number of late talkers was small compared to the size of the other group being entered into statistical analyses, an N-matched random sample of all the non-late-talkers (from both at-risk and control groups) was selected. This group was then used in subsequent analyses of the later talkers selected at age 2;0 vs. other children and will henceforth be referred to as the late talker random sample control group.

***Late talkers at age 5;0***

The selection of late talkers from the same sample at age 5;0 in the JLD-project was based on the following measures.

> Language comprehension:
>
> 1. PPVT (Peabody Picture Vocabulary Test) (Dunn & Dunn 1981)
> 2. WPPSI-R (= Wechsler Preschool and Primary Scale of Intelligence-R) Comprehension Scale (Wechsler 1989)
>
> Language production:
>
> 3. Morphology test (Lyytinen, P. 1988)
> 4. WPPSI-R Vocabulary Scale (Wechsler 1989)

Z-scores for each test were calculated based on the control group's scores, then an average outcome of these four tests was counted for all of the subjects. Late talkers were those who scored more than one standard deviation below the mean of the control group. In total, there were 30 children who were selected as late talkers. Similarly to the analysis of late talkers selected at age 2;0, an N-matched random sample of all the non-late-talkers (from both groups) was selected. This group was then used in subsequent analyses of the later talkers selected at age 5;0 vs. other children and will be referred to as the late talker random sample control group.

### *Poor, middle and good readers at age 7*

Children's reading abilities were investigated during the first class in the fall semester at age 7 by using part of the Finnish standardised ALLU-test (Lindeman 2000). The test was conducted at the very beginning of the first class, thus the children had not yet received teaching in reading. The present subtest of the ALLU measures technical reading skills, more specifically word recognition.

The task consisted of 320 words (four words/picture). The child was asked to connect the correct word of the four word choices to a picture. For example, of the words *työ* 'work', *myös* 'also', *yö* 'night', *syö* 'eat+s' the child was to choose *syö* for the corresponding picture and then draw a line between the word and the picture. The example shows that the test words differed in meaning but were alike regarding structure and length. The words got more complex towards the end of the task and a time limit of five minutes was used for carrying out the task.

Based on the results, the children were divided into poor, middle and good readers. The sum of incorrect answers was subtracted from the sum of correct answers, and the children in the poor reader group (N=38) had more errors than correct answers, children in middle group (N=36) had 14‒15 correct answers and good readers  (N=40) had more than 15 correct answers.

### 5.2.2 Scoring criteria for phonology at age 2;6

Phonological scoring was based on the same transcribed naming task database from which the word analyses were drawn (for data collection and transcription see chapter 3), and it was also based on the same hierarchical and syntagmatic perspective. The investigated phonological elements are listed below; altogether eight elements were studied from the point of view of named target words and correctness of the element:

| HIERARCHICAL LEVEL | | NUMBER OF PRODUCED ITEMS AND THEIR CORRECTNESS |
|---|---|---|
| Word level | ⇓ | 1. Four syllable words<br>2. Trisyllabic words |
| Syllable level | ⇓ | 3. Heavy unstressed syllables |
| Phonotactics | ⇓ | 4. Heterorganic consonant sequences<br>5. Homorganic consonant sequences<br>6. Diphthongs |
| Phoneme level | ⇓ | 7. Phoneme /s/<br>8. Phoneme /r/ |

In addition to these investigated elements, overall production activity was scored, based on the number of namings in the task.

First the number of namings of the target words for each investigated element was counted and secondly, the proportion of correctly produced phonological elements in these productions was analysed. In the naming task the child was to produce each word twice, first during the picture book reading, and secondly during the gluing stickers activity. In cases of extra repetitions of the target word, the correctness of the feature was looked at from the most advanced productions in order to take into account possible self-corrections. In the analysis of general naming activity however, only one production of each target word was considered from both naming rounds. Imitated productions were not considered in any analyses.

The total number of outputs varies across subjects due to several reasons. The namings which were whispered or otherwise unclear were not analysed, nor were productions other than the targeted words. For example in some cases the child may have produced a synonym or may have misinterpreted the picture. Lack of production was sometimes also caused by behavioral reasons, e.g. the child refused to name the picture, or finished only part of the naming task. It may be, that the results of some shy children may have suffered for these reasons.

Throughout the analysis the aim was to score each child's productions with the same criteria. Problematic cases, which arose through variation, were listed and scored similarly throughout the data. In the following, I will present the target words and main criteria for each feature with examples, as well as the main problematic cases and the solutions for scoring. If the production was unclear regarding the specific investigated phonological structure, it was marked as a nonrealisation of that structure, e.g. the heterorganic sequence in *ta(k)tit* for *sakset* 'scissors'.

Also the number of subjects varies in the results because some children failed to produce target words for some elements. In these cases the child is not included in the results. In the results the number of namings and the correctness of produced elements should be examined in relation to each other; the latter shows the proportion of correct features within the namings. In the statistical analysis, however, the variables were analysed separately.

***Total number of items produced in the naming task***

For scoring the total number of items produced in the naming task from both naming rounds one production of each target word was counted, which maximally results in 38 productions (19 words named twice). For controlling the effect of extra repetitions, another variable was counted in which one extra repetition was taken into account from both naming rounds. This would maximally result in four namings of each target word (a total of 76 productions). The children were, however, not encouraged to repeat target words during each naming round.

### Four syllable words

TARGETS (4 words produced twice)
*appelsiini* 'orange'
*lentokone* 'aeroplane'
*liukumäki* 'slide'
*polkupyörä* 'bike'

In this category, only the realisation of syllable number was analysed regardless of phonotactics and phonemes. Those productions that had all four syllables were coded as realisations for this element. For example the following types: *ap.pe.ii.ni, iu.ku.mä.ki, poo.ku.pyö.lä, en.to.ko.ne* and a complete target-like form *ap.pel.sii.ni.* Three of the four four syllable target words were compounds and only *appelsiini* was not. However, since the word analysis showed that similar truncation patterns occur both in noncompound and in compound words, perhaps due to similar footing structure, they were accepted as targets.

If the child produced a bisyllabic form, e.g. *ap.pe, len.to, mä.ki*, it was marked as a nonrealisation of the four syllable item. Bisyllabic *pyörä-*productions of *polkupyörä* were not taken into account for the reason that this bisyllabic form is commonly used in Finnish. Consequently, four syllable quality was not realised in trisyllabic forms such as *ap.sii.ni, leξ.ko.ne, liu.mä.ki* or *pol.pyö.rä.*

In general, synonyms were not analysed. However, in order to provide more productions of four syllable targets, some (6) synonym forms for *liukumäki* were included for the analysis of four syllable items, e.g. *las.ki.mä.ki* for *laskumäki*, because these compound synonym forms have the same latter part of the compound and a similar prosodic structure at word and syllable level.

### Trisyllabic words

TARGETS (6 words produced twice)
*porkkana* 'carrot'
*aurinko* 'the sun'
*orava* 'squirrel'
*lapio* 'shovel'
*banaani* 'banana'
*puhelin* 'telephone'

Similarly to the four syllable targets, only trisyllabicity was examined. Therefore, in addition to target-like forms, productions such as *a.pi.o, pok.ka.na, pa.na.ni, pu.he.ji, a.li.ko, o.va.ra* were scored as a realisation of all three syllables. Truncations to a bisyllabic form were coded as a nonrealisation, e.g. *la.pi, pook.ka, pa.na, pu.he, au.li, o.la.*

Thirteen cases of inflected partitive forms of *banaani*, e.g. *panania* for *banaania* were accepted, even though the number of syllables has increased due

to inflection. A few other four syllable forms e.g. *puhelimi* for *puhelin* in which the child's form reflects inflection (*puhelimeen* Illative) were not accepted.

### Heavy unstressed syllable

TARGETS (6 words produced twice)
*rattaat* 'strollers'
*avain* 'key'
*suklaa* 'chocolate'
*sakset* 'scissors'
*aurinko* 'the sun'
*appelsiini* 'orange

At syllable level I examined the realisation of heavy unstressed syllables, which the children sometimes shortened in order to achieve a light syllable in an unstressed position. For example the following types were coded as realisations of a heavy unstressed syllable *lat.taat, a.vain, suk.kaa, sak.set, tak.ket* whereas productions such as *rat.ta, ap.pe.ii.ni, suk.ka, sas.se, a.va* and *au.ri.ko* were scored as nonrealisations. In bisyllabic targets the examined syllable was the second and final syllable; in *aurinko* and in *appelsiini* the target syllable was the second one, which is similarly a latter syllable of the word-initial foot.

In the trimoraic cases, the syllable sometimes shortened to a bimoraic syllable; these were scored as realisations of a heavy unstressed syllable, e.g. *rattaa, avai.* Thus, only clearly monomoraic CV-syllables were scored as a failure to produce the heavy syllable.

Sometimes the children produced inflected forms, e.g. *suk.laa.ta* (partitive) or *a.vai.met* (nominative plural). Since the heavy syllable remains in an unstressed position these production were included in the analysis. Cases such as *a.je.met* for *avaimet* were scored as a nonrealisation because the target's second unstressed syllable was shortened. Inflected forms *sak.s.i.a* (plural partitive) were not considered because the inflected target form does not include a heavy syllable in an unstressed position.

In some cases it was difficult to define where the stress actually fell in the child's production. This was due to the nature of the naming register in which intonation rises. In addition, the child may have used stress shift as a strategy to overcome a constraint preventing unstressed heavy syllables. This could, however, be interpreted as a successful strategy to produce a target-like word structure at syllable level and such forms were thus accepted in the scoring. To summarise, stress in children's productions was not taken into account in scoring, i.e. the productions were scored purely in terms of moraic realisations of the unstressed heavy syllable in the target, regardless of the child's own stress placement. Since the purpose was to examine the child's ability to produce certain structures of the target words, forms such as *ap.sii.ni* for *appelsiini* were scored as a nonrealisation since the target syllable is deleted.

### Heterorganic consonant sequences

TARGETS (3 words produced twice)
*suklaa* 'chocolate'    (velar+dental)
*sakset* 'scissors'    (velar+dental)
*porkkana* 'carrot'    (dental+velar)

In the scoring of heterorganic consonant sequences, a sequence was accepted regardless of the exact phoneme realisation as long as the components were articulated using different features of place e.g. *polkkana* (dental+velar) for *porkkana* and *taktet* (velar-dental) for *sakset*. Cases where the consonant sequence included different phonemes, but of same articulatory place, were scored as nonrealisations, e.g. *poξkkana* (velar+velar). Special cases that include a metathesis or insertion such as *saktsia* and *tasket* for *sakset* and *sukslaata* for *suklaata* (partitive) were accepted. Productions, which were transcribed as unclear regarding the place of consonants were coded as nonrealisations, e.g. *ta(k)tit* for *sakset.*

### Homorganic consonant sequences

TARGETS (5 words produced twice)
*kenkä* 'shoe'    (velar+velar)
*juusto* 'cheese'    (dental+dental)
*aurinko* 'the sun'    (velar+velar)
*appelsiini* 'orange'    (dental+dental)
*lentokone* 'aeroplane    (dental+dental)

In homorganic consonant sequences a production was scored as a realisation of a homorganic sequence even if the sequence was produced in a different place compared to the target-sequence. These productions, however, had to include a homorganic CC-sequence, e.g. *veξkokone* (velar+velar) for *lentokone* (dental+dental).

     In some cases the target sequence was not realised due to syllable deletion; these cases were coded as nonrealisations, e.g. the sequence in *veξkone* was coded as a nonrealisation even though the production includes a homorganic sequence. It was defined that this sequence is due to syllable deletion and thus is not an attempt to produce the target sequence /nt/. Similarly, the production type *apsiini* includes a heterorganic sequence due to syllable deletion and was likewise coded as a nonrealisation of the target-sequence /ls/.

     The plural form *keξξät,* for *kengät* 'shoes' was not taken into account. Also, if the child produced only *kone* for *lentokone,* it was not considered in the scoring of the sequence (although the productions were analysed as a nonrealisation of a four syllable form).

### *Diphthongs*

TARGETS (7 words produced twice)
*pöytä* 'table'
*veitsi* 'knife'
*avain* 'key'
*aurinko* 'the sun'
*liukumäki* 'slide'
*polkupyörä* 'bike'
*hiekkalaatikko* 'sand box'

A diphthong was accepted if it was realised at the phonotactical level regardless of Faithfulness at phoneme level, e.g. *huikumäki* for *liukumäki*, *aikiko* for *aurinko*. When a child produced only the other half of the compound word, it was still included in the analysis of diphthongs, e.g. *hiekka* for *hiekkalaatikko*.

### */s/ and /r/ -phonemes*

Phonetically the acquisition of /s/ as well as /r/ seems to be a continuum (see Itkonen 1977), which caused problems for the present quantitative analysis. In transcription the variants of these phonemes were coded categorically as /s/, /r/, as another phoneme in the case of substitution or as an unclear production. Additional notes were taken on phonetically deviant phonemes (distortions), but since the purpose of scoring was to define whether the phoneme was realised in the child's output or not, more specific phonetic analyses were not needed for the present purposes. It may be that children with an emerging /s/ or /r/ may have suffered from this type of straightforward coding which was necessary for the quantitative purposes of a large dataset.

It has to be noted that this scoring does not evaluate whether the phoneme is in the child's phonological paradigm 4 for that more data would be needed from each child. Instead, it evaluates whether the child was able to produce these phonemes in the specific target words. Since the target words were the same for all children, this criterion was estimated to be valid enough for any group comparisons. In the following section, the target words for both consonants are presented with further comments on their scoring.

### */s/ -phoneme*

TARGETS (4 words produced twice)
*juusto* 'cheese'
*suklaa* 'chocolate'
*sakset* 'scissors' (/s/ analysed from both positions)
*appelsiini* 'orange'

/s/ was analysed from word-initial and word-medial positions of *sakset*. For this reason the maximum number of productions was 10 instead of 8 although actually four words were produced twice. A problematic issue arose in the scoring of target phonemes, namely the position of the phoneme in words, for example, in the form *uksaata* for *suklaata* (Partitive) word initial /s/ appears metathetically later in the word. Since the position of the phoneme, whether in word-initial or word-medial position, is not under issue here, it was decided that these productions would be accepted as a correct production of /s/.

### */r/-phoneme*

TARGETS (5 words produced twice)
*rattaat* 'strollers'
*porkkana* 'carrot'
*aurinko* 'the sun'
*orava* 'squirrel'
*(polku)pyörä* 'bike'

Phonetic variation in the production of /r/was high. Especially in cases of whispered productions it was sometimes difficult to classify the segment. The main criteria for correct /r/ was a trill and so a variety of phonetic realisations of /r/ were accepted, for example uvular /r/. Flaps were not accepted although by producing it the child is perhaps progressing towards a trilled /r/. There were, however, only ten cases of these in the scoring of /r/-targets so the low number should not have affected the results.

## 5.3 Results

### 5.3.1 General description of the phonological level of 2;6 year olds

#### *Overall number of namings*

The overall results are summarised in Table 42. On average the children produced 27,7 (72,9 %) of the 38 target words (19 targets named twice). If additional repetitions were taken into account, the mean was 29,3 and thus inclusion of extra repetitions does not remarkably increase the number of productions. As anticipated, variation in children's skills regarding production activity at this age was high. There were two children who produced all the target words twice (38), eight produced 37 and eleven 36 items. Three of the children who completed the task scored 0 in terms of productions.[43]

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[43] Productions by Kalle (RG) were characterized by the *ka*-syllable and no words existed. Besides syllables and meaningless sounds Samu (CB) had some word-like productions of which the meaning was difficult to ascertain. Aapo (CB) also made sounds but lacked

In the word level analyses as well as in other subtasks the number of namings and proportion of correct forms varied from zero to maximum values. It should be noted that the number of namings depends on the number of target words, which varies through the investigated elements. In addition, the number of realisations for each element is to be looked at in relation to the number of produced target words, although one could assume that a child who is active in his/her production is also more skilled in the qualitative production of complex structures. On average children produced 4,5 of the four syllable targets (max=8), out of which 3,8 were realised as four syllables. In percentages based on group means, the proportion of realised four syllable forms of produced target words was 84,4 %. Due to the higher number of targets, the mean of produced trisyllabic targets was 9,0, out of which 7,8 were realised as trisyllabic. As expected, at this age truncations do not often take place.

Heavy syllables were realised in most cases: on average out of 7,6 (max=12) productions 5,6 included a heavy syllable. This indicates that the moraic structure of heavy unstressed syllables is not realised as often as the overall number of syllables.

Phonotactical analysis included heter- and homorganic consonant sequences and diphthongs. It seems that heterorganic sequences were the most difficult to produce: on average out of 4,5 (max=6) namings 2,6 included a sequence in which components were articulated with different place. Out of 7,1 (max=10) named homorganic targets, 5,0 included a homorganic sequence. Diphthongs were analysed from a higher number of productions (max=14) and on average children produced 10,6 diphthong targets, out of which as many as 8,7 on average included a diphthong. This indicates that diphthongs in general are more often realised than consonant sequences. Out of the two phonemes, /r/ seems to be more difficult. In fact, /r/ was less often realised than any other phonological element in the present analysis as on average, only 2,3 productions out of 7,2 (max=10) productions included an /r/ phoneme, whereas /s/ was realised in 4,2 cases out of 6,7 (max=10).

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words. They both used signs. Due to lack of words these children scored zero points on all the phonological elements measured. In addition, Tuomo (CB) and Aaro (CB) completed a part of the test and uttered only a few words (4 and 8 namings). Taneli (RB) completed the whole task but was able to produce only 5 words; he also had a habit of repeating his own (non)words (e.g. *allo, hanni*).

TABLE 42   Overall results of phonological scoring. Mean number of namings, mean number of correctly produced phonological elements and proportion (%) of correctly realised elements based on group means.

|  | N of subjects | Mean | % correct |
|---|---|---|---|
| Number of namings (max=38) | 196 | 27,7 | (72,9) |
| Number of namings including extra repetitions (max=76) | 196 | 29,3 | |
| Namings of four syllable targets (max=8) | 193 | 4,5 | |
| Correct four syllable forms (max=8) | 193 | 3,8 | 84,4 |
| Namings of trisyllabic targets (max= 12) | 196 | 9,0 | |
| Correct trisyllabicity (max=12) | 196 | 7,8 | 86,7 |
| Namings of heavy syl. targets (max=12) | 195 | 7,6 | |
| Correct heavy unstressed syl. (max=12) | 195 | 5,7 | 75,0 |
| Namings  of heterorg. sequences (max=6) | 194 | 4,5 | |
| Correct heterorg. sequences (max=6) | 194 | 2,6 | 57,8 |
| Namings of homorg. sequences (max=10) | 195 | 7,1 | |
| Correct homorg. sequences (max=10) | 195 | 5,0 | 70,4 |
| Namings of diphthong targets (max=14) | 194 | 10,6 | |
| Correct diphthongs (max=14) | 194 | 8,7 | 82,1 |
| Namings of /s/ targets (max=10)[44] | 196 | 6,7 | |
| Correct /s/ (max 10) | 196 | 4,2 | 62,7 |
| Namings of /r/ targets (max=10) | 194 | 7,2 | |
| Correct /r/ (max=10) | 194 | 2,3 | 31,9 |

## *Normative aspects further studied*

The scorings were also examined in terms of individual children in order to shed more light on the normative aspect of phonological skills. Table 43 shows the proportion (%) of children who had the element correct in all produced target words (e.g. 2/2 or 7/7) and conversely, the proportion of children who did not have any correct realisation of the element in his/her productions of the target words (e.g. 0/2 or 0/7).

The results reveal the number of children with problems regarding each phonological element at the age of 2;6. Even though the realisation of syllable number was examined disregarding other structures, 8,8 % (17) of the children failed to produce any four syllable forms and 5,6 % (11) trisyllabic words. Conversely, approximately 60 % of the children produced the correct syllable number in all of their productions of the targeted four- and three syllable words. There were no differences in the proportion of those children who succeeded in the production of longer words but there were slightly more of

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[44]   In *sakset* /s/ was analysed from both word-initial and word-medial position. For this reason the maximum number of productions was 10 instead of 8 although actually four target words were produced twice.

those who failed to produce four syllable forms compared to the number of those who failed to produce trisyllabic forms.

Regarding syllable level, 34,9 % (68) produced all the targeted heavy unstressed syllables as heavy. The proportion is lower compared to the productions of four- and three syllable words. However, only 4,6 % (9) had no correct  heavy syllables in their productions of target words.

Surprisingly, there were less of those (24,6 %, N=48) who had all the homorganic consonant sequences correctly in his/her productions of the target words than those who produced all heterorganic sequences correctly (30,9 %, N=60). However, if one looks at the number of those children who failed to produce any hom- or heterorganic sequences correctly, the number of heterorganic sequences is clearly higher with 20,3 % (40) of those who did not produce them compared to 6,2 % (12) who did not produce any homorganic sequences.

Only 30,9 % (60) of the children had a realised diphthong in all of their productions of target words and only 1,5 % (3) had no diphthongs which, on the other hand, indicates that diphthongs are acquired relatively early. It is to be noted, that a production of diphthong was accepted even though it was not target-like on phoneme level.

Besides the hetereorganic consonant sequences, the /r/-phoneme seems to be the most difficult, based on the number of children who failed to produce it in any of his/her productions of the target words. 39,7 % (77) at this age failed to produce /r/ whereas 10,8 % (21) were able to produce it in all targets. The /s/-phoneme was correct more often as only 18,4 % (36) at this age were yet not able to produce the phoneme and 32,1 % (63) produced it in all of their productions of target words.

These results indicate that the hierarchical model of word structures illustrates the developmental path, especially in the sense that word level is acquired before phonotactics and complete phoneme production.

TABLE 43   Overall results of phonological scoring: Percentage (%) of children who produced the element correctly in all target word productions and percentage of the children who did not produce element correctly in any of the produced target words.

|  | All correct % (N=children) | None correct % (N=children) |
| --- | --- | --- |
| Four syllable forms | 60,6 (117) | 8,8 (17) |
| Trisyllabicity | 60,2 (118) | 5,1 (10) |
| Heavy syllables | 34,9 (68) | 4,6 (9) |
| Heterorg. cons. sequences | 30,9 (60) | 20,3 (40) |
| Homorg. cons. sequences | 24,6 (48) | 6,2 (12) |
| Diphthongs | 30,9 (60) | 1,5 (3) |
| /s/-phoneme | 32,1 (63) | 18,4 (36) |
| /r/-phoneme | 10,8 (21) | 39,7 (77) |

### 5.3.2 Group comparisons

In this section the groups of late talkers, at-risk and control children as well as the poor, middle and good readers will be compared according to the results of the phonological scoring at age 2;6.

In order to investigate possible group differences, independent sample t-tests were conducted. Equal variances were not assumed (*p<.05, **p<.01, ***p<.001); an alpha level of .05 was used for all statistical tests and the significance level was not adjusted according to the number of tests. Oneway Anovas were used to investigate the differences between poor, middle and good readers.

### *Comparison of late talkers selected at age 2;0 and a random sample control group*

The children who were selected as late talkers at age 2;0 were compared with a subgroup selected by a random sample of those who were not late talkers at age 2;0. As expected, late talkers were less advanced in the production of all investigated phonological elements (Table 44).

The 34 late talkers produced less target words (mean 21,7) than the 42 controls (mean 28,3). They were less advanced in prosodic elements: on average out of 3,7 namings of four syllable targets, 2,0 were realised as four syllable forms. Also, out of 7,0 namings of trisyllabic target words, only 3,8 were realised as trisyllabic. The corresponding means for control children were 4,5 namings of four syllable targets and 4,2 realisations of four syllable quality, and 9,5 named trisyllabic targets and 8,9 realisations of trisyllabicity. This means that truncation patterns are typical for late talkers at age 2;0 4 as was already seen in the specific word analyses in chapter 4. Besides overall word length in syllables, late talkers were less advanced in the production of heavy syllables.

Of all phonotactical characteristics, heterorganic sequences were the most difficult element for them: on average out of 3,4 productions of the target words only 0,9 included a heterorganic sequence. The corresponding means for controls were 4,6 namings of heterorganic consonant sequence targets and 3,3 realisations of heterorganic sequences. Also, the phoneme /r/ was rarely realised, only 0,7 out of 5,7 productions on average. Although the mean of realised /r/-phonemes was also low for control children (on average 2,7 out of 7,2 productions), the difference was still significant.

TABLE 44 Production of phonological elements in late talkers selected at age 2;0 vs. a random sample control group; means of total number of namings, number of produced target words for each element and means of correct realisations of elements.

| | Late talkers | Control group | t-value |
|---|---|---|---|
| Number of namings (max=38) | 21,7 | 28,3 | 3,28** |
| Number of namings including extra repetitions (max=76) | 23,6 | 29,5 | 2,71** |
| N of subjects included | 34 | 42 | |
| | | | |
| Namings of four syllable targets (max=8) | 3,7 | 4,5 | NS |
| Correct four syllable forms (max=8) | 2,0 | 4,2 | 5,04*** |
| N of subjects included | 32 | 42 | |
| | | | |
| Namings of trisyllabic targets (max=12) | 7,0 | 9,5 | 3,66** |
| Correct trisyllabicity (max=12) | 3,8 | 8,9 | 7,16*** |
| N | 34 | 42 | |
| | | | |
| Namings of heavy syllable targets (max=12) | 5,5 | 7,8 | 3,60** |
| Correct heavy syllables (max=12) | 2,4 | 6,5 | 6,73*** |
| N | 33 | 42 | |
| | | | |
| Namings of heterorg. sequences (max=6) | 3,4 | 4,6 | 3,24** |
| Correct heterorg. sequences (max=6) | 0,9 | 3,3 | 6,08*** |
| N | 33 | 41 | |
| | | | |
| Namings of homorg. sequences (max=10) | 5,4 | 7,2 | 3,10** |
| Correct homorg. sequences (max=10) | 2,4 | 5,7 | 5,97*** |
| N | 33 | 42 | |
| | | | |
| Namings of diphthong targets (max=14) | 8,5 | 10,9 | 2,92** |
| Correct diphthongs (max=14) | 5,2 | 9,3 | 5,13*** |
| N | 33 | 42 | |
| | | | |
| Namings of /s/ targets (max=10) | 5,0 | 6,8 | 3,01** |
| Correct /s/ (max=10) | 1,4 | 4,9 | 5,78*** |
| N | 34 | 42 | |
| | | | |
| Namings of /r/ targets (max=10) | 5,7 | 7,2 | 2,68* |
| Correct /r/ (max=10) | 0,7 | 2,7 | 3,79*** |
| N | 33 | 42 | |

## Comparison of late talkers selected at age 5;0 and a random sample control group

The selection of late talkers (N=30) at age 5;0 was achieved by measuring language production and comprehension. Again, these language measures seemed to correlate with the present study since this late talking group was also significantly less advanced than the random sample control group (N=37) at age 2;6 in the investigated elements, both in the production of target words and in the correctness of the elements. The only exception was in the realisation of the /r/-phoneme in which the difference between the groups did not reach significance. (See Table 45.)

To summarise, late talkers produced significantly less target items for each phonological element. In the overall measure of production activity, they produced on average 22,1 target words whereas the control group produced 28,7 on average. As with the late talker group selected at age 2;0, they produced less four and three syllable words and truncations were more typical than for controls. Besides word length, they also did not produce the heavy unstressed syllables in the target as often as other children: out of 6,1 produced target words an average of 3,8 included a heavy syllable, whereas for control children 7,7 target words were produced, of which 5,4 on average included a heavy syllable. Of phonotactical elements, the difference between late talkers and controls was high especially in the production of homorganic consonant sequences: out of 5,2 produced target words, 2,8 included a homorganic sequence whereas for controls 7,3 targets were produced on average and 5,3 included a homorganic sequence.

The difference in the realisation of /r/ was not significant. It seems that at age 2;6, many children have not fully acquired /r/, not even those whose language production is developing normally, or even above normal.

TABLE 45    Production of phonological elements in late talkers selected at age 5;0 vs. a random sample control group. Means of total number of namings, number of produced target words for each element and means of correct realisations of elements.

|  | Late talkers | Control group | t-value |
|---|---|---|---|
| Number of namings (max=38) | 22,1 | 28,7 | 3,34** |
| Number of namings including extra repetitions (max=76) | 23,6 | 29,9 | 2,97** |
| N of subjects included | 30 | 37 | |
| | | | |
| Namings of four syllable targets (max=8) | 3,2 | 4,9 | 3,87*** |
| Correct four syllable forms (max=8) | 2,2 | 3,9 | 3,69** |
| N of subjects included | 29 | 36 | |
| | | | |
| Namings of trisyllabic targets (max=12) | 7,8 | 9,4 | 2,13* |
| Correct trisyllabicity (max=12) | 5,9 | 8,2 | 2,48* |
| N | 30 | 37 | |
| | | | |
| Namings of heavy syllable targets (max=12) | 6,1 | 7,7 | 2,33* |
| Correct heavy syllables (max=12) | 3,8 | 5,4 | 2,15* |
| N | 29 | 37 | |
| | | | |
| Namings of heterorg. sequences (max=6) | 3,7 | 4,8 | 2,79** |
| Correct heterorg. sequences (max=6) | 1,8 | 2,9 | 2,24* |
| N | 30 | 36 | |

(continues)

TABLE 45 (continues)

| | | | |
|---|---|---|---|
| Namings of homorg. sequences (max=10) | 5,2 | 7,3 | 3,67** |
| Correct homorg.  sequences (max=10) | 2,8 | 5,3 | 4,11*** |
| N | 29 | 37 | |
| | | | |
| Namings of diphthong targets (max=14) | 8,5 | 10,8 | 2,70** |
| Correct diphthongs (max=14) | 6,0 | 9,1 | 3,64** |
| N | 29 | 37 | |
| | | | |
| Namings of /s/ targets (max=10) | 4,8 | 7,0 | 3,51** |
| Correct /s/ (max=10) | 2,4 | 4,7 | 3,37** |
| N | 30 | 37 | |
| | | | |
| Namings of /r/ targets (max=10) | 6,2 | 7,4 | 2,26* |
| Correct /r/ (max=10) | 1,7 | 2,8 | NS |
| N | 29 | 37 | |

### *Comparison of at-risk and control children*

One of the main aims for this study was to examine possible differences in the phonology of children at-risk for dyslexia (N=105) and their controls (N=91). Specific word analyses of production variation in chapter 4 showed that there might be some differences between the groups in word structures. In some words at-risk children had less complete, target-like productions than controls. The difference seemed to be in phonotactics.

The results in Table 46 show that the at-risk group and control group did not differ in this analysis. A significant difference was found only in realisation of /r/-phoneme. The results indicate that on average at-risk children produced slightly less target words (27,3) than controls (28,2), but that the difference did not reach statistical significance. The same tendency, control group's means being slightly higher but not significantly so was seen in almost all of the variables. In four syllable words, for example, at-risk children produced on average 4,4 target words of which 3,6 were four syllable in structure; correspondingly controls produced 4,6 target words of which 4,1 were four syllable in structure. On the contrary, there were basically no differences in the production of trisyllabic targets and in the realisation of trisyllabicity. In the case of heavy unstressed syllables at-risk children produced 7,4 target words on average and heavy syllables were realised in 5,4 of them. Correspondingly, in control group 7,8 target words were produced and heavy syllables were realised in 5,9 of the cases.

In phonotactics at-risk group had slightly less realisations of heterorganic consonant sequences (on average 2,5 out of 4,5 productions) than control group (2,7 out of 4,4 productions). Productions of homorganic consonant sequences did not show any differences but in diphthongs controls produced slightly more target words and realised diphthongs, but also this difference was not significant.

The only significant difference was in the correct realisation of the /r/-phoneme (t=-2.05, p<0.05). This is interesting since the group difference regarding realisation of /r/was also significant for late talkers selected at age 2;0 vs. a random sample control group but not in the comparison of late talkers selected at age 5;0 vs. a random sample control group. To analyse at-risk and control children more carefully, the late talker –group selected at age 5;0 was divided into at-risk and control late talkers.

TABLE 46   Production of phonological elements in at-risk and control groups. Means of total number of namings, number of produced target words for each element and means of correct realisations of elements .

|  | At-risk | Control | t-value |
|---|---|---|---|
| Number of namings (max=38) | 27,3 | 28,2 | NS |
| Number of namings including extra repetitions (max=76) | 28,8 | 30,0 | |
| N of subjects included | 105 | 91 | NS |
| Namings of four syllable targets (max=8) | 4,4 | 4,6 | NS |
| Correct four syllable forms (max=8) | 3,6 | 4,1 | NS |
| N of subjects included | 104 | 89 | |
| Namings of trisyllabic targets (max=12) | 9,0 | 9,1 | NS |
| Correct trisyllabicity (max=12) | 7,8 | 7,9 | NS |
| N | 105 | 91 | |
| Namings of heavy syllable targets (max=12) | 7,4 | 7,8 | NS |
| Correct heavy syllables (max=12) | 5,4 | 5,9 | NS |
| N | 104 | 91 | |
| Namings of heterorg. sequences (max=6) | 4,5 | 4,4 | NS |
| Correct heterorg. sequences (max=6) | 2,5 | 2,7 | NS |
| N | 103 | 91 | |
| Namings of homorg. sequences (max=10) | 7,0 | 7,1 | NS |
| Correct homorg.  sequences (max=10) | 4,9 | 5,0 | NS |
| N | 104 | 91 | |
| Namings of diphthong targets (max=14) | 10,4 | 10,9 | NS |
| Correct diphthongs (max=14) | 8,4 | 9,0 | NS |
| N | 104 | 90 | |
| Namings of /s/ targets (max=10) | 6,7 | 6,8 | NS |
| Correct /s/ (max=10) | 4,2 | 4,3 | NS |
| N | 105 | 91 | |
| Namings of /r/ targets (max=10) | 7,1 | 7,3 | NS |
| Correct /r/ (max=10) | 1,9 | 2,8 | -2.05* |
| N | 104 | 90 | |

### Comparison of at-risk and control late talkers selected at age 5;0

When the late talkers selected at age 5;0 were divided into at-risk and control late talkers, the number of subjects was 24 in the at-risk and only 6 in the control group. This in itself reveals that by using the present selection criteria for late talkers some at-risk children may be behind controls in their language development before school age. Due to the low number of subjects in the control late talker –group statistical analyses were not conducted.

At-risk late talkers produced on average 22,3 target words whereas control late talkers produced slightly less, namely 21,3 (Table 47). In the realisation of prosodic elements, at-risk late talkers had less correct realisations of four syllable forms, trisyllabicity and syllable heaviness. The same tendency was seen in phonotactics, with the exception of the realisation of diphthongs. In this case the control late talkers had fewer diphthongs, against the expectation that at-risk late talkers would be less advanced.

At phoneme level, control late talkers produced less /s/-targets on average (mean 4,3) than at-risk late talkers (mean 5,0) but had more correct realisations of the phoneme (mean 3,3) than at-risk late talkers (mean 2,2). There were approximately the same amount of realisations of the /r/-phoneme (at-risk 1,7, control 1,8), but controls produced less /r/-targets (mean 4,8) than at-risks (mean 6,5).

It seems, therefore, that at-risk late talkers may have more problems in prosodic as well as in some phonotactic and phoneme level elements, however, the results are based on low numbers of control subjects.

TABLE 47   Production of phonological elements in late talkers selected at age 5;0 in at-risk group vs. late talkers in control group. Means of total number of namings, number of produced target words for each element and means of correct realisations of elements.

|  | Late talkers At-risk group | Late talkers Control group |
|---|---|---|
| Number of namings (max=38) | 22,3 | 21,3 |
| Number of namings including extra repetitions (max=76) | 23,5 | 23,7 |
| N of subjects included | 24 | 6 |
| | | |
| Namings of four syllable targets (max=8) | 3,2 | 3,0 |
| Correct four syllable forms (max=8) | 2,1 | 2,5 |
| N of subjects included | 23 | 6 |
| | | |
| Namings of trisyllabic targets (max=12) | 7,9 | 7,3 |
| Correct trisyllabicity (max=12) | 5,7 | 6,8 |
| N | 24 | 6 |
| | | |
| Namings of heavy syllable targets (max=12) | 6,0 | 6,3 |
| Correct heavy syllables (max=12) | 3,6 | 4,7 |
| N | 23 | 6 |
| | | |
| Namings of heterorg. sequences (max=6) | 3,9 | 3,2 |
| Correct heterorg. sequences (max=6) | 1,6 | 2,5 |
| N | 24 | 6 |

<div align="right">(continues)</div>

TABLE 47 (continues)

| | | |
|---|---|---|
| Namings of homorg. sequences (max=10) | 5,1 | 5,3 |
| Correct homorg.  sequences (max=10) | 2,5 | 4,0 |
| N | 23 | 6 |
| | | |
| Namings of diphthong targets (max=14) | 8,7 | 7,8 |
| Correct diphthongs (max=14) | 6,3 | 5,2 |
| N | 23 | 6 |
| | | |
| Namings of /s/ targets (max=10) | 5,0 | 4,3 |
| Correct /s/ (max=10) | 2,2 | 3,3 |
| N | 24 | 6 |
| | | |
| Namings of /r/ targets (max=10) | 6,5 | 4,8 |
| Correct /r/ (max=10) | 1,7 | 1,8 |
| N | 23 | 6 |

### *Comparison of poor, middle and good readers defined at age 7*

The final reorganisation of subjects was done on the basis of the ALLU-subtest at age 7 in order to investigate the relationship between early phonological skills and reading skills. The results for overall production show that poor readers produced on average 25,0 target words, the middle group 26,5 whilst the good readers produced as many as 29,9 target words (Table 48). The difference between the groups was statistically significant.

There were also significant differences in the production of prosodic elements, good readers scoring the best in four syllable forms, trisyllabicity and syllable heaviness, both in the number of named target words and in the correct realisation of elements. For example, poor readers produced 4,1 four syllable targets, out of which 3,2 were realised as four syllable forms whereas good readers produced on average 5,5 targets out of which 4,8 were realised correctly. Even though in most cases the difference was highest between poor and good readers, the group difference was significant also between middle and good readers in the production of four syllable targets (Sheffe, $p < 0.01$) and in the correct realisation of four syllable forms (Sheffe, $p < 0.05$).

In phonotactics the group differences were significant only for diphthongs, both in the production of diphthong-targets as well as in the correct realisation of them. On the contrary, group differences did not reach statistical significance in terms of number of named targets featuring heterorganic consonat sequences, correct realisation of these sequences or the realisation of homorganic consonant sequences. The group difference was, however, significant for the number of named homorganic consonant sequence target words in which good readers produced 7,9 on average, middle group 6,7 and poor readers 6,4 target items.

The group difference was not significant for the /s/-phoneme although the good readers scored higher on average. The groups differed significantly in the production of /r/-targets but the difference in correct realisation of /r/-

phonemes was not significant. In fact, good readers had less correct /r/-phonemes than other children. As was already discussed in the comparison of at-risk and control children, this may reflect the fact that even those who are advanced in their phonological development do not yet necessarily produce the /r/-phoneme at age 2;6.

TABLE 48   Phonological production at age 2;6. Comparison of poor, middle and good readers defined at age 7.

|  | *Poor* | *Middle* | *Good* | *F-value* |
|---|---|---|---|---|
| Number of namings (max=38) | 25,0 | 26,5 | 29,9 | 4,84* |
| Number of namings including extra repetitions (max=76) | 26,4 | 27,9 | 32,2 | 6,03** |
| N of subjects included | 38 | 36 | 40 | |
| | | | | |
| Namings of four syllable targets (max=8) | 4,1 | 3,9 | 5,5 | 8,95*** |
| Correct four syllable forms (max=8) | 3,2 | 3,3 | 4,8 | 6,70** |
| N of subjects included | 37 | 36 | 39 | |
| | | | | |
| Namings of trisyllabic targets (max=12) | 8,0 | 8,6 | 9,6 | 4,01* |
| Correct trisyllabicity (max=12) | 6,5 | 7,4 | 8,6 | 4,25* |
| N | 38 | 36 | 40 | |
| | | | | |
| Namings of heavy syllable targets (max=12) | 6,6 | 7,4 | 8,4 | 5,42** |
| Correct heavy syllables (max=12) | 4,3 | 5,6 | 6,5 | 5,21** |
| N | 38 | 36 | 40 | |
| | | | | |
| Namings of heterorg. sequences (max=6) | 4,1 | 4,5 | 4,6 | NS |
| Correct heterorg. sequences (max=6) | 2,1 | 2,9 | 2,5 | NS |
| N | 38 | 34 | 40 | |
| | | | | |
| Namings of homorg. sequences (max=10) | 6,4 | 6,7 | 7,9 | 4,51* |
| Correct homorg. sequences (max=10) | 4,5 | 4,6 | 5,7 | NS |
| N | 38 | 36 | 40 | |
| | | | | |
| Namings of diphthong targets (max=14) | 9,2 | 10,4 | 11,5 | 5,71** |
| Correct diphthongs (max=14) | 7,2 | 8,7 | 9,4 | 4,25* |
| N | 38 | 36 | 40 | |
| | | | | |
| Namings of /s/ targets (max=10) | 6,1 | 6,5 | 7,4 | NS |
| Correct /s/ (max=10) | 3,5 | 4,5 | 4,8 | NS |
| N | 38 | 36 | 40 | |
| | | | | |
| Namings of /r/ targets (max=10) | 6,3 | 7,0 | 7,8 | 4,68* |
| Correct /r/ (max=10) | 2,2 | 3 | 2,0 | NS |
| N | 38 | 36 | 39 | |

## 5.4  Conclusion

The aim of the phonological scoring was to shed light on normative aspects of Finnish phonological acquisition as well as to provide statistical information concerning group comparisons. The method was an extension of the word specific analyses in which words' hierarchical structure was the core of the

analyses. First of all, the method used in this section revealed that it is indeed possible to analyse different hierarchical levels independently, although one should bear in mind that theoretically the levels are implicationally connected. Thus, for example the ability to correctly realise four syllable forms as such provides information about the child's phonological skills.

The results of the phonological scoring support the hypothesis that word structures are developed from word level to phoneme level since word level elements (three and four syllable structures) were the easiest for Finnish children at age 2;6 – based on group means over 80 % of the target words were produced correctly with those structures. Heavy unstressed syllables were produced correctly less often but still correctly produced in over 75 % of cases. Diphthongs were easy for the children at this age: over 80 % were produced. On the contrary, heterorganic consonant sequences were correctly produced less than 60 % of the time. As expected, /r/ was the most difficult element; only approximately 30 % of the productions were correct.

The normative aspect was further investigated by looking at the proportion of children who at age 2;6 produced a phonological element correctly on all occasions versus those who had no correct productions of the element. The results showed that approximately 60 % of the children produced four syllable and trisyllabic quality correctly in all of their namings of the target words. Less than 10% did not produce syllable number correctly in any of their namings of the target words. A smaller proportion of children (35 %) produced heavy unstressed syllables correctly in all of their namings of target words. Regarding phonotactical elements, 20 % of the children did not produce heterorganic consonant sequences. As expected, the percentage was lower for homorganic sequences as only 6 % of the children did not produce them. Approximately 11 % of the children produced /r/ in all their namings of the target words whereas /s/ was produced by 32 % of the children. 40 % of the children at the age of 2;6 did not produce /r/ in any of their namings of the target words.

Comparison of the late talker groups selected at ages 2;0 and 5;0 also suggests that different hierarchical levels serve as indicators of phonological skills. Linguistically less advanced children can be identified by different types of tests. The contribution of the present analysis is that it provides specific information about their phonological skills.

Contrary to expectations, children at-risk for dyslexia did not prove to be significantly weaker in phonological scoring. The only significant difference was in the realisation of phoneme /r/, which is problematic in the sense that at age 2;6 it is typical for a normally developing Finnish child to substitute or delete the phoneme. However, it might be that the phonological deficit underlying dyslexia causes the at-risk children to concentrate more on whole word structure, on prosodical as well as on phonotactical features at the expense of the phoneme level. In other words, production of individual phonemes possibly does not get as much attention as other features.

Interestingly, the results are consistent with Locke et al. (1997) who likewise did not find significant differences between so-called Potentially-

Dyslexic children and controls even though the PD-group produced less consonant clusters. As Locke et al. (1997: 81) suggested, clearer differences might emerge once we have found out who is actually dyslexic from the group.

Based on their study of at-risk and control late talkers Lyytinen P. et al. (2001) propose that a history of late talking together with a familial risk for dyslexia increases the risk for delays in language acquisition. At-risk and control late talkers were also compared in this study but statistical analyses were not conducted due to low number of subjects. The means, however, indicate that at-risk late talkers may indeed be less advanced than control late talkers at age 2;6.

Perhaps the most striking result of the group comparisons is that of the poor, middle and good readers. Retrospective analyses on the data at 2;6 revealed that the groups differed significantly in their early phonological skills, in prosodic as well as in some phonotactic variables, both in number of produced items and in number of correctly realised elements. Although the differences between the groups on heterorganic consonant sequences and on /s/ were not statistically significance not in number of produced items and neither in number of correctly realised elements, the overall results indicate a strong correlation between early reading skills and early phonology.

# 6  DISCUSSION

The basis of this study was to bring together linguistic theory, phonological acquisition and fundamental questions about early precursors of dyslexia. Because of a large amount of data, the study was able to provide information on variation in Finnish children's word productions at age 2;6 from a normative aspect as well as from children who are at risk for becoming dyslexic. All these different areas provide several aspects for future studies; this study serves as a starting point for studying the early phonology of dyslexic as well as normally-developing children, and furthermore, theoretical questions of phonological acquisition in general were also addressed.

Universal constraints drawn from Optimality Theory were used to explain children's phonological development although construction of elaborate constraint rankings was not within the scope of this study. Suggestions were made on possible constraints that might explain the linguistic phenomena in children's productions. Theoretically the core in the application of OT to child language data is in the reranking of structural constraints which require unmarked structures. Reranking of structural constraints and Faithfulness gradually changes the child's grammar from initial stages to that of the target tongue.

Constraints were used within a hierarchical model of phonological acquisition which was proposed in the present study. It was suggested that a child first learns the prosodic whole word structure, namely word length in syllables as well as heaviness of syllables and then proceeds to more specified phonotactics and phonemes. It was shown that different hierarchical levels can indeed be analysed separately and that they are useful in the investigation of children's phonological skills. Thus, this study attempts to demonstrate the importance of analysing whole word structures in investigations of child phonology.

Apart from the hierarchical perspective, whole word structure can be looked at from the point of view of syntagmaticy, which means that phonological elements are linearly connected and interact in the production process. The effect of syntagmatical interaction, i.e. the effect of the

phonological environment illustrated by constraint interaction, was seen in word-specific production types. Although general trends of production types were found, there were also word-specific production patterns; productions of *orava*, for example, included an exceptionally high number of metatheses.

It is apparent that some words are more complex than others and furthermore, that complexity of word structures affects a child's productions – in a phonologically complex word it propably takes longer for a child to proceed from word level to phoneme level whereas structurally simpler words are acquired earlier. This was seen, for example, in the proportions of truncated forms; structurally complex words were more often truncated. This result is essential from the point of view of cross-sectional data: variation does not occur only inter- and intra-individually but also word-specifically within individuals. If variation is so abundant, can any normative limits be set?

Normativity was studied by a quantification of cross-sectional data, which required generalisations in categorizing children's output. The attempt to fit highly variable data to a hierarchical model of word structure was challenging. However, despite some exceptions having to be made, the classification of forms according to hierarchical levels was fairly successful and revealed not only the variation present from word to phoneme level change but also the most common production types from the words at age 2;6. Cross-sectional naming task data from a large number of subjects enabled the quantification of patterns and contributed to provide a better overall view on the acquisition of Finnish phonology.

A limitation of this type of data is that it may not adequately contribute towards knowledge of individual phonological systems from a developmental aspect. However, it was a goal of this study to shed light on the matter by application of the data to the hierarchical model of acquisition. In other words, variation from unmarked forms to more complex and target-like structures illustrates the general developmental pathways of word structure acquisition.

Late talkers themselves were not the focus of this study, instead, productions from the children selected to the late talker groups at the ages of 2;0 and 5;0 were used to illustrate the developmental aspect. It was evident that late talkers were less advanced than other children at all levels of word structure, a result which supports the whole word analysis. Their productions were characterized, for example, by truncation patterns, which supports the proposition that acquisition of word length is essential in order for the child to proceed in phonology. Late talkers selected at age 5;0 were divided into at-risk and control children in order to preliminarily investigate the effect of late talking and dyslexia risk on early phonology.

Late talkers and other groups were compared statistically by using scores of named target items and correctly realised features in children's productions. The scoring was based on a hierarchical model of word structure, which means that the phonemic content of higher-level structures, in word length and in syllable heaviness, was not taken into account. In the same way, in phonotactical scoring it was crucial that, for example, in heterorganic consonant sequences the consonants were required only to be pronounced with different

place of articulation regardless of the manner of the phonemes. Even though the levels were scored independently they are connected by implication; if a higher-level element, e.g. a syllable, is entirely deleted, the phonotactical element within it is also lost, e.g. a diphthong.

In the scoring, contrary to expectation, the differences between children at-risk for dyslexia and their controls did not reach statistical significance except in production of the /r/-phoneme. It was hypothesised that dyslexia risk, which is probably caused by phonological deficit, manifests in phonological production at an early age especially in prosodic and phonotactical elements. The lower number of of /r/-phoneme realisations might indicate that at-risk children concentrate on other levels of word structure, e.g. the phonotactical level. In addition, in several word-specific analyses at-risk children did not achieve target-like word forms as often as control children. On the other hand, even those children who are phonologically advanced do not necessarily produce /r/ at the age of 2;6.

Interestingly, Catts (1986) has concluded that errors made by dyslexics in naming and word repetition tasks of multisyllabic words were word-specific rather than misarticulations of same sound segment(s) across words. As he proposes, the question might be about poorer analysis skills for phonological details. Multisyllabicity may increase the difficulty of perceiving and producing the exact phonological structure. Other levels of phonological complexity such as phonotactical or syllable level complexity may similarly increase the difficulty of the word.

It is important to note that not all at-risk children become dyslexics and that there may be some control children who become dyslexics. When we have found out which ones actually become dyslexics the groups will be reorganized into dyslexics and nondyslexics and then the results of scoring may reveal group differences, possibly in line with Scarborough's (1990) results, in which dyslexic children were significantly less advanced in phonological accuracy. The benefit of the forthcoming retrospective study will be that phonological skills are explored beyond the phoneme level by taking whole word acquisition into account.

Since it is not yet know who of the at-risk children will actually become dyslexic, and the connection of early phonology to later reading skills is clearly of interest, a retrospective analysis was conducted. It was based on a word recognition test carried out at the very beginning of the first year before the children had received reading teaching at school. Based on the test, the children were divided into poor, middle and good readers regardless of their familial background for dyslexia. This analysis found significant differences between the groups – poor readers scored lower in most of the investigated elements. The results confirm that it may indeed possible to grasp the connection between speech production during language development and later reading skills, although it is premature to claim that children who were classified as poor readers based on this single subtest at the onset of school will later be dyslexics.

The result, however, supports the prediction that the phonological deficit behind dyslexia possibly manifests in early phonology. How and to what extent

it is shown in Finnish is verified more specifically only in retrospective analyses after the children become older and we identify those who are dyslexic. In further studies of the early linguistic skills of dyslexic children one should also conduct qualitative analyses of children's phonological systems, in order to find out more specifically whether dyslexic phonological acquisition is only slower than that of control children or also qualitatively different. For example, those differences may be unexpected prosodic patterns in using intonation, duration and stress in words, as well as at the utterance level. The studies should also be extended to morphology and syntax, since, as proposed by several researchers (Locke 1997: 89; Scarborough 1990), the deficit behind dyslexia concerns other aspects of grammar also. This is to be expected since different components of language interact and are interwoven together. Due to quantification of the data the results of the phonological scoring can in future studies be compared to spontaneuous speech data, which in the project is transcribed and coded in CHAT-format in CHILDES (Child Language Data Exchange System) (MacWhinney 1991; see Nieminen 1999).

Based on the results of the group comparisons, it was found that in addition to the ability to produce phonological structures, overall production activity in an experimental naming task also played a role. The poor reader group as well as the late talkers produced significantly less target items than other children. The present study does not provide direct evidence about the reasons for lack of productions since those were not systematically coded; there were, however, several reasons for a missing production ranging from e.g. unclear articulation to behavioral reasons. It might be that an uncertainty about the whole word structure could cause avoidance of naming; it is noted, for example, that in naming tasks dyslexic children often demonstrate substitutions or circumlocutions of words (see Catts 1986). Perhaps in spontaneous speech production the possible phonological deficit causing the reading difficulties is not as evident as in experimental tests in which the children are compelled to use their linguistic skills in specific ways and can not as easily use avoidance strategies. Therefore, information on both spontaneous speech production as well as on experimental tasks are important and may illustrate different aspects of the deficit. In addition to production, one should investigate the perception skills of at-risk children. Richardson (1998) found significant differences in perception of quantity when the children were six months old; this possible early precursor of dyslexia may be manifested in perception also at later stages.

Only longitudinal data and retrospective analyses provide more exact information on the relationship of early language acquisition to later reading difficulties. Differences between the at-risk children and control children may, therefore, be more discrete than differences between diagnosed dyslexic children and control children as the at-risk group also includes those who will not show any reading deficits later.

To conclude, the present study has provided information on the variation of Finnish children's phonological skills. It will perhaps serve not only researchers of child language but also those working with children and their language acquisition.

**TIIVISTELMÄ**

Tutkimus käsittelee suomalaisten lasten fonologian omaksumista. Tavoitteena on luoda malli sanarakenteiden kokonaishahmon omaksumisesta, jossa sanan eri tasot on otettu huomioon. Sanatasolla tarkastellaan sanan tavumäärää, tavutasolla tavujen pituutta, fonotaksin tasolla konsonanttiyhtymiä sekä diftongeja ja foneemitasolla yksittäiden äänteiden toteutumista lasten tuotoksissa. Teoreettisena lähtökohtana on mallin implikatorisuus, jolla tarkoitetaan, että prosodiset piirteet edeltävät fonotaksin ja foneemien toteutumista lapsen tuotoksessa, esimerkiksi diftongia edeltää kaksimorainen tavu.

Tasoilla tapahtuvia prosesseja voidaan selittää universaaleilla rakennerajoituksilla, jotka pohjautuvat optimaaliteoriaan. Teorian keskeinen ajatus on rajoitusten keskinäinen kilpailu ja rikkominen. Lapsen kielen kehitystä voidaan formaalisti kuvata tunnusmerkittömiin piirteisiin johtavien rakennerajoitusten uudelleen järjestämisellä aikuisen kielioppia vastaavaksi.

Tutkimuksen toisena tavoitteena on vertailla dysleksiariski- ja kontrollilapsia mahdollisten dysleksian ennusmerkkien selvittämiseksi. Nykyisin dysleksia diagnosoidaan vasta kouluiässä lukivaikeuksien ilmaannuttua. Yleisesti dysleksian taustalla ajatellaan olevan fonologinen häiriö, joskin on myös esitetty, että ongelmia on mm. syntaktisissakin taidoissa. Tarkemmin määriteltynä fonologisen häiriön taustalla saattavat olla temporaalisen prosessoinnin ongelmat. Suomalaisista dysleksiariskilapsista tehdyt tutkimukset ovat osoittaneet, että heillä on enemmän vaikeuksia keston havaitsemisessa ja tuottamisessa kuin kontrollilapsilla. Voidaan ajatella, että mahdolliset havaitsemisen häiriöt johtavat epäselvään representaatioon, mikä puolestaan aiheuttaa vaikeuksia sanahahmon tarkassa tuottamisessa. Aiemmat tutkimukset englanninkielisistä lapsista ovat osoittaneet, että dyslektikot ovat heikompia konsonanttien tuottamisessa ennen kouluikää.

Riski- ja kontrollilasten lisäksi tutkimuksessa tarkastellaan kielenkehitykseltään viivästyneitä lapsia. Tavoitteena on selvittää, kuinka heidän tuotoksensa vastaavat sanarakenteen omaksumismallia. Varhaisen fonologian suhdetta lukutaitoon tutkitaan vertailemalla heikkoja, keskitasoisia ja hyviä lukijoita.

Dysleksiariski- ja kontrollilapset on valittu Jyväskylä Longitudinal Study of Dyslexia -projektissa tarkoilla seulontamenetelmillä. Lapsia seurataan syntymästä kouluikään, mikä mahdollistaa heidän kielitaidon vertailun eri ikäkausina. Tähän tutkimukseen osallistui 105 riskilasta (54 poikaa ja 51 tyttöä) sekä 91 kontrollilasta (51 poikaa ja 40 tyttöä). Lisäksi tarkasteltiin näistä lapsista valittuja erilaisia alaryhmiä: Kielen kehitykseltään viivästyneitä lapsia oli kaksi ryhmää: testien perusteella kahden vuoden (N=34) ja viiden vuoden (N=30) iässä viivästyneet lapset. Heikot (N=38), keskitasoiset (N=36) ja hyvät lukijat (N=40) valittiin seitsemän vuoden iässä tehdyn sanantunnistustestin perusteella.

Tutkimuksen aineisto on 2;6-vuotiaille lapsille tehdystä nimeämistestistä. Testin 19 sanaa sisälsivät erilaisia suomen kielen sanarakenteita, ja lapset

tuottivat sanat kahteen kertaan. Aineisto litteroitiin ääni- ja videonauhojen perusteella; litteraattien reliabiliteetti oli 89 %.

Yksittäisiä sanoja analysoitiin tasoittain rajoitusten **näkökul-** masta, ja lisäksi lasten kunkin sanan edistyneimmät tuotokset pyrittiin kvantifioimaan hypoteettisiin kehitysasteisiin mahdollisten riski- ja kontrolli- ryhmän erojen selvittämiseksi. Hierarkkisen mallin mukaan esimerkiksi rattaat-sanan hypoteettinen kehityskulku on *(r)atta > (r)attat > rattaat* ja porkkana-sanan *pokka > po(o)kkana > polkkana > porkkana*.

Variaatio lasten tuotoksissa oli odotetusti suuri. Sanatason muutoksia tarkasteltiin erityisesti kolmi- ja nelitavuisissa tuotoksissa. Kolmitavuisten sanojen lyhentymistä voidaan selittää pyrkimyksellä trokeiseen muotoon. Voidaan ajatella, että rajoitus, jonka mukaan jokaisen tavun täytyy sisältyä rytmiseen jalkaan (PARSE-SYL), on muutoksen taustalla, sillä kolmitavuinen muoto sisältää jalan ulkopuolisen tavun. Kaksitavuistumien määrä vaihteli sanoittain ja oli suurin aurinko-sanassa: noin 19 % kaikista tuotoksista oli lyhentyneitä. Keskimäärin riskilapsilla kaksitavuistumien osuus oli 11,0 % ja kontrollilapsilla 9,9 %.

Aiemmin on esitetty hypoteesi, että nelitavuiset sanat saattavat olla rytmisesti helpompia kuin kolmitavuiset sanat, sillä suomen kielessä ne muodostuvat kahdesta trokeisesta jalasta ja jalan ulkopuolisia tavuja ei ole. Nelitavuisten sanojen analyysi kuitenkin osoitti, että riskilapsilla nelitavuisten sanojen lyhentymistä kaksi- tai kolmitavuiseksi oli keskimäärin enemmän kuin kolmitavuisten sanojen lyhentymistä eli 17,4 %. Kontrollilapsilla nelitavuisten lyhentymisten osuus oli 10,7 %. Muutoksen taustalla saattaa olla rajoitus, jonka mukaan sanassa tulisi olla vain yksi jalka (NotComplex(PrWd)). Kolmita-vuisissa muodoissa kuten *apsiini* 'appelsiini' tai *leξkone* 'lentokone' tämä rajoitus on siten voimakkaampi kuin rajoitus, jonka mukaan tavujen täytyy sisältyä rytmiseen jalkaan.

Tavutasoa analysoitiin erityisesti kaksitavuisissa sanoissa, joissa toinen, painoton tavu on pitkä. Tyypillinen strategia välttää pitkän tavun tuottamista painottomassa asemassa oli lyhentää tavu yksimoraiseksi, esim. *(r)atta* 'rattaat' ja *ava* 'avain'. Tämän muutoksen taustalla voidaan ajatella olevan rajoitus, jonka mukaan painottomien tavujen tulisi olla lyhyitä (Light(Unstressed)). Yksimoraiseksi lyhentyneiden tavujen osuus tavoitesanojen tuotoksissa vaihteli sanoittain 10 prosentista 25 prosenttiin. Lisäksi kolmimoraisista tavuista ilmeni kaksimoraisia välimuotoja. Riskilapsilla oli jonkin verran enemmän tavun lyhentymisiä kuin kontrollilapsilla.

Fonotaksin muutoksia konsonanttien osalta voidaan selittää rajoituksilla, jotka estävät eripaikkaisten konsonanttien peräkkäisyyden tuotoksissa (NoSequence(A...B)). Esimerkiksi rajoitus, joka estää velaarisen ja dentaalisen konsonantin peräkkäisyyden, voi aiheuttaa assimilaation *(s)akke* sakset-sanassa. Artikulaatiopaikan lisäksi tämäntapaiset vierekkäisyysrajoitukset voivat estää vierekkäisten, ääntämistavaltaan erilaisten konsonanttien toteutumisen. Lapsi voi tuottaa esimerkiksi appelsiini-sanassa likvidan ja frikatiivin sijasta likvidan ja klusiilin: *appeltiini.* Samoin esimerkiksi porkkana-sanassa eripaikkainen

konsonanttiyhtymä voi toteutua (*polkkana*), vaikka yhtymän tuotokseen vaikuttaa vielä konsonanttien ääntötapaa koskeva rajoitus.

Diftongien oikenemisen syynä on mahdollisesti rajoitus, jonka mukaan tavun sonanttina on vain yksi vokaali (*COMPLEX-NUCLEUS*). Rajoitus on kuitenkin ongelmallinen, sillä diftongin oikeneminen johtaa pitkään vokaaliin, joka on tavutasolla kaksimorainen. Tyypillisiä lasten muotoja, joissa diftongi ei toteutunut, olivat esimerkiksi *pöötä* 'pöytä' ja *pöölä* 'pyörä'. Lisäksi joissakin tuotoksissa diftongi toteutui, mutta tuotos ei ollut tavoitemuodon kaltainen foneemitasolla, esimerksiksi *pöitä* 'pöytä'. Fonotaktisten rajoitusten keskinäinen vuorovaikutus näkyi esimerkiksi muodoissa, joissa toteutui joko diftongi tai konsonanttiyhtymä mutta eivät molemmat, esimerkiksi muodot *auko* ja *aʒko* aurinko-sanasta.

Foneemitasolla analysoitiin muotoja, jotka olivat prosodisesti ja fonotaktisesti valmiita. Esimerkiksi rattaat- ja porkkana-sanassa /r/-foneemin omaksumisen voidaan ajatella olevan sanarakenteen omaksumisen viimeinen vaihe; valmista muotoa edeltävät siten esimerkiksi *lattaat* ja *polkkana*, joissa /r/ on substituoitunut /l/:llä. Myös foneemitason toteutuminen vaihteli sanoittain. Foneemien toteutumiseen vaikuttivat niiden asema sanassa sekä sanan muut foneemit. /r/ toteutui sanansisäisessä asemassa useammin kuin sananalkuisessa: Pyörä-sanassa /r/:n tuotti 36,0 % riskilapsista ja 46,9 % kontrollilapsista, kun taas rattaat-sanassa /r/:n tuotti 20,3 % riskilapsista ja 31,0 % kontrollilapsista.

Sanakohtaiset analyysit osoittivat, että riskilapsilla oli usein vähemmän valmiita, tavoitteen mukaisia muotoja, mikä voi johtua sanan kokonaishahmon hallitsemisen ongelmista. Kuitenkin esimerkiksi kolmitavuisissa sanoissa kontrollilapsilla oli yhtä paljon kaksitavuistumia kuin riskilapsilla. Saattaakin olla, että mahdollinen fonologisen prosessoinnin häiriö ilmenee erityisesti fonotaksin ja foneemien tasolla. Esimerkiksi orava-sanassa metateesillisten muotojen (*ovala, ovara*) osuus oli riskiryhmässä 34,2 % ja kontrolliryhmässä 21,2 %. Vastaavasti tavoitemuodon kaltaisten tuotosten osuus oli riskiryhmässä 15,1 % ja kontrolliryhmässä 28,8 %.

Tutkimuksen poikittaisaineistosta ei voida tehdä samalla tavoin suoria johtopäätöksiä sanarakenteiden kehityksestä kuin pitkittäisaineistoista. Tämän vuoksi tutkimuksessa tarkasteltiin kielenkehitykseltään kahden vuoden iässä viivästyneiden lasten tuotoksia. He olivat odotetusti selvästi heikompia myös 2;6 vuoden iässä nimeämistestin perusteella; Heille oli tyypillistä mm. pitkien sanojen lyhentyminen, ja vain muutamat tuotokset olivat tavoitemuotojen kaltaisia. Heidän tuotoksensa tukevat tutkimuksessa sanarakenteen omaksumisesta esitettyä mallia, jonka mukaan sanarakenteet kehittyvät tunnusmerkittömistä rakenteista tunnusmerkkisiin, tavoitemuotojen kaltaisiin rakenteisiin.

Sanojen erilaiset tulokset osoittivat, että fonologisessa analyysissä on olennaista sanakohtaisuus ja erilaisten fonologisten elementtien vuorovaikutus. Analyysit osoittivat hierarkkisen mallin toimivuuden, joskin tuotosten kvantifioinnissa erilaisiin luokkiin tehtiin joitakin kompromisseja. Tulosten perusteella sanarakenteita voidaan kuitenkin analysoida tasoittain prosodisista

piirteistä yksittäisiin foneemeihin. Sanahahmot tulisikin nähdä hierarkkisina ja syntagmaattisia kokonaisuuksia, ei vain foneemien jonoina.

Sana-analyysien lisäksi lasten tuotokset pisteytettiin normatiivisuuden ja tilastollisten ryhmävertailujen selvittämiseksi. Nimettyjen tavoitesanojen kokonaismäärän lisäksi tuotoksista tutkittiin nelitavuisuutta, kolmitavuisuutta, pitkiä painottomia tavuja, eri- ja samapaikkaisia konsonanttiyhtymiä, diftongeja sekä /s/ ja /r/ -foneemeja. Samasta tavoitesanasta tarkasteltiin useamman piirteen toteutumista ja kustakin piirteestä laskettiin nimettyjen tavoitesanojen ja oikein tuotettujen piirteiden määrä. Olennaista on, että fonologisten piirteiden toteutumista tarkasteltiin toisistaan riippumattomina ilmiöinä, joskin teoreettisesti ne ovat yhteydessä toisiinsa. Esimerkiki tavumäärän toteutumista analysoitiin välittämättä tavujen pituuden, fonotaksin ja foneemien toteutumisesta tuotoksissa, jolloin mm. *appeiini* 'appelsiini' hyväksyttiin nelitavuisuuden toteutumaksi. Samoin mm. *polkkana* 'porkkana' hyväksyttiin eripaikkaisen konsonanttiyhtymän toteutumaksi riippumatta yhtymän puutteista foneemitasolla.

Pisteytyksen normatiiviset tulokset osoittivat, että 2;6 vuoden iässä nelitavuisuus toteutui noin 84 %:ssa eli keskimäärin lapset tuottivat 4,5 tavoitesanaa (max= 8), joista nelitavuisuus toteutui keskimäärin 3,8 sanassa. Kolmitavuisuus toteutui noin 87 %:ssa eli keskimäärin 9,0 tuotoksesta (max=12) kolmitavuisia oli 7,8. Pitkä painoton tavu toteutui 75 %:ssa eli keskimäärin 7,6 tuotoksesta (max=12) pitkän painottoman tavun sisälsi 5,7.

Fonotaksista eripaikkaiset konsonanttiyhtymät osoittautuivat vaikeimmiksi, sillä ne toteutuivat 58 %:ssa eli keskimäärin 4,5 tuotoksesta 2,6 sisälsi eripaikkaisen yhtymän. Samapaikkainen konsonanttiyhtymä oli piirteen helpompi, sillä se toteutui keskimäärin 70 %:ssa. Fonotaksista diftongi toteutui useimmin: 82 %:ssa eli keskimääräisestä 10,6 kohdesanan tuotoksesta (max=14) diftongin sisälsi 8,7. /s/-foneemi toteutui keskimäärin 62 %:ssa ja /r/ 32 %:ssa eli 7,2 tuotoksesta /r/ toteutui keskimäärin 2,3:ssa.

Lisäksi laskettiin niiden lasten osuus, joilla kukin piirre toteutui kaikissa piirteen tavoitesanojen tuotoksissa ja niiden, joilla piirre ei toteutunut yhdessäkään tavoitesanojen tuotoksessa. Tulokset osoittivat, että 2;6-vuoden iässä noin 60 % lapsista tuotti neli- ja kolmitavuisuuden oikein kaikissa tavoitesanojen tuotoksissaan. Vastaavasti nelitavuisia muotoja ei tuottanut ollenkaan noin 9 % ja kolmitavuisia noin 6 %. Odotetusti suurin osa lapsista hallitsee pitkien sanojen tuottamisen 2;6-vuoden iässä. Fonotaksista eripaikkaisia yhtymiä ei tuottanut 20 % lapsista, kun taas samapaikkaisia yhtymiä ei tuottanut 6 % ja diftongeja ei tuottanut ollenkaan kuin noin 2 % lapsista. Tämä osoittaa diftongien tuottamisen helppouden 2;6-vuoden iässä. Foneemeista /s/:n tuotti 32 % ja /r/:n 11 %. Odotetusti niiden lasten osuus, jotka eivät tuottaneet /s/-foneemia, oli 18 % ja niiden, jotka eivät tuottaneet /r/-foneemia, noin 40 % lapsista.

Kielenkehitykseltään viivästyneet lapset olivat merkitsevästi heikompia lähes kaikissa tutkituissa piirteissä. Erot olivat merkitseviä sekä 2-vuotiaana että 5-vuotiaana viivästyneiden ryhmiin valituilla verrattuna kontrollilapsiin. Eroja oli paitsi eri piirteiden toteutumisessa myös tuotettujen tavoitesanojen määris-

sä. Esimerkiksi nimeämistestissä tuotettujen sanojen kokonaismäärä oli 5-vuotiaana viivästyneiden ryhmään valituilla 22,1 ja heidän kontrolleillaan 28,7 (max=38). Samoin he esimerkiksi tuottivat keskimäärin 7,8 kolmitavuista tavoitesanaa, joissa kolmitavuisuus toteutui keskimäärin 5,9:ssä. Kontrolleilla oli vastaavasti keskimäärin 9,4 tuotosta, joissa kolmitavuisuus toteutui 8,2:ssa. Tulos vahvistaa, että tämäntyyppistä analyysiä voidaan käyttää lasten kielen kehityksen tason arvioimiseen.

Vastoin hypoteesia dysleksiariskilapset eivät eronneet merkitsevästi kontrollilapsista. Ryhmäero oli merkitsevä ainoastaan /r/-foneemissa. Tässä iässä /r/ kuitenkin saattaa jäädä toteutumatta niiltäkin lapsilta, jotka ovat fonologisesti edistyneitä. Saattaakin olla, että mahdollinen dysleksian ennusmerkki tuleekin esille esimerkiksi puheen havaitsemisessa tai sellaisissa eksperimentaalisissa tutkimuksissa, joissa lapsen tehtävät ovat kielellisesti vaativimpia kuin nimeämistestissä. Riski- ja kontrollilapsia tutkittiin lisäksi siten, että 5-vuotiaana viivästyneiden ryhmään valitut jaettiin dysleksiariski- ja kontrollilapsiin. Tulokset osoittivat, että riskilapset, jotka ovat kielen kehitykseltään viivästyneitä, olivat heikompia joidenkin piirteiden tuotoksissa kuin kontrollilapset, jotka ovat kielen kehitykseltään viivästyneitä. Viivästyneet riskilapset (N=23) tuottivat esimerkiksi keskimäärin 5,1 samapaikkaisten konsonanttiyhtymien tavoitesanaa ja yhtymä toteutui 2,5 tuotoksessa, kun taas viivästyneet kontrollilapset (N=6) tuottivat keskimäärin 5,3 tavoitesanaa, joista yhtymä toteutui 4,0 tuotoksessa. Tulokset ovat kuitenkin vain suuntaa-antavia pienten ryhmäkokojen vuoksi.

Tutkimuksen merkittävimpiä tuloksia on kuitenkin se, että sanantunnistustestillä 7 vuoden iässä valittujen heikkojen, keskitasoisten ja hyvien lukijoiden ryhmäerot olivat tilastollisesti merkitseviä. Heikot lukijat tuottivat vähemmän tavoitesanoja ja olivat 2;6-vuoden iässä heikompia kaikissa analysoiduissa prosodisissa piirteissä sekä joissakin fonotaktisissa piirteissä. Tuotettujen tavoitesanojen kokonaismäärä oli heikoilla lukijoilla keskimäärin 25,0 (max=38), keskitasoisilla 26,5 ja hyvillä lukijoilla 29,9. Samoin esimerkiksi nelitavuisuus toteutui siten, että heikot lukijat tuottivat keskimäärin 4,1 (max=8) tavoitesanaa, joista nelitavuisuus toteutui 3,2:ssa, ja keskitasoiset tuottivat keskimäärin 3,9 tavoitesanaa, joista nelitavuisuus toteutui 3,3:ssa. Hyvät lukija tuottivat 5,5 tavoitesanaa ja näistä tuotoksista nelitavuisia oli keskimäärin 4,8.

Se, että heikommat lukijat tuottivat vähemmän tavoitesanoja kuin hyvät lukijat, saattaa olla yhteydessä lukivaikeuksiin liitettyihin nimeämisongelmiin, mutta koska tutkimuksen ensisijainen tavoite oli selvittää tuotosten fonologista rakennetta, nimeämättä jättämisen syitä ei koodattu tarkemmin. Tutkimus kuitenkin osoittaa, että varhainen fonologia on yhteydessä lukutaidon oppimiseen ja että tämä yhteys voidaan saada esille tarkastelemalla lasten sanarakenteiden tuotoksia varsin yksinkertaisesti toteutettavissa olevasta nimeämistestiaineistosta.

Mahdolliset dysleksian varhaiset fonologiset ennusmerkit tarkentuvat vasta jatkotutkimuksissa, kun selviää, keistä riskilapsista tulee dyslektikkoja.

Tällöin voidaan retrospektiivisesti tarkastella dyslektikkojen varhaisia fonologisia taitoja. Tämän tutkimuksen avulla voidaan tarkemmin määritellä, missä suomen kielen piirteissä he mahdollisesti ovat kielen kehitykseltään heikompia 2;6-vuoden iässä kuin lapset, joilla ei ole lukivaikeuksia.

Tutkimus osoitti, että lasten tuotoksia voidaan analysoida sanarakenteen eri tasoilla ja että optimaaliteoreettinen rajoitusnäkökulma sopii muotojen formaaliin kuvaukseen. Jatkossa tulisi analysoida yksittäisten lasten fonologisia systeemejä hierarkkisen mallin mukaisesti ja keskittyä lisäksi tarkemmin mm. painotuksen omaksumiseen. Nimeämistestimenetelmästä voidaan lisäksi kehittää välineitä lasten kielitaidon tason arviointiin. Tämän tutkimuksen normatiiviset tulokset suomalaisten lasten fonologisista taidoista 2;6-vuoden iässä antanevat vertailukohtaa paitsi tutkijoille myös lasten ja heidän kielen kehityksensä parissa työskenteleville.˘

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## APPENDIX 1

List of target words

| Target | | N of children analysed |
|---|---|---|
| rattaat | 'strollers' | 117 |
| avain | 'a key' | 117 (166)[45] |
| suklaa | 'chocolate' | 143 |
| sakset | 'scissors' | 177 |
| pöytä | 'a table' | 182 |
| pyörä[46] | 'a bike' | 139 |
| porkkana | 'a carrot' | 166 |
| aurinko | 'the sun' | 167 |
| orava | 'a squirrel' | 139 |
| lapio | 'a shovel' | 176 |
| banaani | 'a banana' | 153 |
| puhelin | 'a telephone' | 170 |
| appelsiini | 'an orange' | 108 |
| lentokone | 'an aeroplane' | 162 |
| liukumäki | 'a slide' | 156 |
| polkupyörä | 'a bike' | 69 |

Additional target words analysed for phonological scoring:

| | |
|---|---|
| juusto | 'a cheese' |
| kenkä | 'a shoe' |
| veitsi | 'a knife' |
| hiekkalaatikko | 'a sand box' |

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[45] Inflected trisyllabic words were not included in quantitative analysis.

[46] Target word *pyörä* is a colloquial form of *polkupyörä*. Bisyllabic and four syllable productions were thus analysed separately.

**APPENDIX 2**


**Transcription diacrits**


|  |  | Example |
|---|---|---|
| Voiceless vowel | capital letter | [pöytÄ] |
| Voiced stop consonant | capital letter | [Pöytä] |
| Closedness of a vowel | 2 | ʋöda2vaβ |
| Openness of a vowel | 3 | ʋaai3β |
| Frontness of a vowel | 4 | [a4ppesβ |
| Backness of a vowel | 5 | [iukuä5ki] |
| Half-long | 1 | ʋuksa1taβ |
| Long | ð | [liuðumäti] |
| Primary stress | ¿ | ʋɣaiβ |
| Aspirated | ʰ | [ʈiukumäkʰi] |
| Rising intonation | ä | ʋhuhhaaä β |
| Pause | - | ʋ-ɟiiniβ |
| Unclear | brackets | ʋþu(h)iliβ |


ä refers to an open front vowel ∕D"˘
ö refers to a round mid front vowel ∕B"˘

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