Differences in phonologic and prosodic abilities in children with phonological language impairment and phonological-grammatical language impairment assessed with non-word repetition

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Abstract

Prosody can be described as the rhythmic, dynamic, and melodic aspects of language. Swedish has a relatively complex prosodic system compared to, for example, English. A large percentage of Swedish children with language impairment show prosodic problems to some extent. In the present study, non-word repetition was used to assess the phonological and prosodic abilities in children with phonological language impairment and children with phonological-grammatical language impairment. In the study, 10 children with phonological language impairment and 14 children with phonological-grammatical language impairment from 4;3 to 6;2 years of age participated. All children heard the same recorded non-words and words. The group with phonological language impairment received higher scores in all variables, compared to the group with phonological-grammatical language impairment. The results showed significant differences between the groups regarding production of vowels correct in words and production of phonemes correct in non-words as well as production of unstressed syllables in non-words and production of correct stress in non-words. Percent correctly produced vowels in words, but not in non-words, correlated significantly with grammatical ability.

Key words: Children, language impairment, non-word, phonology, prosody

Introduction

A good communicative ability is of utmost importance in a society with great demands on an ability to express oneself in speech and writing, in school as well as at work (1). Language impairment in childhood can often result in relatively large social consequences as the child’s ability to interact with other people is affected due to the fact that what the child says is hard to comprehend (2). Children with phonological impairment and children with phonological-grammatical impairment may, besides deviant phonology, grammar, semantics, and pragmatics, also show deviant prosodic ability. Prosody refers to the acoustic features pitch, length, and loudness (3), which affect the melody and the rhythm of speech (4). The Swedish language has a relatively complex prosodic system compared to English, and approximately 40% of Swedish children with language impairment have some form of prosodic difficulties (5).

The difference between children with language impairment and children with typical language development regarding non-word repetition has been described in previous research, especially for English-speaking children (6,7), as well as for Italian-speaking children (8), Spanish-speaking children (9), and Swedish-speaking children (10), and all of these studies conclude that children with language impairment perform significantly worse than children with typical language development.

In previous research on non-word repetition in children with language impairment the participants have been treated as a homogeneous group. However, it is reasonable to assume that children with varying types and severity of language impairment perform differently regarding specific features of the task. According to the consonant-vowel (CV) hypothesis (11), production of vowels is more linked to grammatical development, while production of consonants is more
related to lexical ability. Thus, children with grammatical problems may have more problems regarding production of vowels than children without grammatical problems. Since vowels also carry most of the prosodic information, this distribution might also be seen in repetition of the suprasegmental features of the words and non-words. In the present study, both children with phonological impairment (the Swedish term corresponding to the International Classification of Diseases, ICD-10, diagnosis F80.0 ‘Specific speech articulation disorder’) and children with phonological-grammatical impairment (F80.1 ‘Expressive language disorder’) are studied regarding their ability to repeat words and non-words with varied intonation and stress. The present study may generate new and increased knowledge about Swedish-speaking children’s prosodic ability. The relatively complex Swedish prosodic system makes it an interesting case to study regarding prosodic aspects. In addition, it is important to study if there is a difference in the prosodic ability between children with different kinds of language impairment.

Swedish is often referred to as a pitch accent language (3). There are contrasts of vowel quantity, word stress, i.e. initial versus non-initial stress, as well as of tonal word accents. In Swedish, there are a few hundred minimal pairs distinguished by tonal word accent alone (12), e.g. /tömten/–/tömtén/ (‘the garden’–‘Santa Claus’). The difference between the tonal word accents is mainly an intonational difference. Accent I patterns of standard Swedish are produced with one pitch peak, although the word has two syllables, whereas accent II pattern is produced with two pitch peaks in the word. However, the choice of word accent is largely predictable from the morphological structure of the word. Words with monosyllabic stems take accent I, and words with disyllabic stems accent II. Rather, they are phonological properties of individual word forms. The word accent distinction is also maintained in non-focal position (4).

Word stress is used in different ways in the languages of the world. Many languages have so-called fixed word stress, e.g. Finnish and Turkish. Swedish uses word stress distinctively in a less predictive way similar to e.g. Russian. In Swedish, a number of minimal pairs can be found where the placement of stress is distinctive e.g. /trumpet/–/trumpēt/ (‘sullenly’–‘trumpet’). However, the placement of stress is not the only difference between these words since the quality of both consonants and vowels is affected by stress (3,4). Stress is also, to some extent, signaled by intonational differences. At phrase level, prosody interacts with syntax and the choice of prosody affects the content in the phrase ‘She washed and dressed the child’ (13).

Irrespective of language, children seem to acquire the ability to use prosodic contrasts at the age of about 18 months (14). At the age of four, children have enough motoric skills to produce adult-like sequences of strong–weak stress (15). Adult-like prosody is fully mastered first at five years of age. Swedish-speaking children with typical language development have, besides some difficulties with tonal word accent, no problems with prosody by the age of four (5).

Swedish-speaking preschool children with typical development often omit unstressed syllables, especially in pretonic positions (16). This is in accordance with the metrical hypothesis suggested by Gerken (17) in a study of English-speaking children with typical language development. In the study, Gerken studied children at the age of 23 months to 30 months and their ability to express articles when repeating phrases, and in spontaneous speech. The result showed that the children more often omitted the article belonging to the subject compared to when it belonged to the object of the phrase. The children omitted more articles belonging to the object when the article was in a combination of weak–strong syllable than in the combination strong–weak syllable (17).

Children with language impairment may have difficulties with grammar, phonology, semantics, and/or pragmatics. The more severe language impairment, the more linguistic domains are affected (2). The prevalence of language impairment in children is about 7%, and it is more frequent in boys than in girls (18). For many of the children, the linguistic problems remain in adulthood (18).

Shriberg and Kwiatkowski (19) suggest that children’s speech should be analyzed from three aspects: according to natural phonological processes, regarding segmental features, and regarding suprasegmental features. The results of a study of children’s spontaneous speech showed that the percentage correctly produced consonants (PCC) is a valid index in order to grade the severity of the phonological disorder (20). Phonological difficulties in Swedish-speaking children with language impairment are manifested in, for example, syntagmatic processes, such as omission of unstressed syllables and assimilations, and in paradigmatic processes, such as fronting, backing, and devoicing (21,22). However, prosodic problems may also be demonstrated at the phrase level, and in a study by Hansson et al. (23) it was found that Swedish-speaking children with language impairment more often omit the indefinite article than language-matched and age-matched children. This indicates that omissions of grammatical morphemes are related to difficulties with prosody (23).
In the late 1990s, Sahlén et al. (10) studied how prosody affected children with specific language impairment, regarding their ability to repeat words and non-words. The authors found that the children omitted pre-stressed syllables six times more often than post-stressed syllables (10). Samuelsson and Löfqvist (24) studied Swedish-speaking children regarding their ability to express tonal word accents. Their results demonstrated that 60.8% of the children with language impairment participating in the study had problems with production of the contrast of tonal word accents (24).

The link between prosodic and linguistic abilities was studied by Marshall et al. (13). Children between 10 and 14 years of age, with language impairment, participated in the study, and they were shown to have good skills in repeating prosodic features. However, the children with language impairment had problems in using prosody as a means to enhance linguistic features, such as phrase boundary signals, when prosody interacted with syntax (13). The demonstrated link between grammatical acquisition and prosody may also be considered supportive of the CV hypothesis, where vowels, as carriers of prosodic information, are argued to be related to acquisition of syntax (25). In experiments involving adult participants it has been demonstrated that prosodic cues provide a strong basis for learning grammatical structures (26).

Scholars have studied possible influences of the speech motor activity for English-speaking children to, seemingly, prefer so-called trochaic patterns, consisting of stressed syllable–unstressed syllable. Goffman (15) found that children with specific language impairment had a less matured segmental and oral motor system when it came to speech production, which resulted in over-using the trochaic pattern (15).

Another theory that has prosodic implications is the CV hypothesis, proposed by Nespor and colleagues (11), which posits that consonants and vowels do different jobs in language development. According to this hypothesis, there is a division of labor between vowels and consonants so that the main role of consonants concerns the lexicon, while the main role of vowels concerns the identification of rhythmical patterns important for syntactic structure (11). The role of consonants in the CV hypothesis originates from the observation that, across languages, consonants allow more quality distinctions than vowels (25). It is also claimed that because consonants are more numerous than vowels in most languages, they are relatively more informative for lexical distinctions. However, Swedish constitutes an exception since it contains an equal number of consonants and vowels: 18 consonants and 18 vowels (27, pp. 12, 20).

An influential theory regarding the origins of language impairment regards the role of the working memory. The ability to retain information in the memory for a short period of time is developed substantially during childhood, and it is trebled during the period from preschool age until puberty (28). The substantial development of this ability of phonological storing that progresses during childhood seems to be a result of many processes that are developed in parallel, e.g. ability to store units, organize/structure information, recall and recreate memory spans (28).

During the 1970s, Baddeley and Hitch divided working memory into three subsystems; the so-called phonological loop, the visuo-spatial sketchpad, and a central executive function. The phonological loop is a temporary storage system for verbal auditory stimuli that is needed in order quickly to recall, for example, a series of numbers or of phonemes/non-words. The visuo-spatial sketchpad stores and processes visual stimuli, and the executive function is responsible for attention (29,30). During the late 1990s, Baddeley suggested that the working memory consisted of yet a fourth system, the episodic buffer, that connects the information from different sources to integrated units (31).

When studying the working memory for series of one-syllable words, Baddeley found that words containing the same vowel were harder to repeat than words that did not resemble each other phonologically (32). Also, the length of the words affects the ability to memorize them. In a study where words with different length were investigated, it was found that the ability to remember series consisting of five words dropped from 90% for one-syllable words to about 50% for five-syllable words (33). The problem with repeating new words is due to overload of the memory, which results in the less prominent features of the word not being stored and therefore being omitted (34).

Children with language impairment also have difficulties in repeating series of numbers and repeating non-words (35). Gathercole (28) found a strong link between the phonological short-term memory and the ability to learn new words (28), and there is a strong correlation between children’s abilities to repeat non-words and lexicon (35). The complex working memory, developed during childhood, has been credited with the ability to process what is to be remembered and, in older children, enhanced concentration (28).

The ability to repeat unknown phonological units is one of the most important linguistic abilities, and it is closely related to word acquisition (36). Non-word repetition is claimed to predict how young children develop their lexicon and their grammar.
(37,38). Botting and Conti-Ramsden (39) found that tests of phonological memory can be used to predict test performance in different language domains (39). Several studies of non-word repetition and real word repetition as predictors of grammatical ability in children with typical language development and children with specific language impairment (SLI) show differences between the groups (35,39–43). Dispaldro and colleagues (8) found repetition tasks a suitable method to assess the linguistic abilities in very young children (8). Dispaldro and colleagues (40,41) also found that real word repetition and non-word repetition showed good sensitivity and specificity in distinguishing between children with typical language development and children with SLI (41), and that non-word repetition is a robust tool for studying specific language impairment in different languages (40). These findings match the results of a study by Girbau and Schwartz (9) that showed that Spanish-speaking children with SLI performed more poorly than children with typical language development (9). A cross-linguistic study by Dispaldro and colleagues (44) showed that non-word repetition is a significant predictor of grammatical ability in both Italian-speaking children and English-speaking children. They also found that real word repetition had a higher predictive value than non-word repetition in Italian, but not in English. The authors concluded that the best choice of task, real word repetition or non-word repetition, could depend on the specific language spoken by the child (44). In a study by Gallon and colleagues (45), the results showed that the scores for children with grammatical SLI decreased as prosodic complexity increased. The authors state that the results indicate that ‘complexity deficits in morphology and syntax can extend to prosodic phonology’ (45, p. 435). Munson and colleagues (46) studied relationships between non-word repetition and other measures of linguistic development in children with phonological disorders. The results showed that the size of frequency effect was independent of measures of the children’s speech perception and their articulatory ability (46).

Gathercole found that English-speaking children had fewer problems with repeating non-words with a structure similar to English phonotactics compared to non-words with a structure unfamiliar to English phonotactics (47). In accordance with Gathercole (47), Dollaghan and co-workers found that non-words with stress similar to real words were repeated more correctly compared to words with stress not found in the children’s language (48).

Sahlén and colleagues (10) studied phonological and grammatical abilities in Swedish-speaking children with language impairment, assessed with repetition of non-words and words. Both non-words and real words were matched regarding stress patterns. The results showed that words were significantly easier to repeat compared to non-words, and that the children’s ability to repeat non-words correlated significantly with their phonological and grammatical development (10).

Gathercole and Baddeley found that children’s ability to repeat non-words was affected if the non-words contained consonant clusters (35). Non-words containing consonant clusters were harder to repeat, and the effect was noted both in children with typical language development and in children with language impairment (35). Roy and Chiat found that the length of the unit to be repeated had a significant effect on children’s ability to repeat (42). Units containing three syllables were significantly harder to repeat than units of two syllables. They also found that the prosodic structure affected the ability to repeat words containing several syllables. The majority of the syllables that were omitted were non-stressed (42). During recent years, an increasing body of research has accumulated on how prosody affects repetition. Archibald and colleagues found that prosodic information affected the ability to repeat multi-syllable units (49).

In a prosodically controlled word and non-word repetition task for two- to four-year-olds, Roy and Chiat (42) found that rate of syllable loss depended on the prosodic structure of the item and that the relative vulnerability of different prosodic positions did not change with age (42). When using the Preschool Repetition Test for evaluation of children with typical language development and clinically referred children, they found differences in the results according to age, item length, and prosodic structure (43). The study showed that prosodic structure had a significant impact on the rate of loss and that unstressed syllables were more vulnerable than stressed ones. Some children in the clinically referred group lost syllables carrying stress and syllables occurring in post-stress position in two-syllable items (43). When Chiat and Roy (38) studied early predictors of language and social communication impairment at ages 9–11 years in a follow-up study of early-referred children, they found that the result of the Preschool Repetition Test (PSRep) at the age 2;5–3;5 years at group level was a weak predictor of morphosyntax at the age of 9–11 years of age. However, at the case level the authors found that most of the children with poor non-word repetition and morphosyntax at the age of 9–11 years had very low scores at the age of 2;5–3;5 years (38).

Dollaghan and Campbell (6) found that non-word repetition is a valid tool for predicting the linguistic level and to distinguish between children
with language impairment and children with typical language development. The authors stressed the importance of standardization of the non-words regarding speech rate, articulation, and intonation, and the need to develop tasks that are diagnostically meaningful for children from different ethnic, socio-economic, and educational backgrounds (6).

In a recent study by Sundström, Samuelsson, and Lyxell, segmental and prosodic aspects of word and non-word repetition in typically developing Swedish-speaking children aged 4 to 6 years were investigated (50). The results demonstrated that repetition accuracy increased between four and six years from 70% to 77% regarding percentage consonants correct in non-words, and from 86% to 90% regarding percentage vowels correct. For real words the repetition accuracy increased from 86% to 91% regarding percentage consonants correct, and from 92% to 95% for percentage vowels correct. It was also demonstrated that tonal word accents I and II provided different conditions for segment repetition in favor of accent II in word and non-word repetition for older children, but only in word repetition for younger children (50). These results suggest that detailed analysis of the error patterns in word and non-word repetition might be used as a diagnostic instrument, also with emphasis on prosodic features of the non-words. Thus, in the present study, we proceed to the clinical groups of children with phonological problems and children with grammatical problems, in order to investigate if word and non-word repetition tasks with detailed segmental and suprasegmental analysis may have an impact on differentiation between these groups. It is also important to gain results from languages other than English: new in research is a systematic examination of Swedish-speaking children regarding their ability to repeat non-words with one to five syllables, with stress in every possible position and with both accent I and accent II. If systematic differences regarding prosodic ability in children with phonological problems and children with grammatical problems are revealed, the results may contribute to designing individually aimed interventions, also concerning prosody.

**Aim**

The aim of the present study was to describe how children with phonological problems and children with grammatical problems in addition to phonological problems produce words and non-words with varied syllable structure, stress, and tonal word accents. The diagnostic label phonological language impairment is the Swedish term corresponding to ‘Specific speech articulation disorder’ (F80.0) according to the International Classification of Diseases (ICD-10), and phonological-grammatical language impairment corresponds to the ICD-10 diagnosis ‘Expressive language disorder’ (F80.1), i.e. grammatical disorder.

Specific questions were:

- Does the ability to repeat segmental and suprasegmental features of words and non-words differ between children with phonological language impairment and children with phonological-grammatical language impairment?
- How may differences in segmental and suprasegmental ability between children with phonological language impairment and children with phonological-grammatical language impairment be described?
- How is repetition of segmental features in non-words affected by suprasegmental features such as number of syllables, stress, and/or tonal word accents?

**Method**

**Participants**

Ten children from 4;4 to 6;2 years of age diagnosed with phonological language impairment and 14 children from 4;3 to 5;8 years of age diagnosed with phonological-grammatical language impairment according to Swedish clinical practice participated in the study (Table I). All participating children had normal hearing. The two groups of children were matched on group level regarding age and dialect. Exclusionary criteria were multilingualism and severe language comprehension deficits that affected the child’s ability to follow instructions. Based on reports from parents and clinicians, there was no record of global development delay or neurological dysfunction. One of the children took part in the non-word repetition task but did not want to take part in the word repetition task. This child was excluded from the study.

| Table I. Number of participating children with phonological language impairment and children with phonological-grammatical language impairment, presented as mean value ± standard deviation (SD) for age, the number (n) of participating children, and gender per group. |
| --- |
| Children with phonological impairment | Children with phonological-grammatical impairment |
| 4;8 ± 0;7 | 4;5 ± 0;5 |
| n = 10 | n = 14 |
| 2 female/ 8 male | 7 female/7 male |
Pretesting

Pretesting included tests of language comprehension, grammatical production, and phonology. Language comprehension was measured with the Swedish Test of Language Comprehension (51). This test includes items that deal with grammatical forms such as different tense forms of verbs, pronouns, prepositions, conjunctions, and negation. Grammatical production was tested with the grammar section of the Lund test for phonology and grammar (52). Tasks addressing plural forms, genitives, prepositions, negation, and verb tense were selected (tasks 27–66). Phonology was tested with the Swedish phonology test (53). This test covers all Swedish phonemes in all possible positions, the two tonal word accents, and different stress patterns.

Procedure

The children’s regular clinicians, all experienced SLPs, conducted the testing, which took about 6–10 minutes of their treatment session. Prior to the testing, the children received identical instructions, i.e. that they were to hear some pretend or real words that did not mean anything that they were asked to repeat. All children repeated a list of 25 recorded non-words and, after that, a list of 25 recorded real words.

Material

The children heard the recorded non-words and real words in headphones, and the children’s utterances were recorded with Olympus LS-11 Digital Portastudio. The tests of non-words had the same phonemes as standard Swedish and were constructed according to Swedish phonotactics. The non-words and the real words had the same number of one- to five-syllable words, presented randomly with respect to the number of syllables in the word. The words and non-words were also matched regarding accent I and accent II. The non-words and the words also had varied phonological complexity, matched in the lists (see Appendix to be found at online http://informahealthcare.com/doi/abs/10.3109/14015439.2014.982171 for the lists and a description of the features of the words and non-words).

Analysis

The recorded material was transcribed and analyzed by the authors regarding segmental variables such as percent correctly produced consonants in non-words (PCCnon-words) and in real words (PCCwords), percent correctly produced vowels in non-words (PVCnon-words) and in real words (PVCwords), as well as percent correctly produced phonemes in non-words (PPCnon-word) and in real words (PPCwords). In the present study, a strict calculation was conducted, i.e. extra sounds or syllables were considered incorrect phonemes, consonants, vowels, or syllables and therefore affected the calculations of PPC, PCC, and PVC (15). Similar analysis was made of suprasegmental variables such as percent correctly produced accents in non-words (AccCnon-words) and in real words (AccCwords), percent correctly produced stress in non-words (SCnon-words) and in real words (SCwords), number of omitted syllables in non-stressed position in non-words (OSyllNPnon-words) and in real words (OSyllNPwords), number of omitted syllables in stressed position in non-words (OSyllISNon-words) and in real words (OSyllISPwords), as well as total number of correct syllables in non-words (TSyllCnon-words) and in real words (TSyllCwords). In order to assess inter-judge reliability, an experienced speech and language pathologist (SLP) transcribed all material from five randomly chosen children.

Reliability

Inter-judge reliability was calculated with Cronbach’s alpha and was 0.99 for non-words and 0.95 for words.

Results

Statistics

For statistical processing of the results, Statistical Package for the Social Sciences® (SPSS) was used. In order to examine possible differences between the variables in the study, t test was used. To examine differences in results between the group of children with phonological language impairment and children with phonological-grammatical language impairment a Mann–Whitney U test was used, with significance level \( P<0.05 \). Inter-judge reliability was calculated with Cronbach’s alpha on 21% of the material. Calculation of correlations between grammatical ability and segmental measurements was performed with Spearman’s rho. Due to restricted range and variance of some of the data, calculations were performed on arcsine square-root-transformed values.

In general, the results demonstrate that all children had rather prominent problems with the segmental features in both repetition tasks, but that children with phonological language impairment performed better on words than non-words, except...
for percentage of correct vowels, where the children with phonological-grammatical language impairment performed better in non-words than in words.

The results regarding segmental variables showed that both groups had most problems with repeating consonants in non-words (PCCnon-word), followed by consonants in words (PCCword). There were significant differences between the groups regarding number of correct vowels in words ($P = 0.01$) (Table II). The children with phonological language impairment scored significantly better on vowels in words than the children with phonological-grammatical language impairment. The groups also differed regarding which segmental variables they proved to have the least problem repeating. The children with phonological language impairment performed best on repetition of vowels in words (PVCwords), followed by vowels in non-words (PVCnon-words). Children with phonological-grammatical language impairment performed best on repetition of vowels in non-words (PVCnon-words) followed by vowels in words (PVCwords) (Table II). The difference between the groups regarding PVC in words is also visible in Figure 1. For all children grouped together, PVC in words, but not in non-words, correlated significantly with grammatical ability, as measured by the grammatical subtest of the Lund test for phonology and grammar ($r = 0.60, P = 0.003$; for the distribution of results see Figure 1). For the group as a whole, PCC did not correlate with grammatical ability, either in words ($r = 0.25, P = 0.26$) or in non-words ($r = 0.25, P = 0.24$).

Regarding suprasegmental variables, both groups performed near ceiling, except for number of syllables. For most of the suprasegmental variables they also performed better on non-words than on words. Furthermore, the results showed significant differences between the groups regarding number of syllables in words ($P = 0.04$), non-stressed syllables in non-words (OSYllNPnon-words) ($P = 0.05$), and in producing correct stress in non-words (SCnon-words) ($P = 0.05$) (Table III). Similar results were not found for word repetition. The results also showed a relatively large difference between the groups for TSyllCnon-words; however, this was not statistically significant. In the present study, no difference on a group level was shown for number of accents correct, either in non-word repetition or in word repetition. Comparing the variables percent accents correct (AccC), percent stress correct (SC), and percent non-word and words with correct number of syllables (TSyllC), children with phonological language impairment received the highest means for SCnon-words ($m = 0.99$), followed by AccCwords ($m = 0.98$) and SCwords ($m = 0.98$). The lowest scores for this group were received for TSyllCwords ($m = 0.86$). Children with phonological-grammatical language impairment received the highest scores for Accnon-words ($m = 0.96$) followed by SCnon-words ($m = 0.92$) and AccCwords ($m = 0.91$). This group received the low-

### Table II. Results concerning segmental variables for the group of children with phonological language impairment and the group of children with phonological-grammatical language impairment, presented as mean value (SD) per variable, $P$ value from comparison by Mann–Whitney $U$ test, number ($n$) of children, and gender per group.

| Segmental variable | Children with phonological language impairment ($n = 10$; 2 female/8 male) | Children with phonological-grammatical language impairment ($n = 14$; 7 female/7 male) | Comparison of groups by Mann–Whitney $U$ test |
|--------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------|
| PCCnon-words       | 50 (8)                                                                   | 46 (9)                                                                           | 0.69                                           |
| PCCwords           | 60 (10)                                                                  | 54 (18)                                                                         | 0.49                                           |
| PVCnon-words       | 77 (5)                                                                   | 72 (7)                                                                           | 0.15                                           |
| PVCwords           | 87 (5)                                                                   | 64 (30)                                                                          | 0.01                                           |

PCCnon-words = percent correct consonants in non-words; PCCwords = percent correct consonants in words; PVCnon-words = percent correct vowels in non-words; PVCword = percent correct vowels in words.

![Figure 1. Scatterplot showing the results for the two groups regarding grammatical ability (as measured by the Lund test) and PVC in words.](image-url)
the two groups of children with language impairment, pronounced; PVC in words was 87% and 64% for typically developing children) (50). The patterns of non-words (PCC 50% and 46% compared to 70% typically developing children of the same age) and words (PCC 60% and 54% compared to 88% for children with typical language development) have been reported to be younger than 4;0 (8–10, 35, 40, 41, 44, 45), but the difference between type of impairment, as shown in the present study, has not been reported before. The fact that children with phonological-grammatical language impairment have problems with non-word repetition (8–10, 35, 40, 41, 44, 45), but the difference between type of impairment, as shown in the present study, has not been reported before. However, Sahlén and colleagues (10) found significant correlations between non-word repetition and phonological and grammatical skills, but no analysis of different features of the non-words affecting different linguistic aspects was included in that study. The fact that children with phonological language impairment performed best in repeating vowels, despite type of words, indicates a certain consistency regarding their phonological ability, which children with phonological-grammatical language impairment did not show.

In the present study, the division of vowels and consonants in the analysis seems to be important.

Discussion
The results of the present study demonstrate that there are differences between children with phonological language impairment (F80.0) and children with phonological-grammatical language impairment (F80.1) regarding their ability to repeat words and non-words; in general, the children with phonological impairment performed better regarding both words and non-words. In comparison to the results of a younger group of typically developing children (50), both groups performed less accurately regarding correct production of segmental features in repetition of words (PCC 60% and 54% compared to 88% for typically developing children of the same age) and non-words (PCC 50% and 46% compared to 70% for typically developing children) (50). The patterns of difference were also present for vowels, but less pronounced; PVC in words was 87% and 64% for the two groups of children with language impairment, respectively, compared to 92% for children with typical language development, and PVC in non-words was 77% and 72% for children with language impairment compared to 86% for children with typical language development. Given the fact that the children with language impairment perform worse than children with typical language development even when the comparisons are made with a group of children that are younger (4;0–4;9 years) than the children in the present study (4;4–6;2), it is clear that the children with language impairment perform below average regarding both PCC and PVC in both words and non-words. In general, the results demonstrate that all children had rather prominent problems with the segmental features in both repetition tasks, but that children with phonological language impairment performed better on words than non-words, except for number of correct vowels, where the children with phonological-grammatical language impairment performed better in non-words than in words. Previous research has shown that children with language impairment have problems with non-word repetition (8–10, 35, 40, 41, 44, 45), but the difference between type of impairment, as shown in the present study, has not been reported before. However, Sahlén and colleagues (10) found significant correlations between non-word repetition and phonological and grammatical skills, but no analysis of different features of the non-words affecting different linguistic aspects was included in that study. The fact that children with phonological language impairment performed best in repeating vowels, despite type of words, indicates a certain consistency regarding their phonological ability, which children with phonological-grammatical language impairment did not show.

In the present study, the division of vowels and consonants in the analysis seems to be important.

Table III. Results concerning suprasegmental variables for the group of children with phonological language impairment and the group of children with phonological-grammatical language impairment, presented as mean value (SD) per variable, P value from comparison by Mann-Whitney U test, number (n) of children, and gender per group.

| Suprasegmental variable | Children with phonological language impairment (n = 10; 2 female/8 male) | Children with phonological-grammatical language impairment (n = 14; 7 female/7 male) | Comparison of groups by Mann-Whitney U test |
|-------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------|
| AccCnon-words           | 96 (35)                                         | 95 (04)                                         | 0.11                                      |
| AccCwords               | 98 (02)                                         | 91 (26)                                         | 0.61                                      |
| SCnon-words             | 99 (02)                                         | 92 (07)                                         | 0.04                                      |
| SCwords                 | 98 (02)                                         | 89 (26)                                         | 0.19                                      |
| TSyllCnon-words         | 88 (06)                                         | 80 (11)                                         | 0.14                                      |
| TSyllCwords             | 86 (12)                                         | 72 (25)                                         | 0.04                                      |
| OSyllINPnon-words       | 3.60 (1.90)                                     | 6.50 (4.07)                                     | 0.04                                      |
| OSyllINPwords           | 3.60 (1.26)                                     | 6.07 (4.87)                                     | 0.20                                      |

AccCnon-words = percent correct accents in non-words; AccCwords = percent correct accents in words; SCnon-words = percent correct stress in non-words; SCwords = percent correct stress in words; TSyllCnon-words = percent non-words with total amount of syllables correct; TSyllCwords = percent words with total amount of syllables correct; OSyllINPnon-words = number of omitted syllables in non-stressed position in non-words; OSyllINPwords = number of omitted syllables in non-stressed position in words.
Although all participating children performed better regarding vowels than consonants, a significant difference was demonstrated regarding the ability to repeat vowels in words, so that children with grammatical problems in addition to their phonological disorder performed worse. This finding fits nicely with the CV hypothesis, which posits that vowels are linked to grammatical acquisition (11). It is reasonable to argue that the specific problems with repeating vowels are linked to the grammatical problems seen in these children, especially since correct repetition of vowels in words correlated significantly with grammatical ability. This argument gets further support by the fact that the children with phonological impairment performed significantly better on consonants in words than on vowels, but that the difference between vowels and consonants in the word repetition task for children with grammatical impairment was not at all as salient, indicating that, for children with grammatical problems, vowels in words are as hard to repeat as consonants. However, the children with both phonological and grammatical problems also performed worse regarding the total number of correctly repeated phonemes, i.e. also consonant segments, indicating that the more pronounced problems with non-word repetition is also an expression of severity of the language impairment, since phonological-grammatical impairment (F80.1) is considered more severe than phonological impairment (F80.0). A link between grammatical problems and prosodic problems has been proposed in previous research (23,54), and since vowels are carriers of prosodic information to a greater extent than consonants, the finding in the present study, that vowels are particularly vulnerable for children with grammatical problems, provides further support for such a linkage. The fact that Marshall et al. (13) did find significant (though modest) correlations between prosody and reception of grammar is also in favor of a relationship between prosodic and grammatical abilities. Compared to non-word repetition, repetition of real words allows the children to draw on long-term memory knowledge to a greater extent. Since vowels mainly carry grammatical information (11), existing grammatical knowledge might facilitate vowel repetition specifically, but only if the stimuli to be repeated permit access to long-term memory representations. Consequently, it should not be surprising that grammatical ability correlates with vowel repetition in real words, but not in non-words.

Working memory is a crucial determinant for the ability to repeat words and non-words (28), and judging by the PCC and PPC, where the two groups performed almost on a par, it appears as if the children in the two groups of the present study were equal regarding working memory. However, there were significant differences between the groups concerning the suprasegmental variables production of unstressed syllables and production of correct stress patterns in non-words. This result may either be an expression of differences between the groups regarding their working memory capacity or an expression of differences in the perception of unstressed elements, which have less phonetic substance than stressed elements. This result is also in accordance both with the metrical hypothesis proposed by Gerken (17) and with other studies where children with grammatical impairment have been shown to omit unstressed syllables rather than stressed (23,55). In the present study, there were not only omissions of syllables, but also addition, which may reflect an underlying prosodic uncertainty (10). It may also be assumed that grammatical impairment may comprise problems both with perception and working memory as well as with prosody.

For suprasegmental aspects, the difference between words and non-words identified for segmental variables, shown in previous research (10,35), is not shown in the present study. In contrast, the children with grammatical impairment performed better on non-words than words regarding repetition of suprasegmental features. This finding indicates that prosodic features are not as dependent on working memory as segmental variables, and it may be interpreted as an indication of prosodic structures being stored in the long-term memory. The child with the lowest PPC had a higher number of omitted unstressed syllables in non-words than the child with the highest PPC. This result suggests that there may be a difference between the children regarding complex working memory (28), prosodic certainty (10), or perceptual problems (56).

In previous research where non-word repetition has been used to diagnose language impairment, the children with impairment have been compared to children with typical language development (6,7,42,56). The results of these studies demonstrate that non-word repetition is a valid tool to differentiate between those groups. Edwards and Lahey (56) also argue that non-word repetition ability may enhance the understanding of language impairment. In the present study, it was also shown that non-word repetition, if analyzed in great detail, may differentiate between different types of language impairment. The results of the present study clearly demonstrate the need for analyses beyond PCC and binary scoring for non-word repetition tasks.

Conclusions and future directions

The significant difference between the groups of participants regarding production of vowels in words,
and total number of phonemes in non-words, indicates that non-word repetition tasks may be used as a diagnostic tool to differentiate between children with phonological language impairment (F80.0) and children with phonological-grammatical impairment (F80.1), if thoroughly analyzed.

The difference between the groups regarding production of vowels supports the CV hypothesis (11), which proposes a link between acquisition of grammar and vowels.

The analysis of suprasegmental variables also seems to differentiate between different types of language impairment.

The results of the present study are promising, but in order to reach a better understanding of different types of language impairment and their underlying factors, further development of non-word repetition tests, and especially how they are analyzed, is needed.

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Supplementary material available online

Supplementary Appendix