Non-word repetition in children with cleft palate: a relation between phonological memory and vocabulary

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Abstract

The hypothesis that the size of the vocabulary of 2-year-old children with cleft palate is related to their phonological memory is tested with a non-word repetition (NWR) task and a parent questionnaire. NWR accuracy, real-word repetition accuracy, receptive vocabulary and productive vocabulary were assessed in 13 children between 25 and 30 months with cleft palate and 14 typically developing children between 25 and 28 months. The results show that children with cleft palate have smaller receptive vocabularies than typically developing children. NWR accuracy and real-word repetition accuracy were poorer in children with cleft palate. No differences were found between real-word and non-word repetition accuracy and no correlations were found between vocabulary and NWR in children with cleft palate. This indicates that children with cleft palate produce less accurate independent of their vocabulary size. Several possibilities are discussed to explain these results: a phonological memory deficit, a phonological perception deficit or an articulatory deficit. These findings require more research to the cause of this poor repetition accuracy and its influence on vocabulary.

1. Introduction

It is remarkable to see how fast children learn the words of their language. The first word is produced between 10 to 15 months (Benedict, 1979). After the 50-word milestone, children's vocabularies increase from 8 to 11 new words per month to 22 to 37 new words per month (Benedict, 1979). In this study the relation between phonological memory and vocabulary is explored in a special population, namely children with a cleft palate. Results are compared to a population of typically developing children. The phonological memory of these two groups of 2-year-old children is tested with a non-word repetition task. Measurement of vocabulary skills is obtained by using the N-CDI, a parent questionnaire.

Children with cleft palate have a range of speech and language problems (Jansonius, 2003). As cleft palate is a congenital disorder in lip, jaw and/or palate, the most obvious problems that arise are deviations in speech production. Hypernasality and articulation problems, especially in consonants that require oral air pressure, are very common (Jansonius, 2003). A frequently observed phonological process in children with cleft palate is backing (Chapman, 1993). This process is a so-called compensatory articulation disorder, which can cause serious delays in language development (Pamplona, 2000).

However, not only speech production is affected in children with cleft palate. Scherer and d'Antonio (1995) used both parent questionnaires and direct observational measures to study the early language development of 16- to 30-months-old children with cleft palate. They found a smaller expressive vocabulary and limited phoneme inventories compared to typically developing children. The results imply that there is a relation between poor intelligibility and a delay in the development of expressive language, which could be caused by a trade-off

between phonetic and linguistic complexity (Nelson and Bauer, 1991). The more complex a word, the less intelligible the pronunciation becomes. If speech production interferes with language complexity, this might also influence the vocabulary development, because the child then might use less complex word forms. This should be further investigated.

In a study of Hoff et al. (2008) a relation between phonological memory and productive vocabulary development in 2 year-old children was found. Phonological memory is a short-term phonological storage component of working memory (Gathercole & Baddeley, 1989). Initially, word learning is all about learning unfamiliar phonological forms. Gathercole & Baddeley (1989) argue that the phonological short-term memory may mediate the long-term storage of phonological information, which is an important factor in vocabulary development. This link has been further studied in clinical populations (Gathercole & Baddeley, 1990; Snowling, 2006). In these studies it is suggested that disordered language development may even be a relatively direct consequence of phonological memory impairments (G&B, 1990). In 2 year-old children both vocabulary and phonological representations are developing, which may affect children's phonological memory (Hoff et al., 2008).

Altogether, children with cleft palate also seem to have, apart from their speech production problems, smaller expressive vocabularies. It has also been shown that vocabulary development can be linked to phonological memory at 2 years of age. For children with cleft palate, the question is if a smaller vocabulary size can be explained by a phonological memory deficit. In order to investigate this we need to measure phonological memory performances, which will be done by a non-word repetition task.

1.1 Non-word repetition

From the perspective that word learning initially involves learning unfamiliar phonological forms, which in turn relies on phonological short-term memory, a non-word repetition task seems well-suited to measure these phonological memory abilities (Gathercole & Baddeley, 1989, 1990; Hoff et al. 2008). Hoff (2008) confirmed the validity of a non-word repetition task as a means to assess phonological memory in young children. A non-word repetition task reflects the encoding, storage and retrieval of phonological representations in short-term memory (de Bree, 2007). These representations consist of information about each speech sound of the stored word. Gathercole (2006) states that the ability to repeat non-words

is highly dependent on phonological storage capacity and that both word learning and non-word repetition require phonological storage.

Considering the discrepancy in real word and non-word repetition accuracy, which has been observed in 24-month-old children (Hoff, 2008), it seems essential to discuss the underlying processes. In the Levelt-model (1999) for word production the process from intention to sound wave is divided into several steps. Some important steps in word production are those of lexical selection and phonological encoding followed by phonetic encoding and articulation. The difference between the tasks of repeating real words and non-words lies in the routes through the production model that can be taken. In both real- and non-word repetition the word-to-be-repeated, i.e. the perceived word, passes through phonological memory. A familiar, real word will find a match in the lexicon and subsequently all the intermediate steps up to articulation will be taken. This is called the lexical route. A non-word on the other hand cannot follow this lexical route, because there is no matching form in the lexicon. Rather, information from phonological memory goes straight to phonetic encoding and articulation. This is called the non-lexical route. By definition, then, the repetition of non-words does not involve lexical access, and the speaker can therefore not make use of this source of information (Den Ouden, 2002). This dual route system, which distinguishes between lexical and non-lexical speech production, can be used to measure the functioning of the phonological memory. Of course the repetition of both types of words relies on this memory. However, while the repetition of familiar words can be facilitated by access to information in the lexicon, the accuracy of the repetition of non-words solely relies on information stored in and retrieved from phonological memory.

Based on this dual route system a discrepancy can be expected between real word and non-word repetition in children with CP. Also, children with cleft palate will have smaller productive vocabulary scores (Scherer & d'Antonio, 1995). These scores will be related to their non-word repetition accuracy.

With this study more insight in the phonological development of children with cleft palate is provided. This is useful from a clinical perspective, since more insight will lead to the development of more effective treatments. In addition, phonological development of language-disordered children can provide us with more information about the speech and word learning process in general.

2. Methodology

2.1 Participants

Two groups were selected for this study, 13 children with a cleft palate (mean age 27,86 months) and 14 typically developing children (mean age 26,57 months). The children from the cleft palate (CP) group were selected from the University Medical Centre of Utrecht (UMCU). They all had Dutch as their primary language and no mental retardation. The type of cleft varied; four children had a cleft palate only, six children had a unilateral cleft lip, jaw and palate, three children had a bilateral cleft lip, jaw and palate and one child had a cleft lip and jaw. Of course it would have been preferable to have a more homogeneous group with only one type of cleft, but because of the specific age range only a small group of patients was available.

It is well known that children with a cleft palate often suffer from Otitis Media with Effusion (OME), which causes fluctuating medium hearing loss. Several studies (Shriberg, 2000; Winskel, 2006) showed that hearing loss can cause problems in language development. For this reason children with a severe hearing loss (>40 dB, Jansonius, 1999) did not participate in this study. At the time of testing most children in the CP group had undergone two surgeries: Lip and soft palate had been closed, according to the protocol at the age of 3 and 9 months respectively. The typically developing children functioned as a control group. These children also had Dutch as their primary language and had no medical history. The two groups were matched for age, gender and socio-economic status.

2.2 Material

To measure the vocabulary skills N-CDI 2 (Zink & Lejaegere, 2002), the short version of the N-CDI/Woorden en Zinnen was used. Because the short version is easy to fill out for the parents, a reliable receptive and productive vocabulary score can be determined. The short version has been validated and is highly correlated with the complete version (Zink & Lejaegere, 2002). The list is developed for children between 16 and 30 months old. It contains 112 words. For each word the parent can enter whether the child understands and produces this word. This leads to a receptive and a productive vocabulary percentile. The vocabulary scores of the participants in this study are calculated in percentiles, according to the scoring protocol of Zink & Lejaegere (2002).

The repetition task consisted of 12 real-words and 12 non-words, both monosyllabic and disyllabic (see table 1 and appendix I). All disyllabic stimuli conformed to the dominant stress pattern of Dutch (strong-weak). The real words were obtained from the N-CDI/Woorden en Zinnen. The real and non-words contained equal numbers of labial and dorsal consonants, in order to make the test feasible for both the control group and the CP-group. Word-initially, labial consonants are easier to produce than dorsal consonants for typically developing children (Levelt 1994, Beers 1995). However, children with cleft palate often show backing (Chapman, 1993). This suggests a preference for dorsal consonants.

	Real-word repetition	Non-word repetition
1 syllable	6	6
2 syllables	6	6

Table 1: experimental design of the repetition test

The non-words were constructed on the basis of the real words, by changing the vowel. To ensure that the new speech sound combinations were equally common compared to the Dutch real words, the diphone transitional probability (DTP) was calculated for each real word and non-word. A document with DTPs for spoken Dutch in CELEX was used to do this (F. Adriaans, Universiteit Utrecht, p.c.) The mean DTP for real words was -1,186 and -1,227 for non-words. These means were not significantly different (t=0.695; p=0.496), indicating that the frequency with which adjacent phonemes were combined in the test items did not differ between real-word and non-word stimuli.

2.3 Procedure

Children were tested at home to make them feel more comfortable. After a short play-session to familiarize the child with the researcher, the test began. The entire session was recorded with a digital audio-recorder (M-AUDIO microtrack II). The child was seated on his care-taker's lap next to the researcher. Together they looked at a book with pictures. This book was merely used to motivate the children to talk. After naming some of the pictures the researcher introduced the stimuli of the test ("Kun je zeggen *poes*? Zeg maar *poes*.") The researcher repeated the stimulus up to three times. In case of no response, the next stimulus was introduced. Real-words and non-words were presented in three blocks containing all different conditions (table 1). To keep the child motivated, the picture book was used again

after some stimuli if necessary. Only the word productions in the word- and non-word repetition task were used for statistical analysis.

2.4 Statistical analysis

Transcriptions of the production data were made by the researcher using Phon (version 1.4b935) to segment the speech samples and Praat (Boersma & Weenink, version 5.1.02) to observe the speech sounds. Inter-rater reliability was obtained by having an experienced speech therapist from the cleft palate team from UMC Utrecht perform a blind transcription of the data of two randomly selected subjects (10% of the data). Phoneme-by-phoneme agreement was calculated to be 88,3 % (for consonants). Subsequently, for each child a Percentage Consonant Correct (PCC; Shriberg, 1982) was calculated. The speech of children with cleft palate is in many ways deviant from the speech of normal developing children. In order to make a sensible comparison between the PCC of the cleft palate children and those of the typically developing children, the scoring rules from Shriberg (1982) were used. According to this measure, a (deviant) nasal pronunciation of a sound is not scored as incorrect since for some cleft palate children it is anatomically impossible to produce consonants without a nasal release. Children who repeated less than half or no stimuli at all were excluded from the production measurements. Real-word and non-word repetition (NWR) accuracy were compared with a non-parametric Mann-Whitney test. NWR accuracy expressed in PCC and percentile scores from the N-CDI were correlated with Spearman's Rho.

3. Results

The mean of the receptive vocabulary percentile for the children with cleft palate was 29,4 (SD = 32,83) and for the control group 51,9 (SD = 33,00). A Mann-Whitney test showed that this difference was significant (U = 51,5; p = 0,027; one-tailed). The mean vocabulary percentile of the control group (51,9) almost equals the standard group with percentile 50.

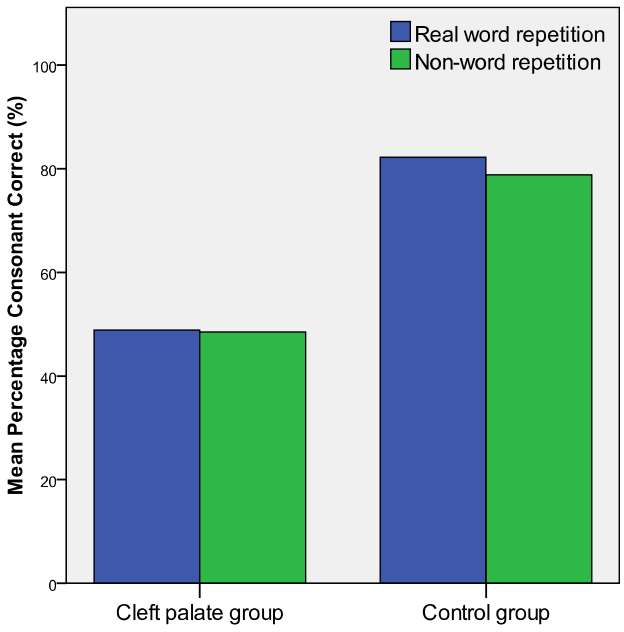

Figure 1: Mean percentage consonant correct for real word and non word repetition calculated for the CP group (N=8) and the Control group (N=10)

The mean repetition accuracy for real words was 48,9 % for children with a cleft palate (N=8) and 82,2 % for the control group (N=10). Mean NWR accuracy was 48,5 % for the CP group and 78,8 % for the Control group (figure 1). Again a Mann-Whitney test revealed significant differences between the two groups in real-word repetition accuracy (U = 12; p = 0,007; one-tailed) and non-word repetition accuracy (U = 14; p = 0,011; one-tailed). The expected difference between real-word repetition accuracy and non-word repetition accuracy did not reach the criterion of $p < 0,05$, neither in the cleft palate group, nor in the control group.

The inter-correlations among receptive vocabulary percentile, productive vocabulary percentile, real-word repetition accuracy and non-word repetition accuracy are presented for each group in table 2 and 3.

Cleft Palate group	I	II	III
I Receptive vocabulary percentile	-		
II Productive vocabulary percentile	0,821**	-	
III Real-word repetition accuracy	0,358	0,283	-
IV Non-word repetition accuracy	0,216	0,042	0,861***

Table 2: Inter-correlations among receptive vocabulary percentile, productive vocabulary percentile, real-word repetition accuracy and non-word repetition accuracy within the Cleft palate group (N=8)

Control group	I	II	III
I Receptive vocabulary percentile	-		
II Productive vocabulary percentile	0,860***	-	
III Real-word repetition accuracy	0,591*	0,656**	-
IV Non-word repetition accuracy	0,122	0,394	0,691**

Table 3: Inter-correlations among receptive vocabulary percentile, productive vocabulary percentile, real-word repetition accuracy and non-word repetition accuracy within the control group (N=10)

* => p = 0,07

** => Significant at p < 0,05 level

*** => Significant at p < 0,01 level

To test whether these scores indeed reflect phonological memory demands, and not just articulatory performance, a part correlation between vocabulary scores and non-word repetition accuracy was performed by removing the variance shared with real word repetition accuracy. When looking at receptive vocabulary percentiles, the part correlation with NWR accuracy for both the cleft palate group (r = 0,431; p = 0,322) and for the control group (r = -0,329; p = 0,284) were not significant. The part correlations for the productive vocabulary scores with NWR accuracy for both the cleft palate group (r = 0,120; p = 0,793) and the control group (r = -0,091; p = 0,736) were not significant either.

Both groups were also matched on socio-economic status by dividing the education of the parents into high and low categories. The control group showed no significant differences (receptive t = -0,524, p = 0,617; productive t = -0,321, p = 0,761) in vocabulary percentiles between the two categories.

Comparing the scores for the non-responders on the repetition task with the responders for each group, we didn't find any significant differences on age and vocabulary. There seems to be a tendency in the control group for lower productive vocabularies among non-responders (U = 8,5, p = 0,052, one-tailed).

4. Discussion

This study examined the role of phonological memory in early word learning of children with cleft palate and typically developing children by means of a non-word repetition task and a parent questionnaire. The question is whether poor vocabulary scores can be explained by a phonological memory deficit. This study is based on the finding of Hoff et al.

(2008) that vocabulary size and NWR accuracy are related in typical developing 2-year-old children.

At first glance, the results of the present study seemed to show this correlation in children with cleft palate as well. Receptive vocabulary percentiles were smaller in the CP group, while productive vocabulary percentiles showed no significant differences between the two groups. These findings are not in line with the results of Scherer and D'Antonio (1995), where children with cleft palate only showed delays in expressive language, but not in receptive language. The small receptive vocabulary percentiles in the present study might point to problems with auditory or phonological perception. In other groups of children with perception deficits, like hearing impaired children, also smaller receptive vocabulary scores are found (Hayes, 2009)**.** This possibility should be further investigated.

The CP group showed a smaller repetition accuracy overall compared to the control group. This does not seem surprising, because children with cleft palate have a poorer speech production. It must also be taken into consideration that most children still needed an operation to close the hard palate at the time of testing.

Although the results initially appeared to show the expected correlation between NWR accuracy and vocabulary in children with cleft palate, further measurements showed no correlations between these variables in children with cleft palate, not even in a part correlation which eliminated the influence of articulation. Significant correlations between vocabulary percentiles and the repetition task were only found in the control group, however, only between receptive and productive vocabulary percentile and real-word repetition accuracy. The finding that there is no correlation between NWR and productive vocabulary in the control group deviates from Hoff et al.'s study (2008), where they did find a correlation. A factor that might be involved in this discrepancy is group size. Because of the high number of non-responders on the repetition task, in the present study measurements could only be taken from a small group.

This brings us to the large number of non-responders in both the real-word and non-word repetition task. There seems to be a tendency in the control group for smaller productive vocabularies among non-responders. The question for the non-responders in both groups is what causes their refusal to repeat. The difference in vocabulary size suggests inability, but also the task itself could influence the results. Our task was slightly different from the one used in Hoff et al. (2008). For the non-word repetition task they presented toys to the children and said: "This is my friend [non-word], can you say [non-word]?" The present study, however, did not make use of toys or other visual stimuli: the children were simply asked to

repeat the words that the researcher said. Apparently there is a task difference between repeating the names of visible toys and repeating plain auditory stimuli: young children prefer to name objects.

Independent of vocabulary size, the children with cleft palate produce less accurate word forms. As no significant differences were found between repetition of non-words and real words in both groups, an account in terms of a phonological memory deficit is not immediately obvious. Going back to the lexical and non-lexical route for word and non-word repetition, there are three possible sources related to the speech production process that can account for the overall poor repetition accuracy in children with cleft palate: phonological memory, phonetic encoding and articulation, and speech perception. Let us first consider the phonological memory deficit we expected to find. If children would use the non-lexical route for both real word and non-word repetition, a phonological memory deficit could underlie both types of repetition. Alternatively there could be a phonological perception deficit. Several studies (Whitehill & Francis, 2003; Bisschop, 2009) discovered phonological perception problems in children with cleft palate who showed production deficits. Because of this perception deficit, incorrect phonological representations are stored in and retrieved from phonological memory. A final possible explanation for the poor repetition accuracy in children with cleft palate is a deficit in phonetic encoding and articulation. Both the lexical and the non-lexical route pass through these modules.

In summary, this study contributes to the lexical and phonological development in a group of cleft-palate children. Children with cleft palate tend to have smaller (receptive) vocabularies than their same age peers. The present study brings to light several inconsistencies with earlier studies. It is therefore valuable to replicate this test with perhaps a larger group size. As no correlations were found between vocabulary and NWR, three possibilities are mentioned that can account for the poor repetition accuracy in children with cleft palate. A phonological memory deficit could be confirmed with a picture naming task. This task forces a lexical route and therefore diminishes the influence of phonological memory on the output. A phonological perception deficit should be investigated with perception experiments, which require no speech production. Finally, an articulatory deficit can be clarified by an error analysis of the items produced in the repetition tasks. If the errors made in the real-word repetition task are similar to the errors made in the non-word repetition task, a phonetic/articulation deficit is likely. This type of future research can determine the

underlying cause of speech problems in children with cleft palate, which will help to develop a speech therapy that can offer the most effective treatment.

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6. Appendix I: Stimuli

1 Syllable		**2 Syllables**	
Real words	**Non-words**	**Real words**	**Non-words**
Koud	**Keit**	**Ketting**	**Kotteng**
Geit	**Geet**	**Tafel**	**Tofil**
Kaas	**Kuus**	**Gieter**	**Goter**
Vis	**Vas**	**Pony**	**Pina**
Boek	**Biek**	**Varken**	**Virken**
Poes	**Paas**	**Baby**	**Bibo**