

The difference in PMLU scores for Dutch children (2;0-6;0) with a phonological impairment following the FAN-procedure or the chronological procedure

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Abstract

Title: The difference in PMLU scores for Dutch children (2;0-6;0) with a phonological impairment following the FAN-procedure or the chronological procedure

Background: Phonological mean length of utterance (PMLU) scores could be used to get a first indication for phonological disorders. A PMLU score is usually obtained over a spontaneous speech sample after a FAN analysis. In order to make the PMLU suitable for clinical use, it should be calculated on a language sample as small as possible and be less time consuming.

Research questions: 1. What is the difference in PMLU scores for Dutch children (2;0-6;0) with a phonological impairment between a spontaneous language sample obtained by the FAN procedure and a chronological procedure over the first 25 words? 2. What is the difference in PMLU scores between a spontaneous language sample of 25 words and a spontaneous language sample of 50 words obtained by the chronological procedure?

Method: The study includes 14 Dutch children with a suspicion of a phonological impairment. Children's spontaneous language was recorded. PMLU scores were calculated for the language sample sizes 25 following the FAN procedure and the chronological procedure and language sample size 50 following the chronological procedure. Reliability testing was used to examine whether a clinically relevant and applicable PMLU can be determined.

Results: The selection procedure of the words give no significant difference in PMLU between the groups and a high correlation on the PMLU scores.

Conclusion: Selecting the first 25 words of a spontaneous language sample seems to give applicable PMLU scores for young children aged 2;8-5;0 years.

Recommendations: Future research should focus on repeating this research with a larger sample size and repeated measures within a sample. Furthermore, younger children with a phonological impairment should be included in a future study to make a validity study possible in the future.

Keywords: PMLU, phonological mean length of utterance, children, phonological disorders

Samenvatting

Titel: Het verschil in PMLU scores voor Nederlandse kinderen van 2;0-6;0 jaar met een fonologische stoornis verkregen volgens de FAN-procedure of de chronologische procedure.

Achtergrond: *Phonological Mean Length of Utterance* (PMLU) is geïntroduceerd als een eerste indicatie om fonologische stoornissen bij kinderen vast te stellen. Een PMLU score wordt berekend over een spontane taalsample na een FAN analyse. Om de PMLU geschikt voor klinisch gebruik te maken, moet de berekening over een zo klein mogelijke taalsample gedaan worden en minder tijdrovend zijn.

Onderzoeksvragen: 1. Wat is het verschil in PMLU scores bij de eerste 25 woorden voor Nederlandse kinderen (2;0-6;0 jaar) met een fonologische stoornis tussen een spontane taalsample die wordt berekend met de FAN procedure en een spontane taalsample die wordt berekend met de chronologische procedure? 2. Wat is het verschil in PMLU scores tussen een spontane taalsample van 25 woorden en een spontane taal steekproef van 50 woorden berekend volgens de chronologische procedure?

Methode: De studie omvat 14 Nederlandse kinderen met een vermoedelijke fonologische stoornis. De spontane taal van de kinderen is gebruikt voor deze studie. PMLU scores werden berekend voor een taalsample van 25 woorden (verkregen volgens de FAN procedure en volgens de chronologische procedure) en voor een taalsample van 50 woorden (verkregen volgens de chronologische procedure). Betrouwbaarheidstesten werden gebruikt om te onderzoeken of een klinisch relevant en betrouwbaar PMLU kan worden bepaald.

Resultaten: De selectieprocedure geeft geen significant verschil in PMLU scores tussen de groepen en een hoge correlatie tussen de PMLU scores.

Conclusie: De eerste 25 woorden van een spontane taal sample selecteren lijkt toepasbare PMLU scores te geven voor jonge kinderen van 2;8-5;0 jaar.

Aanbevelingen: Toekomstig onderzoek moet zich richten op het herhalen van dit onderzoek met een grotere steekproef. Bovendien moeten jongere kinderen met een fonologische stoornis worden opgenomen in een toekomstig onderzoek om in de toekomst een validiteitstudie mogelijk te maken.

Trefwoorden: fonologische stoornis, Phonological Mean Length of Utterance, taalsample, kinderen, PMLU

Introduction

Phonological speech disorders are common in young children. The prevalence of speech production problems varies from 1,1% to 6,4% between studies (1-4). A phonological disorder is a linguistically based speech-sound disorder (5). It is characterized by speech production disorders that significantly impact intelligibility (6). For example, children with these problems may make age-inappropriate speech sound deletions and/or substitutions (7). In the Netherlands, the diagnosis of speech sound disorders is regularly determined by using naming tests, such as '*Logo-Art articulatieonderzoek*' or '*Metaphon*' (8,9). However, more information can be gained from a spontaneous language sample (10,11). A spontaneous speech sample shows the daily communication of the children. A FAN analysis (Phonological Analysis of Dutch, *Fonologische Analyse van het Nederlands*) can be performed with such a sample (12). This analysis give a speech and language therapist (SLT) detailed information about the phonological development of a child, for example the phonological processes or the contrasts used. Also, it are words selected by the child itself, where a naming task consists predefined items. Although a FAN analysis provides much information, it is a time consuming procedure for SLTs (11). That amount of time is not always available in private practices. A less time consuming alternative using a language sample to diagnose a phonological disorder is currently lacking.

A measure, such as phonological mean length of utterance (PMLU) could be used for a first indication if a child is at risk for a phonological disorder (10,13-20). The PMLU score measures the increase in the average word length in combination with the increase in the number of correct spoken sounds in a word (14). The rules to calculate PMLU can be found in Appendix 1. According to the literature, a reliable PMLU can be measured over 100 words (10,14).

In previous small studies the PMLU scores were obtained from a spontaneous speech sample (16,20-22). Research with typically developing (TD) children showed that a language sample of 25 (out of a sample of 100 words) randomly selected words produced similar PMLU scores as language samples of 50, 75 and 100 successive words. Furthermore, for young children the PMLU scores grow with age (16). Other research showed that randomly choosing 25, 50 or 75 words of a sample showed no difference in PMLU scores (21). However, research with PMLU scores following the FAN procedure sample compared with a random sample of 25 words, gave conflicting results (22). This is possibly due to a bias in the build-up of the FAN-samples. Of words that appear several times in the sample, only the first occurrence will be noted. Next appearances will not be listed separately in the sample, but are added to the first occurrence. Consequently, at the beginning of a sample words are

relatively less complex than later in the sample. Also, in children with phonological disorders, the non-random selection of the first 25 words out of a FAN-sample compared to 50 words leads to differences in the PMLU scores (20). In order to make the PMLU score suitable for clinical use, it is important that it is calculated on a language sample as small as possible and will still remain reliable. Besides that, the procedure needs to be less time consuming than a FAN analysis.

A chronological procedure, where all subsequent occurrences of words are used, can easier be applied in the private practice than the FAN procedure. Since the chronological procedure will be less time consuming and faster to execute, is it important to know whether the chronological procedure provides a different PMLU than the FAN procedure.

Therefore, in this study two procedures will be compared, the FAN procedure (only notation of first occurrences) and the chronological procedure (notation of all subsequent occurrences of words). A Dutch example of multiple words is listed in figure 1. For the FAN-procedure words will be listed only once, so every word will be different. For the chronological procedure all words will be listed, so double words are allowed. The expectation is a difference in PMLU scores depending on the selection of words.

Research questions

-What is the difference in PMLU scores for Dutch children (2;0-6;0) with a phonological impairment between a spontaneous language sample obtained by the FAN procedure and a chronological procedure over the first 25 words?

- What is the difference in PMLU scores for Dutch children (2;0-6;0) with a phonological impairment between a spontaneous language sample of 25 words and a spontaneous language sample of 50 words obtained by the chronological procedure?

Methods

Design

This study was a cross-sectional quantitative descriptive study. The duration of this study was 6 months.

Participants

This study included Dutch children with assumedly a phonological speech disorder aged between 2;0-6;0 years. The children were described as unintelligible by their parents and made errors with vowels and consonants in the Logo-Art naming test or Methaphon screening (8,9). The children were recruited in two private practices in the Netherlands. SLTs asked the parents of eligible children to participate in this study. For all participating children, informed consent by parents was obtained. Inclusion of children took place between December 2015 and May 2016. This study was performed according to the principles of Helsinki (23).

The children had to meet all of the following inclusion criteria: children with speech production problems based on a phonological naming test, Dutch as native language, monolingual Dutch-speaking, presumable IQ scores above 85 and aged between 2;0-6;0 years. However, children with detectable hearing problems and significant hearing loss of >20 dB at the best ear, preterm-born and dysmature children and children with oral malformations were excluded.

The selection of criteria was identical to those used in recent research on PMLU (20). This was due to practical reasons; it creates a possibility for a larger validity study in the future because the results are comparable.

Procedure

In order to determine the influence of the selection procedure, spontaneous speech samples of children in the age of 2;0-6;0 years with a suspicion of a phonological disorder were collected. The children were first tested with a naming test to determine the suspicion, to set the starting point for the children. In that naming test, the children had to make at least one atypical phonological process error for their age. Where typical phonological processes are normal processes for a certain age, are atypical phonological processes unusual processes, such as deletion of the initial consonant or the addition of a consonant or syllable (12). Of both selection procedures, FAN and chronological, the first 25 words of the language samples were compared with each other in order to determine the impact of the procedure on the PMLU score.

In addition, in order to determine whether there is a difference between a sample of 25 words and a sample of 50 words for determining the PMLU score in the chronological procedure, the PMLU scores of samples of 25 and 50 words were compared.

Data collection was done by recording the spontaneous language of the children. The data was collected from a 20-minute play situation between child and their own SLT. The first 5 minutes were not analysed, because the children had to get used to the recording situation. Seventy-five child realizations of words were transcribed for this study. The target word is the adult realization of a word and may be a lexical item or a grammatical item. Only spontaneously realized words were accepted for the analysis; imitations and unintelligible items were excluded.

For the PMLU scores, both the child's target word and the child's realization of the words were calculated. The child's target words were first given points for all segments (one point for each consonant and vowel) and an additional point for all consonants. The child's own PMLU scores were calculated by assigning a point to all segments in the word, and one extra point for each correct consonant. For example, when a child produces the word 'laaf' he/she gets a PMLU score of 5. But, when a child produces the word 'laa' instead of 'laaf' he/she gets a PMLU score of 3.

All PMLU scores were totalled and then divided by the number of words, leading to the average PMLU. PMLU values were calculated manually and the calculation was conducted according to the rules found in Appendix 1 (14,16,17). For each child, PMLU scores were calculated over the first 25 words obtained by the FAN procedure (25 FP), as well as over the first 25 words obtained by the chronological procedure (25CP), and finally also over the next 50 words obtained by the chronological procedure (50CP).

Statistical analysis

For the analysis, a Wilcoxon Signed Rank Test was used to compare the different groups. This non-parametric test was done because the data for the 25CP and 50 CP groups were not normal distributed. This test illustrated the ranking of the results and whether they match each other. When there was no difference found between the groups, an Interclass Correlation Coefficient was calculated to check if the procedures were highly correlated to each other for each child. In this way, something can be said about the similarity of the results for each child obtained by the different selection procedures. For the analysis, IBM SPSS Statistics 22 was used.

Results

Table 1 shows the characteristics of the population. Of the 20 selected children, 14 parents gave permission for their child to participate in this study. From the 14 children, there are 9 boys and 5 girls. The age range of the population is 2;8-5;0 years. The average number of months of therapy, prior to this study, was three. The PMLU values for all fourteen children with a suspicion of a phonological impairment are presented in Table 2. The differences between the PMLU scores for the 25CP and the 25FP group range between -0,48 and 0,44. The differences between the PMLU scores for the 25CP and the 50CP group range between -0,64 and 0,58.

**table 1 and 2 insert here*

The Wilcoxon Signed Rank Test shows no difference between the 25CP and the 25FP group ($z = -1,689$, $p = .091$). In the other groups, 25CP and 50CP, no difference is found ($z = -0,188$, $p = .851$). Also, the 25FP group in comparison with 50CP show no difference ($z = -1,193$, $p = .233$).

The Interclass Correlation Coefficient showed a high correlation between the 25CP and the 25FP group ($r = 0,847$, $p < .000$). Between the other groups, 25CP and 50CP, the correlation was ($r = 0,737$, $p = .003$). Also, a correlation ($r = 0,741$, $p = .002$) was shown between the 25FP group and the 50CP group.

**table 3 insert here*

Table 3 shows the different words the children used in the samples of 25 words (25CP and 25FP). For the 25FP samples, all children used 25 different words. The difference in the 25CP samples range between 13 and 23 different words (mean = 18,57, SD = 2,87).

Discussion

Main findings

The aim of this study was to determine the influence of the selection procedure on the PMLU scores in Dutch children with a phonological impairment between 2;0-6;0 years old. Although there are different words in the samples, this study shows no significant difference between using the 25 chronological words and the 25 FAN words procedure. The correlations between those groups were significant and high. Furthermore, no significant difference was found in number of words used (25CP versus 50CP). In this comparison, the correlation was also high.

The different procedures in this study show no significant difference in PMLU scores. In a previous study a difference in PMLU scores was found between a random and non-random selecting procedure. However, in that study no chronological order by all words was used. The words of a FAN analysis were used, so only first occurrences were used in the calculation of the PMLU scores (20).

In this study, no significant difference in PMLU scores was found in the sample size. Previous research showed already that randomly choosing 25, 50 or 75 words of a sample showed no difference in PMLU scores (21).

In order to make the PMLU score suitable for clinical use, it is important that it is calculated on a language sample as small as possible and will still remain reliable. This study shows no significant difference in PMLU scores for the sample size of 25 or 50 words following the chronological procedure. It seems that an applicable PMLU can be calculated over 25 words. A previous study showed a sample size of 25 words is enough for a reliable PLMU (14). This study supported that a sample of 25 words is enough for an applicable PMLU.

Besides a small language sample and still a applicable PMLU score, the procedure needs to be less time consuming than a FAN analysis. The chronological procedure can be done in a small amount of time. Only 25 words are needed to be recorded to calculate a PMLU score. This can easily be done in a private practice. Therefore, this study shows calculated PMLU scores suitable for clinical use, when following the chronological procedure.

Furthermore, a cautious compare can be made with the PMLU scores of the TD children (16). An overview of the TD scores are shown in table 4. The PMLU scores of the children with a phonological impairment are below the PMLU scores of the TD children. However, this is based on small studies.

Strengths and limitations

This study has both strengths and limitations. The primary strength of this study is the use of a clinical procedure to calculate the PMLU scores. The procedure of using 25 chronological words of a spontaneous sample of a child is close to real spontaneous speech. Using the chronological procedure, all words are included for the calculation of the PMLU scores. In previous small studies, a sample of a FAN analysis was used, where only the first occurrences were used, which comes less closer to spontaneous speech (16,20-22). Secondary, the study was conducted by protocol. For all children, a naming task was done before deciding they could participate. Also, each video does not include the first 5 minutes and the rules of Ingram adjusted for Dutch were followed in scoring (14,16,17). Therefore, this study is reproducible.

To appreciate the findings of this study, some aspects require further consideration. The current study has also some limitations. First, the sample size of this study is a limitation. Only 14 children were included in this study. Second, only one child was younger than 3 years old in this study. Younger children were desired for this study, due to do a larger validation study in the future. However, it is not common in private practices to see children younger than 3 years with speech production problems. Mostly, they are referred to the SLT after 3;6 years of age.

Furthermore, not all children had recent started with speech therapy, some had already have had a few months of therapy for this study at the start of the study. However, a starting point was determined by doing a naming task before participation in this study. Therefore, it was known that they still made age-inappropriate phonological errors and could the children participate in this study.

Conclusion

In this study, the selection procedure of the words give no significant difference in PMLU between the groups and a high correlation on the PMLU scores. Selecting the first 25 words of a spontaneous language sample seems to give applicable PMLU scores for young children with a phonological disorder aged 2;8-5;0 years.

Recommendations

The present study leaves some questions unanswered which would be interesting to be addressed in future research examining PMLU as a diagnostic instrument for children with SSD. First, future research should focus on repeating this research with a larger sample size. Also, in future research repeated measures should be done over larger language samples. For example, three times measuring 25 words following the chronological procedure within a sample. This way, it can be measured if taking multiple measurements from a sample, provides similar PMLU scores for a child. Furthermore, younger children with a phonological impairment should be included in a future study to make a validity study possible in the future.

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Tables and figures

Figure 1: Example of a Dutch sample

Word	25 chronological procedure	25 FAN procedure
1	it (ik)	it (ik)
2	er	er
3	mooi	mooi
4	uit	uit
5	zie	zie
6	it (ik)	it (ik)
7	zie	zie
8	er	er
9	wel	wel
10	mooi	mooi
11	uit	uit
Number of words counted	11	6

Table 1: Characteristics of the population

N	14
Gender	
- boy/girl	9/5
Mean age in months (SD)	48 (7) [range: 32-60]
Mean months of therapy (SD)	3 (3) [range: 1-11]

Table 2: PMLU values for all fourteen children with a suspicion of a phonological impairment

Child	25 chronological	25 FAN	50 chronological
1	5,08	5,08	5,76
2	5,20	5,64	4,86
3	4,24	4,60	4,50
4	4,60	4,64	4,88
5	4,32	4,44	4,02
6	3,56	3,96	4,08
7	4,16	4,64	4,40
8	4,84	4,72	4,26
9	4,60	4,92	4,58
10	5,00	5,00	5,28
11	4,20	4,48	4,16
12	4,56	5,04	4,36
13	4,48	4,16	4,38
14	3,96	3,52	3,72
Mean (SD)	4,49 (0,46)	4,63 (0,52)	4,52 (0,53)

Table 3: Different number of words between the 25CP and 25FP samples

Child	Different words CP	Different words FP	Difference CP and FP
1	19	25	6
2	18	25	7
3	20	25	5
4	21	25	4
5	22	25	3
6	17	25	8
7	15	25	10
8	22	25	3
9	16	25	9
10	23	25	2
11	17	25	8
12	19	25	6
13	18	25	7
14	13	25	12
Mean (SD)	18,57 (2,87)	25 (0)	6,43 (2,87)

Table 4: The phonological stages of PMLU of Rodenburg-Van Wee for TD children (16)

Group	Age	Range PMLU production
A, B	1;3 – 1;11	3,5 – 4,5
C, D, E	2;0 – 2;8	4,5 – 5;0
F, G, H, I	2;9 – 3;11	5,0 – 6,0

Appendix 1 - Rules for the calculation of the PMLU.

Rules for the calculation of the PMLU, adjusted for Dutch by Rodenburg-Van Wee (14,16,17)

1. *Sample-Size Rule*: Select at least 25 words, and preferably 50 words for analysis, depending on sample size. If the sample is larger than 50 words, select a selection of words that cover the entire sample, e.g., every other word in a sample of 100 words.
 2. *Lexical-Class Rule*: Count words (e.g., common nouns, verbs, adjectives, prepositions and adverbs) that are used in normal conversation between adults. This excludes child words, e.g., mommy, daddy, tata etc. Counting child words can inflate the PMLU if a child is a reduplicator. Grammatical morphemes should be avoided, these can reduce the PMLU score.
 3. *Compound Rule*: Do not count compound words as a single word unless they are spelled as a single word, e.g., 'cowboy' but not 'teddy bear', i.e. 'teddy bear' would be excluded from the count. This rule simplifies the decisions about what constitutes a word in the child's sample.
 4. *Variability Rule*: Only count a single production of each word. If more than one occurs, then count the most frequent one. If there is none, then count the last one produced. Counting variable productions may distort the count if there is a highly variable single word.
 5. *Production Rule*: Count 1 point for each consonant and vowel that occurs in the child's production. Syllabic consonants receive one point. Do not count more segments than are in adult words. For example, a child who says 'foot' as [hwut] has two consonants counted, not three. Otherwise, children who add segments will get higher scores despite making errors.
 6. *Consonants Correct Rule*: Assign 1 additional point for each correct consonant. Correctness in vowels is not counted since vowel transcriptions are typically of low reliability. Syllabic consonants receive an additional point in the same way as nonsyllabic consonants. A child who applies liquid simplification, for example, will get 1 point for producing a vowel, but 2 points if the syllabic consonant is correct.
 7. *Position Rule*: Only segments that are generalised in the right position, are counts as correct. This rule is valid for word level. When an initial consonant is getting a final consonant because of vocal deletion, this position is correct.
 8. *Input Rule*: Children's words must be compared to the real words, and not to standard targets in spoken language or the written version of the word. Use of dialect and everyday speech has to be taken with.
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