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Master's Thesis

Retesting with the C-BiLLT: What makes the difference?
A follow up study for comprehension of spoken language in children with Cerebral Palsy

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Summary

Objective

This paper describes a follow up study of comprehension of spoken language in children with severe cerebral palsy (CP). The research questions were 1) Does level of spoken language comprehension develop over the years in children with severe CP and is the C-BiLLT is able to detect changes in level of comprehension of spoken language in children with CP after two years? 2) Which factors influence the development of comprehension of spoken language in children with severe CP?

Methods

To measure level of spoken language comprehension, two assessments of the Computer Based Instrument for Low Motor Testing (C-BiLLT) were performed with an interval of two years in 26 children with severe CP (mean age 84 months, age range 19 months to 181 months, 11 spastic CP, 15 dyskinetic CP). To acquire information about factors that could have influenced the level of spoken language comprehension, a survey was distributed to both parents and speech and language therapists of the participants. A regression analysis is used to answer the research question.

Results

The results are Age Group (t = 1,001, sig. 328), Type of CP (t = 1,306, sig. ,206), Comprehension Aim (-,601, sig. ,555) Communication Device (t= 1,135, sig ,269). Although the results were not significant, the type of CP explained most of the variance, along with the use of a speech generating communication device and the age of the participants. Whether or not the aim of the speech and language therapy was to improve the comprehension of spoken language explained the least of the variance. Implications of this study and recommendations for further research are discussed.

Introduction

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, behavior, epilepsy, and secondary musculoskeletal problems (Rosenbaum, 2007). The motor disorders in CP can be classified by type, localization and severity. The different types of motor disorders are spastic paresis, dyskinetic paresis and ataxic paresis. Bilateral and unilateral forms of motor disorders can be differentiated. The severity of functional motor limitations of the gross motor functions in children with CP can be classified with the "Gross Motor Function Classification System" (GMFCS). This system distinguishes 5 levels. Each level reflects the highest degree of transfer that the child is able to achieve between 2 to 12 years of age. A child with CP in level I can walk without limitations, while a child with a CP in level V is transported in a manual wheelchair (Meihuizen-de Regt, 2009). CP in level IV and V with a severe learning disability is defined as severe CP (SCPE, 2002, Himmelman 2006). The severity of functional motor limitations is often related with language and motor speech problems (Bax, 2006, Fennell, 2001, Pirila, 2007, Roebroeck, 2006, Straub, 2009). Consequently, a child with level IV of the GMFCS is more likely to have speech and language problems than a child with level II of the GMFCS.

Communication in Cerebral Palsy

Speech and communication impairment can be associated with any type of CP (Pennington, 2004). Children with severe CP are known to have difficulties in communication. Speech impairment is present in 80 to 100% of people with severe CP (Roebroeck et al 2006, Voorman, 2009) The disorders are often a combination of dyspraxia and apraxia, and/or sensibility disorders. In children with a mild to moderate CP, verbal abilities are often more developed than nonverbal abilities. When the development of communication is disturbed, the cause of this disturbance needs to be evaluated. An observation of speech and language production and comprehension of spoken language is needed. In addition, it is important to

inventory how the child communicates in daily situations, and how successful this communication is.

Computer-Based Instrument for Low Motor Testing: C-BiLLT

In the VU University Medical Centre in Amsterdam, an instrument to assess spoken comprehension abilities in children with severe CP is developed. This "Computer-Based instrument for Low Motor Language Testing" (C-BiLLT) is designed for children with severe CP, classified with GMFCS level IV or V (Geytenbeek et al, 2010, Canchild, 2007). *"The C-BiLLT assesses a child's ability to understand spoken language by means of responding to orally presented questions pertaining to visually presented stimuli."*(Geytenbeek et al, 2010). The C-BiLLT requires minimal motor action of the child. The questions can be answered by any body part of the child. The sequence of the items is based on the Dutch Comprehension Scale of the "Reynell Developmental Language Scales" (RDLS) (Van Eldik, 1997), but the content of the items is different. The chosen nouns and verbs refer to the daily environment of a child with physical impairments. Items of the test do not refer to objects and situations that are meant to manipulate with.

The equipment of the C-BiLLT consists of a notebook, a 19-inch flat touch screen with built-in speakers, and two special input switches used for responding. The switches are also visually represented at the bottom of the flat screen. The equipment is adjustable to any position. The child can respond by touching the screen or the input switches, pointing to the screen, or using eye gaze. The computer provides visual feedback of the response of the child with a red frame around the selected picture. The test consists of two parts. For each part, a learning module is used to make the child aware of the association between the switches, the representations of the switches on the computer screen and the actual stimuli. In the first 30 items, the child is asked to select the correct image out of 2 images (see figure 1). In the second learning module, the child learns the method of linear scanning (see figure 2). In the following 46 items, the child is asked to select the correct image out of 4 images. The score contains one point for each correct answer. The total score is the sum of all scores.

Reliability and Validity of the C-BiLLT

The inter- and intra observer agreement of the C-BiLLT in typically developing children is high, with an Intra Correlation Coefficient of 0.92 and 0.96 respectively. In the study for interrater reliability of C-BiLLT for typically developing children, both intra-observer (N = 137) and inter-observer reliability (N = 37) are good, with ICCs of 0.97 and 0.96 respectively. The intra-observer reliability for children with CP was also good, with an ICC of 0.97.

The validity of the C-BiLLT was investigated by comparing the C-BiLLT with two other tests that theoretically measure similar constructs: the Reynell Developmental Language Scale and the Peabody Picture Vocabulary Test-III (PPVT-III). Also, the Raven's Coloured Progressive Matrices (CPM) was used, which is a non-verbal logic reasoning test. The C-BiLLT and the RDLS showed the strongest correlation, (r=0.93, [n=423]) followed by the PPVT-III (r=0.88 for the control group [n=117], and r=0.87 for the CP group [n=33]) and by the CPM r=0.43 (n=103). The face, construct, and convergent validity of the C-BiLLT are good. (Geytenbeek, 2010, 2012).

Responsiveness

With the C-BiLLT, comprehension of spoken language in children with severe CP can be measured. If an improvement in comprehension of spoken language of the child with CP occurs, the C-BiLLT should be able to detect this improvement. If comprehension of spoken language of a child is deteriorating, this should also be revealed in the test results of this child. This is called the responsiveness of a test. It is useful to evaluate the responsiveness of the C-BiLLT, because the test can be used for repeated measurements indicating a possible grow curve for the level of comprehension of spoken language in children with CP. If the C-BiLLT is responsive, it can also be used to evaluate the effect of language therapy in children with severe CP.

Factors of influence

If there is a change in the C-BiLLT score after two years, it is important to know to which factors the child was exposed. Factors that can influence the development of the child are

for example the age of the child, the medical diagnosis, changes in health of the child, presence or absence of accompanying impairments such as epilepsy and (changes in) (anti-epileptic) medication. Additionally, changes in the home environment, changes in behavior, frequency of linguistic therapy and treatment purposes may influence the development.

Research questions

Does level of spoken language comprehension develop over the years in children with severe CP and is the C-BiLLT able to detect these changes in level of comprehension of spoken language in children with CP after two years?

Which factors influence the development of comprehension of spoken language in children with severe CP?

When the participants are retested with the C-BiLLT, changes in the scores are expected. In the next paragraph, the following hypotheses are postulated:

Hypotheses

1. If typically developing children are tested and retested with the C-BiLLT with an interval of two year, a growth is expected because the children have matured (see table 1). In typically developing children, the mean scores per age group differ at least 2 points. The difference in scores between the younger age groups is much larger than the difference between the older groups, as displayed in table 1. The development of children with CP varies considerably, which makes it difficult or to predict the outcomes for a group of children with severe CP. It is expected to witness a larger growth in children with CP younger than seven years than in children with CP older than seven years because language of younger children develops more explosively than the language of older children (Goorhuis, Schaelaekens, 2000, Bates, 1992).
2. Aside from the age of the child, the diagnose of the child is expected to have an effect on the level of comprehension of spoken language. A study of Geytenbeek et al (in progress, 2012) found a significant relation between MRI pattern and C-BiLLT score. Children with basal ganglia necrosis (grey matter damage) scored significantly

higher than children with white matter injury. The preterm born child is more vulnerable for white matter damage, mostly causing spastic CP whereas the term born child is more vulnerable for grey matter damage often causing dyskinetic CP. According to these findings, it is expected that children with a dyskinetic CP show a larger positive difference between the first C-BiLLT score and the second C-BiLLT score than children with a spastic CP. Children were initially diagnosed by four types of CP: Spastic, Dyskinetic, Mixed or Dyskinetic/Atactic. Four participants were classified as Mixed or Dyskinetic/Atactic. Their subgroups were not sufficient for further analysis. Since these participants are mainly characterized by symptoms of a dyskinetic CP, they were added to the group of participants with a dyskinetic CP, in accordance with the SCPE criteria (2002).

3. Many children with severe CP receive intensive speech and language therapy. It is important to understand if changes in the development of spoken language comprehension are the result of speech and language therapy or other factors. Therefore the effect of therapy for spoken language comprehension is analyzed. since the conclusions of studies about effects of treatment for spoken language comprehension in CP cannot be generalized (Dada, 2009, Pennington, 2011), no expectations can be formed. However, it is hypothesised that intensive speech and language therapy for comprehension of spoken language has an effect on the level of comprehension of spoken language in children with CP.
4. The use of a Communication Device requires higher cognitive functioning and language comprehension (Hjelmquist, 1994, Romski, 1993). Therefore it is expected that participants with a Communication Device obtain more progress in spoken language comprehension than participants without a Communication Device.

Methods

Participants

The test group consists of 26 non speaking children with CP (12 boys, 14 girls, mean age of 7;0 years and an age range of 1;6 to 15 years old) in level III (1), IV (10) and V (15) of the GMFSC classification system (see table 2). A convenience sample was drawn from the

validation study of C-BiLLT. The parents of the children signed a written approval for the assessment of the C-BiLLT. Children with visual impairments were excluded from the study. The ages are normally distributed.

Experimental design

A quasi experiment in an empiric and explorative research study within a test-retest design is used to evaluate the research questions (see figure 3). The study is approved by the Medical Ethical commission of the VU medical Center of Amsterdam.

Language assessments

The first C-BiLLT assessments were carried out by a trained speech and language therapist. Approximately two years after the first assessment, the children are re-tested with the C-BiLLT by a trained speech and language therapist. The assessments took place in the educational environment of the child.

Survey

The parents and speech and language therapist of the child filled out a survey to make an inventory of all the possible factors of influence. The survey is distributed by email and filled out online (see appendix A and B). The response rate of the speech and language therapists was 96%. The response rate of the parents was 93%.

Factor analysis

The age of the participant is expected to influence the results. To analyse the effect of age on the development of comprehension of spoken language, the participants are divided in two groups (table 4, figure 8). Because the median and the mean of the ages at the moment of the assessment is 7 years, the limit for the division over the groups is 7 years. This way, the scores of younger participants (maximally 7 years old) older participants (minimally 7 years old) can be compared.

The participants are also divided in two groups based on their diagnosis: spastic or dyskinetic CP. The results of participants with a spastic CP are compared to the results of participants

with a dyskinetic CP and the effect of the diagnose on the change in scores on the C-BiLLT is analyzed.

Also a division is made based on the presence or absence of speech and language therapy focussed on spoken language comprehension. The results of participants who receive speech and language therapy focussed on spoken language comprehension are compared to the results of participants who do not receive speech and language therapy focussed on spoken language comprehension. The effect of the aims for spoken language comprehension on the change in scores on the C-BiLLT is analyzed.

Finally, the group is divided by the use of a Communication Device. The results of participants with a communication device are compared to the results of participants without a communication device and the effect of the use of a communication device on the change in scores on the C-BiLLT is analyzed.

Statistical analysis

To evaluate the effect of factors of type of CP, age group, aims for spoken language comprehension and the use of a Communication Device on the development of comprehension of spoken language, a regression analysis is carried out.

The number of factors in the analysis can be maximally 10-15% of N (StatSoft InC, 2012). In this study, for N=26, 3 to 4 factors can be analyzed.

In order to carry out the regression analysis, to the following assumptions is met:

- The model is homoscedastic and linear.
- The residuals are normally distributed.
- There is no multicollinearity (Moore, 2007).

In this regression model, a significance level of α 0.05 is used. The found F-value tests the hypothesis that all of the regression coefficients are 0 (Moore, 2007).

Results

Raw scores

Figures 4 and 5 show the raw scores of the first and second C-BiLLT assessment. There is a change in the scores: the overall scores in the second assessment are higher than in the first assessment. Individual development or improvement cannot be concluded from these scores because the value of the score depends on the age of the participant.

Figure 6 illustrates how the individual raw scores relate to the age of the participants and progress in age equivalents. The connecting black lines show progress: the participant obtained a higher age equivalent group on the second assessment than on the first assessment. The dashed lines represent a change in the score that did not lead to a change in classification by age equivalent group. In 16 out of 26 cases the second score resulted in a change in age equivalent group.

For example, participant n. 5 was 102 months old at the first assessment. A raw score of 17 points was obtained, classified in age equivalent group '<18 months'. At 131 months, the test was repeated. In this assessment, 37 points are obtained, classified in age equivalent group '24-30' months. Progress was identified, as is illustrated with a black line.

Factors of influence

Type of CP

Figure 7 and table 3 illustrate the score of children with a spastic cp and a dyskinetic CP. Of the participants with a spastic CP, 45% improved by at least one age equivalent group. Of the participants with a dyskinetic CP, 73% improved by at least one age equivalent group.

Age of the participants

Participants older than seven years of age showed higher scores than participants younger than 7 years. Most of the older participants older than seven years (69%) showed progress in the age equivalent groups, while in the younger group 50% of the participants showed progress (table 4, figure 8). The compared age groups were both normally distributed.

Therapy for language comprehension

To analyze the effect of language comprehension therapy, the speech and language therapists were asked what the aim of the therapy of their client was between the first and second C-BiLLT assessment. Two groups are compared (see table 5, figure 9). In the first group, comprehension of spoken language was not a aim of the therapy. In the second group, comprehension of spoken language was the aim of the therapy. Of the participants without a comprehension aim, 60% showed progress on the C-BiLLT. Of the participants with a comprehension aim, 64% showed progress.

The use of a Communication Device

The survey showed that many children with CP use a Speech Generating Communication Device (80% of the dyskinetic participants and 55% of the spastic participants, see table 6 and figure 10). The dyskinetic participants with a Communication device show more progress in spoken language comprehension than spastic participants with a Communication Device (9/12 = 75% and 3/6 = 50% respectively, see figure 10). The difference in progress between participants with and without a Communication Device is obvious (67% and 50% respectively, table 6).

Regression analysis

The R Squared is ,247. This means that 24,7% of the variance of the progress in the age equivalent groups is explained by the variables Type of CP, Age Group, Comprehension Aim and Communication Device in this model. The small Adjusted R Squared (,104) means that 10,4% is the estimated amount of explained variance for the population. This means that only 10,4% of the differences in progress of the population of children with severe CP can be explained by the calculated coefficients. In table 7, information about the regression analysis is displayed. Table 8 displays the results of the regression analysis.

None of the variables explained the variance in level and change of language comprehension of the children with severe CP (*P* = 0.183, F = 1,723). However, Group of Age, Type of CP and Communication Device have a higher t-value (t = 1,001,t = 1,306, t= 1,135) than Comprehension Aim(t = -,601). Type of CP has the highest t- value and is therefore the most explaining variable in the model.

Discussion

Although the difference was not significant, of the analyzed factors, Type of CP explained the most of the variation. This meets the expectation that more children with a dyskinetic CP show progress on comprehension of spoken language than children with a spastic CP (Geytenbeek et al, 2012) .

The expectation of differences between children older than 7 and children younger than 7 was that younger children would show more progress than older children. However, results, show the opposite: Children older than 7 years showed more progress than children younger than 7 years. Age group was not a significant factor in the regression model, but Age Group did influence the progress. This is in contrast with typically developing children, who progress more rapidly in their language development than older children (Goorhuis, Schaelaekens, 2000, Bates, 1992). This might be due to the delay in language development in children with severe CP (Pennington, 2004, Voorman 2009), which might result in a later spurt in the vocabulary development. Unfortunately, longitudinal study of vocabulary development and receptive language development in children with CP is not yet available.

Therapy for language comprehension did not appear to effect the progress of the scores on the C-BiLLT in this study. In the regression analysis therapy aim explained the least of the variance. Literature describes positive trends in the communicative development in children with CP after treatment, however, there is little evidence for the effectiveness of speech and language therapy in children with CP. The aims and methods of therapy are hardly standardized, making randomized controlled trial a challenge (Pennington 2003). Moreover, receptive vocabulary does not only expand my means of speech and language therapy, but it expands by overall language input and stimulation (Goorhuis, Schaelaekens, 2000). The effect of sheer speech and language therapy is therefore difficult to prove.

The use of a Communication Device explains a part of the variation in the progress in comprehension of spoken language in children with CP ($t = 1{,}135$). This effect is the strongest for children with dyskinetic CP. This was also the expectation, since the use of a communication device requires higher cognitive functioning (Hjelmquist, 1994, Romski, 1993). To use a Communication Device, knowledge about the linguistic value of symbols is

required to communicate. Communication Device was not a significant factor in the regression analysis.

Limitations of this study

The interpretation of the scores is usually carried out by the use of percentile scores or quotients. The percentile scores of the C-BiLLT are only available for children within the age range from 18 – 76 months. Thus, the scores of only half the test group can be evaluated. Moreover, the percentile scores of the C-BiLLT are based on the scores of typically developing children. Many of the participants in this study obtained low scores, resulting in a percentile equal to zero. An increase in the raw scores would not result in a different percentile for most of the participants, so individual growth in spoken language comprehension would not be revealed. Therefore, percentile scores are not a proper method to evaluate the change in the scores of the participants.

To evaluate the change in the obtained score in the C-BiLLT, age equivalent groups are used (see table 1). The use of age equivalents for diagnostic purposes is questionable, because it can provide a distorted view on the development of the child. Age equivalent can be less reliable, because some abilities develop more rapidly than others. A delay of six months in one ability could have more serious consequences than a delay of six months in another ability (Neijenhuis, 2001). In this study, the age equivalent groups are used to obtain insight in growth in level of spoken language comprehension. The change in score must be high enough to result in a change in age equivalent group. The age equivalent groups are used in the regression analysis.

Because of the small sample size (N=26) and the small Adjusted R Squared (,104) the conclusions cannot be generalized for the population of children with CP. The effect sizes are low, which could be caused by the small sample size.

Conclusion

The aim of this study was to answer the research questions 1) is the C-BiLLT is able to detect a change in the comprehension of spoken language in children with CP after two years and

2) which factors influence the development of comprehension of spoken language in children with severe CP?

1) There results from the second C-BiLLT assessments differed from the first results. In 16 of the 26 cases the second score resulted in a change in age equivalent group. Therefore, the C-BiLLT is able to detect a change in comprehension of spoken language in children with severe CP.

2) The regression model does not provide significant results for the variables Type of CP, Age Group, Comprehension Aim and Communication Device. However, the type of CP and the use of a Communication Device appear to be predicting factors for the progress in the comprehension of spoken language in children with severe cerebral palsy.

Not all factors could be analyzed in the regression analysis because of the small sample size. Repeating the analysis with a large test group might provide a stronger model and useful information about the factors that could influence the comprehension of spoken language in children with severe CP. To obtain information about the course of the development of comprehension of spoken language in children with severe CP, a large scale longitudinal study is recommended.

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References:

Publications:

- Baron, Reuben M. and Kenny, David A. The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. Journal of Personality and Social Psychology 1986, Vol. 51, No. 6, 1173-1182 0022-3514/86/
- Bax M, Tydeman C, Flodmark O. Clinical and MRI Correlates of Cerebral Palsy: The European Cerebral Palsy Study. JAMA. 2006;296(13):1602-1608.
- Dada S., Alant, E., The Effect of Aided Language Stimulation on Vocabulary Acquisition in Children With Little or No Functional Speech. American Journal of Speech-Language Pathology Vol.18 50-64 February 2009. doi:10.1044/1058-0360(2008/07-0018)
- Fennell, Eileen B. and Dikel, Thomas N. Cognitive and Neuropsychological Functioning in Children With Cerebral Palsy. J Child Neurol 2001 16: 58, DOI: 10.1177/088307380101600110.
- Geytenbeek J.J.M., Heimb M.J., Vermeulen R.J., Oostrom K.J.. Assessing Comprehension of Spoken Language in Nonspeaking Children with Cerebral Palsy: Application of a Newly Developed Computer-Based Instrument. Augmentative and Alternative Communication, June 2010 Vol. 26 (2), pp. 97–107
- Geytenbeek J.J.M., Harlaar L., Stam M., Ket H., Becher J. G., Oostrom K., Vermeulen J.. 2010, Utility of language comprehension tests for unintelligible or non-speaking children with cerebral palsy: a systematic review. Developmental Medicine & Child Neurology DOI: 10.1111/j.1469-8749.2010.03807.x
- Hjelmquist, E Linguistics, AAC, and metalinguistics in communicatively handicapped adolescents Augmentative and alternative communication [0743-4618] yr:1994 vol:10 iss:3 pg:169
- Himmelman, K., Beckung, E., Hagberg, G., & Uvebrant, P.Gross and fine motor function and accompanying impairments in cerebral palsy. 2006, Developmental Medicine and Child Neurology 48, 417–423.
- Husted, Janice A., Cook, Richard J., Farewell, Vern T., Gladmand, Dafna D. 2000, Methods for assessing responsiveness: a critical review and recommendations. Journal of Clinical Epidemiology 53 459–468 Elsevier.
- Kennes J, Rosenbaum P, Hanna SE, Walter S, Russell D, Raina P, et al. Health-status of school aged children with cerebral palsy: information from a population-based sample. Developmental Medicine and Child Neurology (2002) 44: 240–247.
- Neijenhuis, C.A.M., Engel-Hoek, van den, L., Gerven, van, M., Hulst, van, K. Coppens-Schellekens, W. & Mugge, A.M. (2001). Het gebruikt van centielscores bij interpretatie van logopedische testresultaten. Logopedie en Foniatrie, 10, 253-256.
- Odding, E., Roebroeck, M. E., & Stam, H. J. (2006). The epidemiology of cerebral palsy: Incidence, impairments and risk factors. Disability and Rehabilitation, 28, 183–191.
- Pennington L, Goldbart J, Marshall J. Speech and language therapy to improve the communication skills of children with cerebral palsy. Cochrane Database Syst Rev. 2004;(2):CD003466.

- Pennington L, Goldbart J, Marshall J., Speech and language therapy to improve the communication skills of children with cerebral palsy (Review). *The Cochrane Library* 2011, Issue 9.
- Pirila S., Meere, vd, J., Pentikainen T., Ruusu-Niemi P., Korpela R., Kilpinen J, Nieminen P.. (2007) Language and motor speech skills in children with cerebral palsy. Journal of Communication Disorders 40 (2007) 116–128
- Romski, M.A., Sevcik, R.A., Language Comprehension: Considerations for Augmentative and Alternative Communication. AAC Augmentative and Alternative Communication 0743-4618/93/0904–0281 Volume 9, December 1993
- Rosenbaum P, Paneth N, Leviton A, et al. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl 2007; 109: 8-14.
- Straub, K., Obrzut, J.E., Effects of Cerebral Palsy on Neuropsychological Function 2009, J Dev Phys Disabil 21:153–167
- Voorman, J. M., Dallmeijer, A. J., Van Eck, M., Schuengel, C. and Becher, J. G. (2010), Social functioning and communication in children with cerebral palsy: association with disease characteristics and personal and environmental factors. Developmental Medicine & Child Neurology, 52: 441–447. doi: 10.1111/j.1469-8749.2009.03399.x

Books:

- Altman, 1991. Practical Statistics for Medical Research. London: Chapman and Hall. Recommended Freedman, D., Pisani, R., Purves, R. Statistics
- Bates, E. (1992). Early language development and its neural correlates. In S.J. Segalowitz, & I. Rapin (Eds.), Handbook of Neuropsychology (Vol. 7, pp. 69-1 10).
- Drenth, P. J. D. & Sijtsma, K. (2006). "Testtheorie". Houten/Diegem: Bohn Stafleu Van Loghum (vierde herziene druk) Chapter 6.3.2 P 210.
- Eldik, van, M.C.M., Schlichting, J.E.P.T., Lutje Spelberg, H.C., Meulen, van der, B.F., Meulen,. van der, Sj. Reynell Test voor Taalbegrip – Handleiding. 1997, Berkhout Nijmegen BV.
- Goorhuis-Brouwer, S.M., Schaerlaekens, A.M. *Handboek taalontwikkeling, taalpathologie en taaltherapie bij Nederlandssprekende kinderen*. Uitgeverij De Tijdstroom, Utrecht, 2000-2001, ISBN 90-5898-004-9.
- Meihuizen-de Regt, M.J. Moor, de, J.M.H., Mulders, A.H.M. (red.) 2009 "Kinderrevalidatie" ISBN 9789023245070
- Moore, D.S., McCabe, G.P., Craig, B., Introduction to the Practice of Statistics. W.H.Freeman & Co Ltd, 6th Revised edition (2007) ISBN-13: 9781429216234 ISBN: 1429216239
- Tinsley, Howard E. A. & Brown, Steven D. (Eds.). "Handbook of Applied Multivariate Statistics and Mathematical Modeling". (2000). New York: Academic Press.
- Twisk, Jos WR. "Applied Multilevel Analysis: A Practical Guide". Cambridge University Press, UK 2006, pp 196, ISBN 100521614989 (PB), ISBN 100521849756 (HB)

Web pages:

- Responsiviteit van meetinstrumenten, Prof. dr. ir. Riekie de Vet, VU Medisch Centrum. http://nvmt.nl/upload/PPTRiekiedeVet.pdf

- http://motorgrowth.canchild.ca/en/GMFCS/resources/GMFCS-ER.pdf
- StatSoft, Inc. (2012). Electronic Statistics Textbook. Tulsa, OK: StatSoft. WEB: http://www.statsoft.com/textbook/
- Surveillance of Cerebral Palsy in Europe (SCPE). (2002) http://www-rheop.ujf-grenoble.fr/scpe2/site_scpe/index.php

Figures and tables

Figure 1: Example of an item of the C-BiLLT (discriminating between nouns): The child is asked: *Where is the television?* The original item is presented in full color (Geytenbeek, 2010).

Figure 2: Example of an item of the scanning section. The child is asked: *"Can you show me? The dog lies in the basket."* The original item is presented in full color (Geytenbeek, 2010).

Figure 3: Schematic design of the study

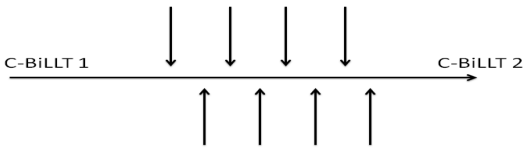

Table 1: Mean scores on the C-BiLLT of the norm group of typically developing children.

Group	Age months	Mean score	St. dev.
1.	18-24	22,57	11,48
2.	24-30	42,63	9,209
3.	30-36	47,14	5,991
4.	36-42	53,73	6,123
5.	42-48	58,08	5,212
6.	48-54	60,54	4,240
7.	54-60	62,73	4,484
8.	60-66	64,27	4,316
9.	66-72	66,31	3,884
10.	72-78	68,41	2,570
11.	78-84	70,45	2,622

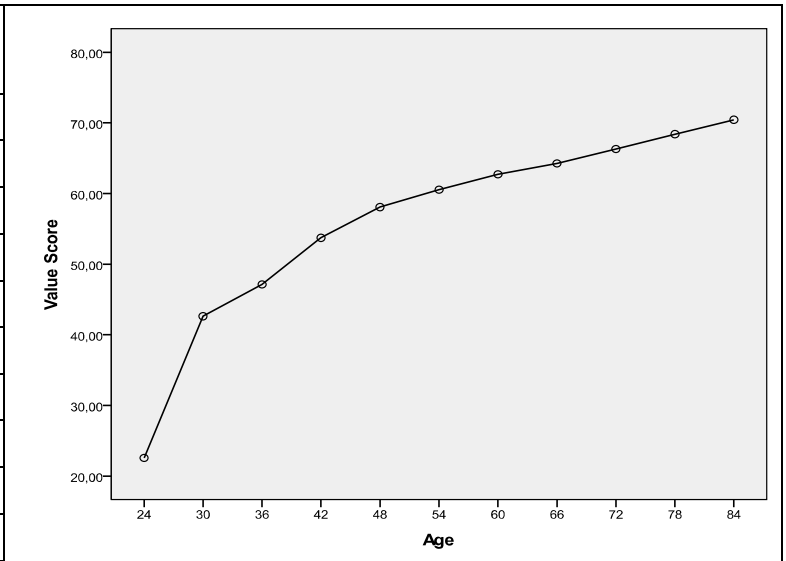

Table 2: Schematic representation of the test group

	GMFCS3	GMFCS4	GMFCS5	Total
Spastic CP	0	4	7	11
Dyskinetic CP	1	6	8	15
Total	1	10	15	26

Figure 4: Raw scores of the first C-BiLLT assessment.

Figure 5: Raw scores of the second C-BiLLT assessment. The x-axes represent the age at the moment of the assessment. The y-axes represents the raw score. Pyramids represent scores of participants with a Dyskinetic CP. Dots represent scores of children with a Spastic CP.

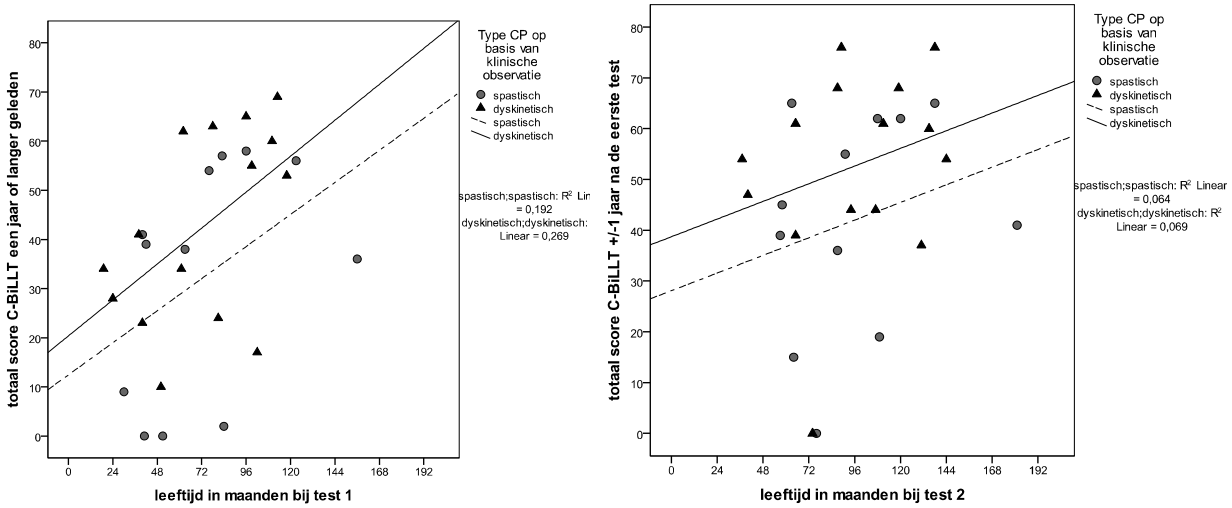

Figure 6: Raw scores from the first and second assessment of the C-BiLLT. On the X-axis, the age is represented in months. On the Y-axis, the score is represented.

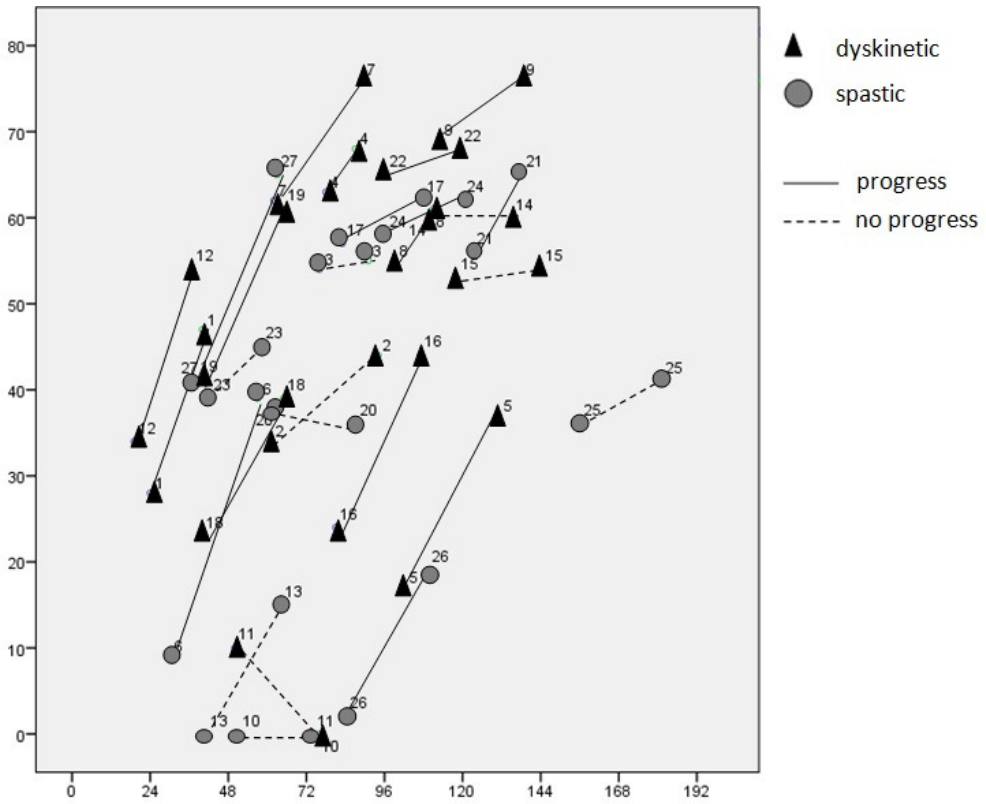

Table 3: Frequencies of progress and the number of age equivalent groups the participants improved are displayed.

Type of CP	N	No progress	Progress	Number of age equivalent groups improved						
				0	**1**	**2**	**3**	**4**	**5**	**6**
Spastic	11	6 (55%)	5 (45%)	6	2	2	1	0	0	0
Dyskinetic	15	4 (27%)	11 (73%)	4	3	4	2	1	0	1
Total	26	10 (39%)	16 (61%)	10	5	6	3	1	0	1

Figure 7: This figure represents the change in age equivalents obtained by the individual participants. On the y-axis, the age equivalent group numbers are displayed as in table 1. The lines display the distance between the obtained age equivalent groups of the first and second assessment. On the left, the equivalents of the participants with a spastic CP are represented. On the right, the equivalents of the participants with a dyskinetic CP are represented.

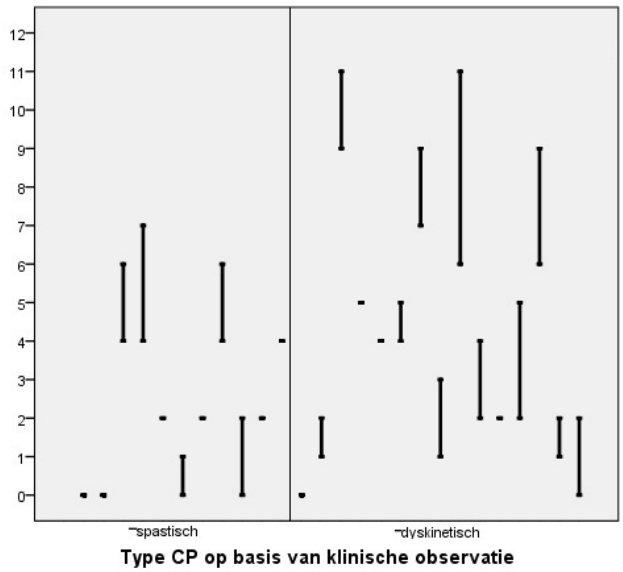

Table 4: Schematic representation of the distribution over the age groups.

Type of CP	N	Younger<7	Older > 7
Spastic	11	4	7
Dyskinetic	15	6	9
Total	26	10	16
Age Group:	N	Younger<7	Older > 7
No progress	10	5 (50%)	5 (31%)
Progress	16	5 (50%)	11 (69%)
Total	26	10	16

Figure 8: Two age groups are compared to analyze the effect of age on the change in scores. On the left, participants younger than seven years are displayed. On the right, participants older than seven years are displayed. On the y-axis, the age equivalent group numbers are displayed as in table 1.

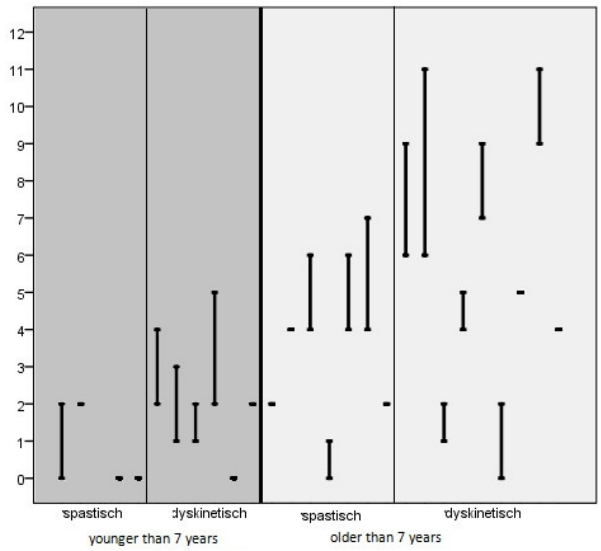

Table 5: Schematic representation of distribution over 'therapy aim'.

Type of CP	N	No aim	Aim
Spastic	11	6	5
Dyskinetic	15	9	6
Total	26	15	11
Therapy	N	No aim	Aim
No progress	10	6 (40%)	4 (36%)
Progress	16	9 (60%)	7 (64%)

Figure 9: On the left, scores are displayed from participants who did not have language comprehension as a therapy aim. On the right, scores are displayed from participants who had language comprehension as a therapy aim. On the y-axis, the age equivalent group numbers are displayed as in table 1.

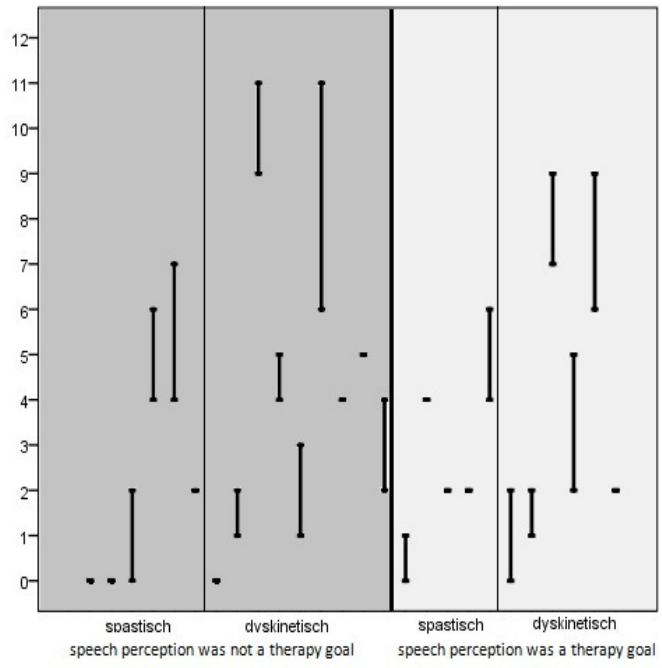

Table 6: Schematic representation of distribution over Communication Device

Type of CP	N	No S.G.D	Uses SGD
Spastic	11	5 (45%)	6 (55%)
Dyskinetic	15	3 (20%)	12 (80%)
Total	26	8 (31%)	18 (69%)
Uses:	N	No progress	Progress
No S.G.D.	8	4 (50%)	4 (50%)
S.G.D.	18	6 (33%)	12 (67%)

Figure 10: Two groups are compared to analyze the effect the use of a Speech Generating Communication Device on the change in scores. On the left, the scores of participants who do not use a S.G.D are displayed. On the right, the scores of participants who use a S.G.D are displayed. On the y-axe, the age equivalent group numbers are displayed as in table 1.

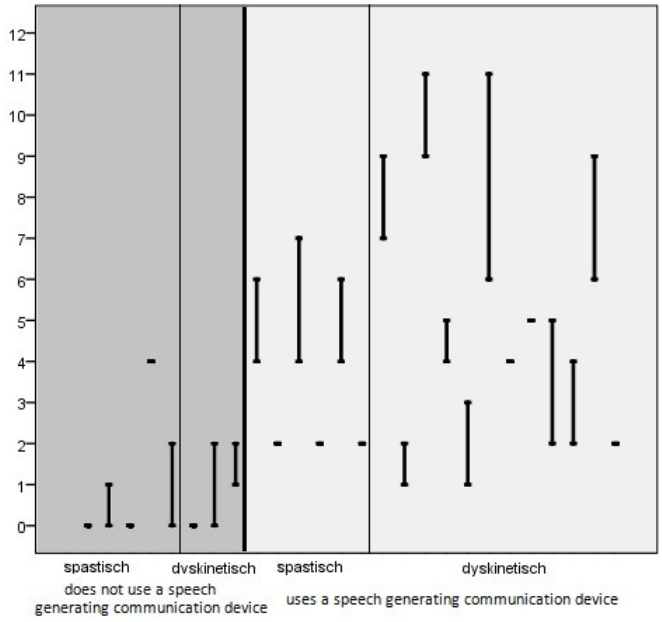

Table 7: Information about the Regression analysis

Dependent variable	Progress by Number of age equivalent groups*
Fixed Factors	Type CP Age group Therapy aim for language comprehension Use of a Communication Device
Software	SPSS 18.0
Method	Enter
Computed using alpha	$\alpha = 0.05$
Hypothesis	H0: $\beta p = 0$, none of the explanatory variables are predictors of the response variable in this model.
Correlation Coefficient	R Squared = ,247 (Adjusted R Squared = ,104)

* All groups are formed in six-months intervals, with the exception of the first group '<18 months'. This group is larger but cannot be further specified because the norm groups of the C-BiLLT start by 18 months.

Table 8: Regression Analysis

Variable	B coefficients	SE	t	Sig.	Eta sq.
(Constant)	-1,286	1,371	-,937	,359	,341
Age Group	,643	,642	1,001	,328	,060
Type of CP	,786	,602	1,306	,206	,046
Comprehension Aim	-,357	,595	-,601	,555	,007
Communication Device	,786	,692	1,135	,269	,043
Source	DF	Sum of squares	Mean square	F	
Model	4	14,368	3,592	1,723	
Residual	21	43,786	2,085	P	
Total	25	58,154		,183	

Appendix A

Survey for the parents of the participants, created on www.thesistools.com

Geachte ouder,

In deze vragenlijst vindt u een aantal vragen over uw kind en over gebeurtenissen in het leven van uw kind in het afgelopen jaar. Het invullen van de vragenlijst duurt ongeveer 10 minuten.

Start

Pagina: 2

1.

Wat is de naam van uw kind? *

2.

Wat is het geslacht van uw kind? *

- jongen
- meisje

3.

Wat is de geboortedatum van uw kind? *

4.

Wat is uw hoogst genoten opleiding? *

- WO
- HBO
- MBO
- LBO
- Anders namelijk:

5.

Wat is uw nationaliteit? *

6.

In welke taal wordt thuis tegen uw kind gesproken? *

7.

Met welk type CP is uw kind gediagnosticeerd? *

- Spastisch
- Dyskinetisch
- Atactisch
- Niet bekend

8.

Heeft uw kind epilepsie? *

- Ja
- Nee

9.

Wat voor aanvallen zijn dit? *

- Absence, lichte kortdurende aanval
- Verslapping van de spieren
- Grote aanval, alle spieren verstijven
- Anders, namelijk:

10.

Hoe oud was uw kind toen de eerste epileptische aanval kwam? *

11.

Gebruikt uw kind anti-epileptische medicatie? *

- [ ] Ja, namelijk: (merk en dosering)...
- [ ] Nee

12.

Is de medicatie van uw kind het afgelopen jaar veranderd? *

- [ ] Ja, de dosering is verhoogd
- [ ] Ja, de dosering is verlaagd
- [ ] Ja, het merk is veranderd
- [ ] Nee

13.

Is uw kind het afgelopen jaar in het ziekenhuis opgenomen? *

- [ ] Ja, omdat...
- [ ] Nee

14.

Welke veranderingen hebben het afgelopen jaar thuis plaatsgevonden?
U mag meerdere antwoorden geven.

- [ ] Verhuizing
- [ ] Scheiding
- [ ] Geboorte van broertje of zusje
- [ ] Sterfgeval binnen de familie
- [ ] Anders namelijk:
- [ ] Geen veranderingen

15.

Op welke manier communiceert uw kind thuis?

- [ ] Spraak
- [ ] Geluiden

- [ ] Lichaamstaal
- [ ] Gebaren
- [ ] Communicatieboek, bladen, picto's etc.
- [ ] Communicatieapparaat met spraakuitvoer
- [ ] Anders namelijk:

16.

Door wie is deze vragenlijst ingevuld? *

- [ ] Vader
- [ ] Moeder
- [ ] Vader en moeder samen
- [ ] Anders, namelijk

Verstuur vragenlijst

Pagina: 3

Hartelijk dank voor het invullen van de vragenlijst. De antwoorden zullen vertrouwelijk worden behandeld.

Met vriendelijke groet,

Cynthia Tuinstra-Werkman,
Logopedist, student logopediewetenschap.

Appendix B

Survey for the speech and language therapists of the participants, created on www.thesistools.com

Appendix 2 Survey for the speech and language therapist
Geachte logopedist,

In deze vragenlijst vindt u een aantal vragen over het kind en over gebeurtenissen rondom de therapie in het afgelopen jaar. Het invullen van de vragenlijst duurt ongeveer 10 minuten.

Start

Pagina: 2

1.

Wat is de naam van het kind? *

2.

Wat is het geslacht van het kind? *

- jongen
- meisje

3.

Wat is de geboortedatum van het kind? *

4.

Wat is uw hoogst genoten opleiding? *

- WO
- HBO
- MBO
- LBO

- [ ] Anders namelijk:

5.

Wat is uw nationaliteit? *

6.

Hoelang kent u het kind al? *

- [ ] Een half jaar of korter
- [ ] Korter dan een jaar, langer dan een half jaar
- [ ] Een tot twee jaar
- [ ] Langer dan twee jaar

7.

In welke omgeving heeft u contact met het kind?

- [ ] Op school/dagbesteding in de groep
- [ ] Op school/dagbesteding, individueel
- [ ] Anders namelijk...

8.

Met welk type CP is het kind gediagnosticeerd? *

- [ ] Spastisch
- [ ] Dyskinetisch
- [ ] Atactisch
- [ ] Niet bekend

9.

Heeft het kind behalve CP nog andere beperkingen?
U mag meerdere antwoorden geven.

- [ ] Autisme
- [ ] Ernstige verstandelijke beperking, IQ < 50

- [ ] Licht verstandige beperking IQ 50 – 70
- [ ] Ontwikkelingsachterstand (op school?)
- [ ] Gehoorstoornis
- [ ] Visusstoornis
- [ ] Voedingsproblematiek
- [ ] Slikstoornis
- [ ] Spraakstoornis
- [ ] Nee, geen van deze stoornissen
- [ ] Anders namelijk

10.

Wat is het GMFCS-niveau van het kind? *

- [ ] Niveau IV
- [ ] Niveau V
- [ ] Ik weet het niet

11.

Wat was de logopedische therapiefrequentie per week van het kind in het afgelopen jaar voor individuele therapie? *

12.

Wat was de logopedische therapiefrequentie per week van het kind in het afgelopen jaar voor groepstherapie? *

13.

Was er een verandering in de logopedische therapiefrequentie? *

- [ ] Ja, de frequentie per week ging omhoog
- [ ] Ja, de frequentie per week ging omlaag
- [ ] Nee, er was geen verandering

14.

Wat was het doel van de therapie?
U mag meerdere antwoorden geven.

- ☐ expressieve taalontwikkeling
- ☐ receptieve taalontwikkeling
- ☐ conversatievaardigheden
- ☐ eet- en drinkproblemen
- ☐ Anders, namelijk...

15.

Op welke manier communiceert het kind in de therapie?
U mag meerdere antwoorden geven.

- ☐ Spraak
- ☐ Geluiden
- ☐ Lichaamstaal
- ☐ Gebaren
- ☐ Communicatieboek,picto's
- ☐ Communicatieapparaat met spraakuitvoer
- ☐ Anders, namelijk...

16.

Heeft het kind in het afgelopen jaar een communicatie-apparaat met spraakuitvoer gekregen? *

- ○ Ja, langer dan een half jaar geleden
- ○ Ja, korter dan een half jaar geleden
- ○ Nee, geen communicatie-apparaat gekregen
- ○ Nee, het apparaat was er al langer dan een jaar geleden

Verstuur vragenlijst

Pagina: 3
Hartelijk dank voor het invullen van de vragenlijst. De antwoorden zullen vertrouwelijk worden behandeld.

Met vriendelijke groet,

Cynthia Tuinstra-Werkman,
Logopedist, student logopediewetenschap.