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RESEARCH REPORT

Convergent validity of functional communication tools and spoken language comprehension assessment in children with cerebral palsy

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Abstract

Background: The majority of children with cerebral palsy (CP) experience challenges in functional communication from a young age. A pivotal aspect of functional communication is language comprehension. A variety of classification systems and questionnaires are available to classify and describe functional communication skills in children with CP. A better understanding of the convergent validity of (subsections of) these tools, as well as their relationship with spoken language comprehension, will be valuable in both clinical practice and research.

Aims: To investigate the convergent validity of (subsections of) functional communication tools and the relationship with spoken language comprehension in children with CP.

Methods & Procedures: Cross-sectional data on 138 children were subdivided into three developmental stages based on (Dutch) educational phases: ages 18 months–3;11y (n = 59), 4;0–5;11 years (n = 37) and 6;0–8;11 years (n = 42). The following functional communication tools were used to classify and describe functional communication: Communication Function Classification System (CFCS), subscales of the Caregivers Priorities and Child Health Index of Life with Disabilities—Dutch Version (CPCHILD-DV) and the Focus on Communication Under Six-34 (FOCUS-34) questionnaire. Spoken language comprehension was assessed with the Computer-Based instrument for Low motor Language Testing (C-BiLLT). Correlations between the functional communication tools, and with the C-BiLLT, were calculated using Pearson's and Spearman's correlation coefficients. It was hypothesized a priori that correlations of at least 0.60 suggest good convergent validity.

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Outcomes & Results: At all developmental stages, a significant ordered decreasing tendency of communication outcomes was found across CFCS levels; lower CFCS levels were associated with lower scores on the CPCHILD-DV and FOCUS-34, and with a lower level of spoken language comprehension (C-BiLLT). Correlation coefficients of the functional communication tools exceeded 0.60 at all developmental stages. Correlations between C-BiLLT raw scores and the functional communication tools varied between 0.351 and 0.591 at developmental stage 18 months–3;11 years, between 0.781 and 0.897 at developmental stage 4;0–5;11 years, and between 0.635 and 0.659 at developmental stage 6;0–8;11 years.
Conclusions & Implications: The functional communication tools assessed in this study showed convergent validity at all developmental stages. The CFCS, currently most widely used in paediatric rehabilitation, is adequate in the classification of functional communication. However, for more detailed clinical goal setting and evaluation of change in functional communication, the additional use of FOCUS-34 or CPCHILD-DV is recommended.

KEYWORDS
assessment tools, cerebral palsy, functional communication, spoken language comprehension

What this paper adds

What is already known on the subject

- A range of functional communication tools are available that help describe and classify functional communication in children with CP. These include the CFCS, subsections of CPCHILD-DV and FOCUS-34. The CFCS classifies functional communication in daily life with familiar and unfamiliar partners. Specific subsections of the CPCHILD-DV and FOCUS-34 include items that pertain to communicative participation. The innovative C-BiLLT provides a standardized method to assess spoken language comprehension in children with CP and significant motor impairments.

What this paper adds to existing knowledge

- In the present study, convergent validity was confirmed between CFCS and specific subsections of the CPCHILD-DV and FOCUS-34. Correlations between these functional communication tools and the C-BiLLT were moderate to strong.

What are the potential or actual clinical implications of this work?

- For clinical and research purposes (for instance, accurate prescription of augmentative and alternative communication—AAC), healthcare and educational professionals together with parents need to know how functional communication tools converge and how functional communication levels relate to the comprehension of spoken language. The CFCS provides a valid classification of functional communication abilities in children with CP.

However, to measure change in functional communication and to evaluate treatment outcomes, use of additional functional communication tools such as the CPCHILD-DV and FOCUS-34 is recommended. When discrepancies are found between communicative abilities and spoken language comprehension, it is strongly recommended that valid tools are used in a more detailed examination of the child's spoken language comprehension skills and functional communication.

INTRODUCTION

The majority of children with cerebral palsy (CP) experience challenges in functional communication from a young age (Pennington et al., 2004; Voorman et al., 2010). These challenges may include difficulties in speech intelligibility and/or in language and pragmatic abilities, but use of augmentative and alternative communication (AAC) can help to overcome these challenges (Kristoffersson et al., 2020). Children with communication challenges are restricted when expressing their needs and wants, building relationships and learning language (Light & Drager, 2002), all of which may contribute to lower participation in various life domains (Fauconnier et al., 2009). When assessing communication, functional outcomes should reflect how an individual communicates in a range of situations (Thomas-Stonell et al., 2013).

Valid and standardized assessment of functional communication and spoken language comprehension is essential for decision making regarding the prescription and evaluation of AAC, as well as decisions regarding adequate educational programmes (Dietz et al., 2012; Drager et al., 2010; Geytenbeek et al., 2010; Light & Drager, 2007). The positive effects of using AAC are well known (Hunt-Berg, 2005; Romski & Sevcik, 1997) and children who use AAC show increased levels of educational and social participation over time (Hunt-Berg, 2005). The use of AAC also plays an important role in language learning and communicative development (Romski & Sevcik, 1997). Nevertheless, AAC seems to be under-used. For example, in a group of children with CP with severe speech problems, only half were using AAC to improve daily communication (Andersen et al., 2010). Children who experience challenges in communication benefit from regular assessment of spoken language comprehension and communication, which helps provide the support and assistance they need to participate in social communication, with or without use of AAC (Geytenbeek et al., 2015).

A variety of classification systems and questionnaires are available to help describe and classify functional communication skills in children with CP. The Communication Function Classification System (CFCS; Hidecker et al., 2011), which classifies functional communication in daily activities with familiar and unfamiliar partners, has five levels. The CFCS also offers health and educational professionals and parents a standardized, joint language with which to discuss functional communication levels. The Caregivers Priorities and Child Health Index of Life with Disabilities (CPCHILD; Narayanan et al., 2006) is a parent-reported questionnaire that includes a communication and social interaction section which focuses on the daily communicative environment and social interactions of the child. The Focus on Communication Under Six (FOCUS; Thomas-Stonell et al., 2010) is a questionnaire that describes communicative participation in preschool, at home, in school and in the community, and was specifically developed to measure longitudinal changes in communicative functioning. Previous research found strong evidence for good construct validity and predictive validity between the CFCS and FOCUS, as reported by speech language therapists (SLTs) and parents (Hidecker et al., 2011).

Spoken language comprehension is pivotal for functional communication (Pennington et al., 2020) as it provides a foundation for the acquisition of the meaning of symbols and other communicational signs (Sevcik, 2006). In order to communicate effectively, a prerequisite is to understand the communication partner (Hoff, 2015). When SLTs wish to determine the most suitable AAC, proper evaluation of an individual's comprehensive language skills is crucial. For instance, it is essential to know if a child with communication needs is able to follow verbal commands (Dietz et al., 2012). In the past, considerable effort was expended to adapt existing language assessment tools for use in children with CP. A transformative innovation—the Computer-Based instrument for Low motor Language Testing (C-BiLLT)—was developed and validated in the Netherlands (Geytenbeek et al., 2014). The C-BiLLT was shown to be valid and reliable, and emerging evidence suggests cross-cultural applicability (Fiske et al., 2020). The C-BiLLT, which provides a standardized assessment of language comprehension in children with CP with significant motor impairments (Geytenbeek et al., 2014), is now in use in the Netherlands, Belgium and Norway, with pilot studies completed in Sweden, Germany, Romania, the UK, Ireland and Canada.

In clinical rehabilitation, the development of children with CP is compared with typical developing (TD) children. In typical language and communication development, consecutive developmental stages can be distinguished that are demarcated by age-related milestones (Hoff, 2015). Educational systems typically lean heavily on TD developmental stages. Allocating children to developmental stages based on the educational system seems to make comparisons between CP and TD children easier for educational professionals, healthcare professionals and parents and therefore makes these findings much more usable. Furthermore, when functional communication and spoken language comprehension are described and assessed, selection of an appropriate tool to obtain valid functional outcomes requires the developmental stage of the child to be taken into account (Hoff, 2015). Especially in toddlers (<4 years), relationships between functional outcomes may differ from relationships found in older children. Even in TD language and communication, toddlers form a heterogeneous group and more often depend on non-verbal communication. It is thought that receptive communication and spoken language comprehension precedes expressive language and communication (Carroll, 2008; Hoff, 2015).

Investigating the convergent validity of functional communication tools in children with CP will help improve clinical practice and support further research. It is also of interest to understand the relationship between spoken language comprehension and the outcomes of functional communication as measured with these tools. Therefore, the main objectives of the present study were (1) to investigate the convergent validity of (subsections of) available functional communication tools for children with CP (i.e., CFCS, FOCUS-34 and CPCHILD-DV); and (2) to study the relationship between spoken language comprehension (as measured with the C-BiLLT) and the outcomes of functional communication tools. We hypothesized good convergent validity between functional communication tools at all developmental stages, and moderate to strong correlations between the functional communication tools and the C-BiLLT.

METHODS

Design and participants

Cross-sectional baseline data were retrieved from the Cerebral Palsy—Communication and Language Learning (CP-CaLL) project. This is a multi-site prospective longitudinal cohort study that prospectively follows children with CP to investigate the development of spoken language comprehension and functional communication, together with its determinants. Children were divided into three developmental stages that match the Dutch educational system: 18 months–3;11 years (toddlers), 4;0–5;11 years (preschool children) and 6;0–8;11 years (schoolchildren). Children were recruited between November 2017 and August 2018 through convenience sampling of hospitals, rehabilitation and daycare centres throughout the Netherlands. Inclusion criteria were (1) a confirmed diagnosis of CP; (2) age between 18 months and 8;11 years; and (3) at least one parent fluent in Dutch. Exclusion criteria were (1) severe auditory problems (hearing threshold of ≥31 dB for the best ear); (2) severe visual problems (<0.3 corrected with spectacles for the best eye); (3) diagnosis of severe cerebral visual impairment (CVI); and (4) diagnosis of neurological disorders other than CP. The use of C-BiLLT has not been investigated in children with severe auditory and visual problems, or in children with a severe diagnosis of CVI (Geytenbeek et al., 2014). As validity has not been confirmed in these children, we chose to exclude this group from participation.

The Medical Ethical Committee of Amsterdam University Medical Centers, location VUmc, reviewed the study. The committee stated that the Medical Research Involving Human Subjects Act (WMO) does not apply to this study. This study complies with the General Data Protection Regulation (GDPR). Written informed consent was obtained from the child's parents/caregivers, following Medical Ethical Committee guidelines.

The total CP-CaLL cohort consists of 207 children. Parents/caregivers of 138 children (67% of the total cohort) completed the questionnaires (see next sections) and were included in the present study. This sample did not differ significantly from the 69 children for whom parents did not respond to the questionnaires, either in terms of age ($p = 0.289$), gender ($p = 0.231$), motor type ($p = 0.188$), motor distribution ($p = 0.759$), GMFCS) ($p = 0.721$), CFCS ($p = 0.196$) or the use of AAC ($p = 0.288$).

Language and functional communication tools

Assessment of language and functional communication was carried out in the child's educational environment or at their home and was administered by clinically trained speech language researchers (EV, JG) or a certified SLT from the child's own rehabilitation or daycare centre. The online questionnaire comprised questions from the FOCUS-34 (Oddson et al., 2019) and the CPCHILD-DV questionnaire (Narayanan et al., 2006), and parents completed the questionnaire via Castor EDC (Castor EDC, 2019).

Communication Function Classification System (CFCS)

The CFCS was developed for individuals with CP between the ages of 2 and 18 years (Hidecker et al., 2011; Van der Zwart et al., 2016). The CFCS classifies the everyday communication performance of an individual with CP to one of five possible levels, varying from level I, which corresponds to no restrictions in communicative functioning, to level V, which corresponds to seldom effective communication even with familiar communication partners. All methods of communication performance are considered when determining the CFCS level, including use of speech, gestures, behaviour, eye gaze, facial expressions and AAC. The concurrent validity and intra-rater reliability of the Dutch-language version of the CFCS (CFCS-NL) is good. Interrater reliability between parents and SLTs was fair, while interrater reliability between SLTs was good (Van der Zwart et al., 2016).

Focus on the Outcomes of Communication Under Six-34 (FOCUS-34)

The FOCUS-34 questionnaire (Oddson et al., 2019) inventories communicative participation in preschool children aged from 18 months to 6 years and covers the home, school and the community. This tool was intended for parents or SLTs and was designed to evaluate changes in a child's communication during or after speech–language therapy. The FOCUS-34 has been shown to be a valid tool when measuring longitudinal changes in communication (Oddson et al., 2019), and change due to treatment is measured using the total FOCUS-34 score. The FOCUS-34 consists of two parts and naturally includes a total of 34 items. Part 1 comprises questions about grammar, speech and talking that are not suitable for all children in our cohort. In this study part 2 of the FOCUS-34, which focuses on effective communication, was therefore used. We decided to exclude one question ('My child will try to carry on a conversation with adults who do not know my child well') as it refers to conversational skills rather than functional communication skills. Answers on the FOCUS-34 with corresponding scores are: 'Cannot do at all', 0; up to 'Can always do without help' with a score of 6. Ten FOCUS-34 questions (with a maximum score of 60) were used, selected because they focus on the efficiency of daily communication with or without the use of AAC (see Table S1 in the additional supporting information). While the FOCUS-34 was originally developed and validated for children aged up to 6 years, in this study we also included children aged between 6;0 and 8;11 years.

Caregivers Priorities and Child Health Index of Life with Disabilities—Dutch version (CPCHILD-DV)

The CPCHILD-DV questionnaire (Narayanan et al., 2006) measures parents/caregivers' perceptions of the health, comfort and wellbeing, functional possibilities and difficulty in nursing of children, and covers children aged 4–18 years with severe motor problems corresponding to GMFCS levels IV or V (Palisano et al., 1997). The questionnaire consists of nine sections, and only section 4 'Communication and social interaction' was used in this study. This section focuses on daily communication and communicative participation. Answers, with corresponding scores, on this section of the CPCHILD-DV are: 'Almost impossible', 0; up to 'No problem at all' with a score of 6. The questionnaire comprises nine questions (see Table S1 in the additional supporting information), with a maximum total score of 54. Good test–retest reliability was reported for the communication and social interaction domain, and interrater reliability was moderate to good. Convergent validity of this subsection was moderate and content validity scored by the parents was good (Zalmstra et al., 2015).

Computer-Based instrument for Low motor Language Testing (C-BiLLT)

The C-BiLLT (Geytenbeek et al., 2014) assesses spoken language comprehension directly, and consists of a pretest and a computer test with a maximum score of 87. The pretest is administered to ensure that the child is able to communicate a choice between two objects and/or photos, based on object naming. When the pretest is successful, the computer test is administered. The computer test consists of 85 items, with increasing difficulty in terms of linguistic complexity, and follows the spoken language comprehension stages from one-word sentences to compound-complex sentences. The C-BiLLT incorporates different access methods when answering questions, such as a touchscreen or (computerized) eye-gaze pointing. Integrating different access methods allows even children with the most severe gross and fine motor skill problems to independently answer questions. Norm data and corresponding percentile scores are provided from the age of 18 months to 7 years. For children 7 years or older, test results are expressed as age equivalents based on attained raw scores. The C-BiLLT shows good to excellent reliability and validity measures (Geytenbeek et al., 2014). C-BiLLT scores were used to classify spoken language comprehension as 'below average' (i.e., percentile scores <16 for children younger than 7 years; and raw scores <74 in children older than 7 years) and 'average' (i.e., percentile scores ≥16 in children younger than 7 years; and raw scores ≥74 in children older than 7 years). Based on this classification, children could also be divided between below average and average spoken language comprehension groups.

Sociodemographic and other functional outcomes

Other classification systems in addition to the CFCS were used to describe functional mobility (GMFCS; Palisano et al., 1997), arm hand functioning (Manual Ability Classification System—MACS; Eliasson et al., 2006), and speech production (Viking Speech Scale—VSS; Pennington et al., 2013a), scored by the child's rehabilitation physician and therapists (see Table S2 in the additional supporting information for an overview). Demographic (age and sex) and additional CP-related and other clinical data (e.g., motor type, motor distribution and use of AAC) were collected from medical records.

Statistical analysis

Statistical analyses were performed in each of the three developmental stages (i.e., toddlers, preschool and school children), and in the spoken language comprehension groups (i.e., based on below average and average spoken language comprehension) separately. Descriptive statistics were used for the demographic data and communication scores. Scatterplots were used to illustrate the relationship between age, CFCS level and raw (sub)scores of C-BiLLT, FOCUS-34 and CPCHILD-DV. Mean scores for each language and communication measure within each CFCS level were calculated and compared across CFCS levels using a statistical test for trend, that is, one-way analysis of variance (ANOVA) with a trend analysis for linear, quadratic and cubic trends. In all calculations, raw (sub)scores of C-BiLLT, FOCUS-34 and CPCHILD-DV were used in order to be congruent across all developmental stages and tools, since normed scores are not available for subsections of the FOCUS-34 and CPCHILD-DV, or for children older than 7 years on the C-BiLLT. Correlation coefficients were calculated using either Pearson's correlation (for continuous variables; C-BiLLT raw scores, CPCHILD-DV and FOCUS-34 subscores) or Spearman's rank correlation (for categorical variables; CFCS). Correlation coefficients were used to determine convergent validity of the different functional communication tools, and correlations between functional communication tools and the C-BiLLT. It was hypothesized a priori that good convergent validity is represented by correlations of at least 0.60 (Terwee et al., 2007). Pearson's correlation coefficients of <0.30 were considered weak, 0.31–0.60 as moderate, and >0.61 as strong. Spearman's rank correlation coefficients of <0.20 were considered very weak, 0.20–0.40 as weak, 0.41–0.60 as moderate, 0.61–0.80 as strong and ≥0.80 as very strong (Campbell & Swinscow, 2009). For testing convergent validity, a target sample of at least 50 participants within each age group is preferred (De Vet et al., 2011). Statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, 2019). Missing data were addressed using listwise deletion.

RESULTS

Participants

A total of 138 children (boys, $n = 77$; girls, $n = 62$) and their parents/caregivers participated (Table 1).

Communication and language scores

Both in the total group ($n = 138$) and at the different developmental stages, the mean scores on the C-BiLLT, CPCHILD-DV and FOCUS-34 differed significantly ($p < 0.001$) between CFCS levels. At all developmental stages (Table 2) and in the spoken language comprehension groups (below average and average) (see Table S3 in the additional supporting information), a significant ordered decreasing tendency of scores was found in functional communication and language measures across the CFCS levels ($p < 0.001$). Higher mean scores were found in children with lower CFCS levels, that is, better functional communication (Table 2). The majority of children with average spoken language comprehension were classified at CFCS levels I and II, while most of the below average group was classified as CFCS III, IV or V. More than half of the children in the below average spoken language comprehension group had speech problems or no speech at all. Compared with children with average spoken language comprehension, a larger proportion of children with below average language comprehension used AAC (Table 3).

TABLE 1 Demographics of 138 children with CP

Patient characteristics	Toddlers, 18 months–3;11 years N (%)	Preschool children, 4;0–5;11 years N (%)	Schoolchildren, 6;0–8;11 years N (%)	Total cohort, 18 months–8;11 years N (%)
Total	59 (43)	37 (27)	42 (30)	138 (100)
Age (months)				
Range	17–47	48–71	72–107	17–107
Mean (SD)	35.31 (8.70)	60.70 (7.34)	90.26 (9.51)	58.84 (24.81)
Gender				
Boys	29 (49)	27 (71)	21 (50)	76 (55)
Girls	30 (51)	11 (29)	21 (50)	62 (45)
Motor type				
Spastic	51 (91)	32 (91)	33 (83)	116 (89)
Non-spastic	5 (9)	3 (9)	7 (18)	15 (11)
Missing	3	2	2	7
Motor distribution				
Unilateral	23 (39)	14 (38)	13 (31)	50 (36)
Bilateral	36 (61)	23 (62)	29 (69)	88 (64)
GMFCS				
I	16 (28)	9 (24)	9 (21)	34 (25)
II	13 (23)	11 (30)	14 (34)	38 (28)
III	9 (16)	3 (8)	4 (9)	16 (12)
IV	12 (21)	10 (27)	11 (26)	33 (24)
V	6 (11)	4 (11)	4 (9)	14 (10)
Missing	3	0	0	3
MACS				
I	10 (21)	8 (24)	8 (21)	26 (22)
II	10 (21)	10 (29)	12 (31)	32 (26)
III	7 (15)	12 (35)	14 (36)	33 (27)
IV	7 (15)	2 (6)	3 (8)	12 (10)
V	2 (4)	2 (6)	2 (5)	6 (5)
n.a.; age <2 years	12 (25)			12 (10)
Missing	11	3	3	17
CFCS				
I	12 (22)	14 (39)	16 (38)	42 (32)
II	7 (13)	9 (25)	10 (24)	26 (19)
III	7 (13)	2 (6)	5 (12)	14 (10)
IV	16 (29)	11 (31)	9 (21)	36 (27)
V	4 (7)	0 (0)	2 (5)	6 (5)
n.a.; age <2 years	9 (16)			9 (7)
Missing	4	1	0	5
Viking Speech Scale				
I	n.a.	10 (29)	17 (44)	27 (21)
II		11 (32)	11 (28)	22 (17)
III		4 (12)	8 (21)	12 (9)
IV		9 (27)	3 (8)	12 (9)

(Continues)

TABLE 1 (Continued)

Patient characteristics	Toddlers, 18 months–3;11 years *N* (%)	Preschool children, 4;0–5;11 years *N* (%)	Schoolchildren, 6;0–8;11 years *N* (%)	Total cohort, 18 months–8;11 years *N* (%)
n.a.; age <4 years	59 (100)			59 (45)
Missing	0	3	3	6
Use of AAC				
No	33 (56)	26 (70)	27 (68)	86 (63)
Yes	26 (44)	11 (30)	13 (32)	50 (37)
Missing	0	0	2	2

Note: AAC,Augmentative and Alternative Communication; CFCS, Communication Function Classification System; GMFCS, Gross Motor Function Classification System; MACS, Manual Ability Classification System; n.a., not applicable.

Convergent validity of functional communication tools

In all three developmental stages, correlations between the different functional communication tools were significant, varied between 0.660 and 0.906 and thus confirmed good convergent validity (Table 4). In the spoken language comprehension groups, correlation coefficients varied between 0.602 and 0.823, confirming good convergent validity between the functional communication tools (Table 5).

Relationship between C-BiLLT and functional communication tools

Correlations between the three functional communication tools and C-BiLLT raw scores were significant, showing a moderate correlation for toddlers (0.351–0.591), and strong correlations for preschool (0.781–0.897) and schoolchildren (0.635–0.659) (Table 4).

DISCUSSION

In this study we found good convergent validity for three functional communication tools (CFCS and subsections of CPCHILD-DV and FOCUS-34), and a moderate to strong relationship between functional communication and spoken language comprehension (C-BiLLT). Our hypotheses were also confirmed for all developmental stages, that is, good convergent validity between the CFCS and subscales of the CPCHILD-DV and FOCUS-34. With the exception of the toddler group, strong correlations were found between the functional communication tools and spoken language comprehension, as assessed by the C-BiLLT in preschool and schoolchildren up to 8 years of age.

Functional communication tools

The CFCS is a widely used tool and has been validated for the classification of functional communication in children with CP. When wishing to describe communicative participation in more detail, additional tools such as the FOCUS-34 and the communication and social interaction subsection of the CPCHILD-DV can be used. Using these questionnaires, clinical goals for speech language therapy, a recommendation for AAC or defined educational goals can be established and evaluated, especially regarding longitudinal changes in communicative abilities. The present study found an overall tendency of scores within the different developmental stages, with lower (better) levels of CFCS showing (better) higher scores on the functional communication tools.

Although originally developed for children up to the age of 6, the FOCUS has been previously assessed in children older than 6 years, so the present study is no exception (Pennington et al., 2013b; Washington et al., 2015). In the study of Pennington et al. (2013b), clinically meaningful changes were reported in children with CP up to the age of 11 years. Furthermore, although adaptations of the FOCUS (i.e., using a selection of questions) have not been investigated for validity and reliability, previous adaptations were successfully used to investigate particular communicative domains such as speech (Rusiewicz et al., 2017). While the purpose of the present study was not to assess meaningful changes, our results showed a good convergent validity between a subscale adaptation of FOCUS-34 and the CFCS. It should be noted that the questions included from the FOCUS-34, such as 'The child can communicate effectively with adults who know the child well', are similar to the distinction between levels II and III of the CFCS, referring to the familiarity or unfamiliarity of the communication partner to the child. Nevertheless, other FOCUS-34 questions, such as 'The child is included in games by other children',

TABLE 2 Language and communication outcomes by CFCS level in developmental stages

Language and communication outcomes		CFCS level					
		Mean (SD)					Analysis of variance (ANOVA) with trend analysis
	Ranges	I	II	III	IV	V	*F* (*p*)
Toddlers: 18 months–3;11 years							
C-BiLLT raw score	0–68	47.67 (12.83)	44.71 (15.81)	50.43 (10.89)	37.50 (18.40)	11.50 (21.69)	16.042 (< 0.001)
CPCHILD-DV subscore	5–53	44.75 (6.38)	39.71 (6.45)	40.43 (6.35)	34.19 (6.80)	18.25 (4.99)	53.420 (< 0.001)
FOCUS-34 subscore	0–60	50.67 (9.72)	35.14 (15.52)	30.71 (10.05)	24.88 (16.85)	4.75 (3.40)	37.632 (< 0.001)
Preschool children: 4;0–5;11 years							
C-BiLLT raw score	1–74	66.36 (6.64)	56.33 (16.93)	57.00 (1.41)	27.36 (19.51)	n.a.	31.296 (< 0.001)
CPCHILD-DV subscore	14–54	45.64 (6.43)	41.11 (10.25)	33.00 (7.07)	28.00 (9.73)	n.a.	24.236 (< 0.001)
FOCUS-34 subscore	2–60	52.86 (4.87)	46.56 (12.80)	35.50 (9.19)	19.00 (16.14)	n.a.	45.467 (< 0.001)
Schoolchildren: 6;0–8;11 years							
C-BiLLT raw score	2–84	76.50 (5.05)	67.20 (9.53)	65.75 (7.37)	61.22 (12.64)	9.50 (10.61)	104.130 (< 0.001)
CPCHILD-DV subscore	17–54	48.56 (6.92)	40.80 (7.45)	36.40 (10.41)	35.44 (7.30)	20.00 (4.24)	28.015 (< 0.001)
FOCUS-34 subscore	2–60	57.31 (5.02)	43.10 (7.28)	37.60 (16.58)	33.22 (12.68)	2.50 (0.71)	66.273 (< 0.001)
Total cohort: 18 months–8;11 years							
C-BiLLT raw score	0–84	64.88 (14.41)	57.38 (16.38)	56.15 (11.09)	40.33 (21.43)	10.83 (17.49)	65.047 (< 0.001)
CPCHILD-DV subscore	11–54	46.50 (6.66)	40.62 (7.99)	37.93 (7.99)	32.61 (8.30)	18.83 (4.40)	85.338 (< 0.001)
FOCUS-34 subscore	1–60	53.93 (7.07)	42.15 (12.26)	33.86 (12.20)	25.17 (16.17)	4.00 (2.90)	115.817 (< 0.001)

Note: CFCS, Communication Function Classification System; C-BiLLT, Computer-Based instrument for Low motor Language Testing; CPCHILD-DV, Caregivers Priorities and Child Health Index of Life with Disabilities-Dutch Version; FOCUS-34, Focus on the Outcomes of Communication Under Six-34; n.a., not applicable.

TABLE 3 CFCS, VSS and use of AAC in spoken language comprehension groups, based on C-BiLLT scores

	Spoken language comprehension ($N = 136$; missing: $N = 2$)		
	Below average	Average	
	N (%)	N (%)	χ^2 (p)
Total	75 (55)	61 (45)	
CFCS			
I	7 (17)	35 (83)	34.592 (< 0.001)
II	15 (58)	11 (42)	
III	7 (58)	5 (42)	
IV	27 (75)	9 (25)	
V	6 (100)	0 (0)	
VSS			
I	4 (15)	22 (85)	26.109 (< 0.001)
II	10 (45)	12 (55)	
III	8 (67)	4 (33)	
IV	11 (92)	1 (8)	
n.a.; < 4 years	37 (64)	21 (36)	
Use of AAC			
No	41 (48)	44 (52)	5.643 (0.018)
Yes	34 (69)	15 (31)	

Note: Below average: percentile scores < 16 for children younger than 7 years; and raw scores < 74 in children older than 7 years); average: percentile scores ≥ 16 in children younger than 7 years; and raw scores ≥ 74 in children older than 7 years.
AAC, Augmentative and Alternative Communication; CFCS, Communication Function Classification System; n.a., not applicable; VSS, Viking Speech Scale.

can provide additional valuable information on the child's communicative skills in daily situations.

At all developmental stages, the CFCS and the CPCHILD-DV Communication and social interaction subsections showed good convergent validity. The CPCHILD-DV was originally normed and validated for the total questionnaire but not for use in separate subsections. However, a questionnaire with accompanying norm data is not necessary when setting and evaluating clinical goals (Oddson et al., 2019), as an individual child's subscores can be compared with their earlier subscores when monitoring changes in communication over time. Based on the results of the present study, questions relevant to communication performance can be administered to children with CP up to the age of 8 years at all GMFCS levels. While a ceiling effect may occur in children at GMFCS levels I–III, in the present study only 5 (4%) children reached the maximum score of 54 on the CPCHILD-DV (2 children were at GMFCS level II, 2 at GMFCS level III and 1 child at GMFCS level IV). Our approach resembled both the original CPCHILD study (Narayanan et al., 2006) and a recent Scandinavian study (Pettersson et al., 2019). The latter study also administered the questionnaire to ambulatory children and reported good construct validity and good test–retest reliability. It is important to remember that good communicative abilities are desirable in all children, across all GMFCS levels.

An overall ordered decreasing tendency was found in the mean scores of all tools across CFCS levels. However, differences in C-BiLLT mean scores between CFCS levels II and III were modest in toddlers and preschool children, as were differences in CPCHILD-DV mean scores between CFCS levels II and III in toddlers. An explanation for this disruption in trend could be the small number of children per developmental stage and per CFCS level. The CPCHILD-DV subsection appears less sensitive in toddlers when compared with the FOCUS-34 subsection. Furthermore, the distinction between CFCS level II and III is effective communication (receiving and sending) with known and unknown communication partners (level II) and effective communication only with known communication partners (level III). The FOCUS-34 and CPCHILD-DV subscores show that children at CFCS level II obtain higher subscores than children at CFCS level III. When considering C-BiLLT raw scores, the distinction between CFCS level II and III is unlikely to be caused by the level of spoken language comprehension (receiving), but is more likely due to expressive communication skills (sending; f.i. language production and successful use of AAC). The majority of children at CFCS level II and III were speaking (n = 39, 98%), and while the majority of children at CFCS level II do not use AAC (n = 18, 69%), around half of the children at CFCS level III use AAC ($n = 6$, 46%).

TABLE 4 Correlations between language and communication outcomes in developmental stages and itotal cohort

Correlations	Toddlers 18 months–3;11 years				Preschool children 4;0–5;11 years				Schoolchildren 6;0–8;11 years				Total 18 months–8;11 years			
	1[a]	2	3	4	1[a]	2	3	4	1[a]	2	3	4	1[a]	2	3	4
1. CFCS [a]	–				–				–				–			
2. CPCHILD subscore	−0.665	–			−0.660	–			−0.669	–			−0.667	–		
	(< 0.001)				(< 0.001)				(< 0.001)				(< 0.001)			
3. FOCUS-34 subscore	−0.699	0.828	–		−0.774	0.906	–		−0.816	0.836	–		−0.765	0.853	–	
	(< 0.001)	(< 0.001)			(< 0.001)	(< 0.001)			(< 0.001)	(< 0.001)			(< 0.001)	(< 0.001)		
4. C-BiLLT raw score	−0.351 (0.017)	0.534	0.591		−0.781	0.803	0.879		−0.635	0.604	0.659		−0.578	0.723		
	−0.351 (0.017)	(< 0.001)	(< 0.001)	–	(< 0.001)	(< 0.001)	(< 0.001)	–	(< 0.001)	(< 0.001)	(< 0.001)	–	(< 0.001)	(< 0.001)	(< 0.001)	–

Note: C-BiLLT, Computer-Based instrument for Low motor Language Testing; CFCS, Communication Function Classification System; CPCHILD-DV, Caregivers Priorities and Child Health Index of Life with Disabilities—Dutch Version; FOCUS-34: Focus on the Outcomes of Communication Under Six-34.

[a]Spearman's correlation coefficient. Correlation coefficients > 0.60 are shown in bold. *p*-values are shown in parentheses.

Relationship between functional communication tools and spoken language comprehension

In preschool and schoolchildren, functional communication seems to reflect spoken language comprehension and vice versa. In toddlers, however, receptive communication precedes and facilitates the acquisition of language across different domains, and toddlers typically show large variations in language and communication development (Carroll, 2008). Because young children have limited active vocabulary and speech production, they are often more dependent on non-verbal communication and are not yet able to express their wants and needs clearly and consistently (Carroll, 2008; Hoff, 2015).

In the present study, the questions included from the FOCUS-34 and CPCHILD-DV specifically reflect social communication, that is, effective communication with family and interaction with peers, rather than receptive communication. This might explain the weak correlation between the functional communication tools and the C-BiLLT in toddlers. In older, typically developing children it is assumed that communication abilities and understanding language are more in balance and of similar level (Carroll, 2008; Hoff, 2015). As also noted in the development of typically developing children, we found that communication abilities and spoken language comprehension skills are strongly correlated in children with CP from the age of 4 years.

When discrepancies are found between communicative abilities and spoken language comprehension, especially in children aged 4 years and older, it is strongly recommended that standardized assessments be used in a more detailed examination of their language comprehension and functional communication. This issue became even more prominent when children at various developmental stages were divided based on their level of language comprehension, that is, average or below average. In children with average spoken language comprehension, 77% (n = 46) were classified at CFCS levels I and II, 8% (n = 5) at level III, 15% (n = 9) at CFCS IV, and 0% at CFCS level V. Apparently, children with average spoken language comprehension are likely to be classified at CFCS levels I and II, or could be classified at these levels with use of AAC. Nonetheless, it should be remembered that children with below average spoken language comprehension were sometimes classified at CFCS level I (11%, n = 7) or II (24%, n = 15). These findings underline the fact that average spoken language comprehension skills do not automatically mean that an individual can communicate effectively, and vice versa, that is, children with below average

TABLE 5 Correlations between language and communication outcomes in spoken language comprehension groups

Correlations	Below average SLC 18 months–8;11 years				Average SLC 18 months–8;11 years			
	1[a]	2	3	4	1[a]	2	3	4
1. CFCS[a]	–				–			
2. CPCHILD subscore	**−0.629** (< 0.001)	–			**−0.602** (< 0.001)	–		
3. FOCUS-34 subscore	**−0.671** (< 0.001)	**0.823** (< 0.001)	–		**−0.745** (< 0.001)	**0.818** (< 0.001)	–	

Note: CFCS, Communication Function Classification System; CPCHILD-DV, Caregivers Priorities and Child Health Index of Life with Disabilities—Dutch Version; FOCUS-34, Focus on the Outcomes of Communication Under Six-34; SLC, spoken language comprehension.
[a]Spearman's correlation coefficient. Correlation coefficients >0.60 are shown in bold. *p*-values are shown in parentheses.

spoken language comprehension can still communicate effectively.

The C-BiLLT provides normed data up to the age of 7 years and age-equivalents are used for children older than 7 years, with the risk of ceiling effects. In our study, however, only three schoolchildren older than 7 years were close to the maximum score. Moreover, C-BiLLT scores ranged from 2 to 84; thus the majority of these children experience a delay in spoken language comprehension. These data suggest that the C-BiLLT is appropriate for use in children older than 7 years who have a suspected delay in spoken language comprehension. Nonetheless, when a child achieves a maximum score on the C-BiLLT, we recommend that an additional language comprehension test be administered (adapted to the child's fine and gross motor abilities).

Limitations

The results of the present study should be interpreted in the light of several limitations. First, none of the children in the preschool group were classified at CFCS level V, suggesting that this group may not be perfectly representative of the CP population at this developmental stage. On the other hand, in young children with CP motor type, cognitive, language and communicative skills are often not yet determined and/or difficult to assess and/or may change considerably over time. Second, the numbers included in the three developmental stages were relatively small; the recommended sample sizes of 50 were not reached in the preschool and school age groups (Terwee et al., 2007). Third, the Dutch language version of the FOCUS-34 questionnaire has yet to be validated. Notwithstanding, the questions included from the FOCUS-34 show overlap with the wording of questions from the CPCHILD-DV Communication and Social interaction subsection. Finally, as children with severe auditory and visual problems and severe CVI are excluded from participation in the present study, the results of the present study cannot be generalized to this population.

CONCLUSIONS AND CLINICAL IMPLICATIONS

We found good convergent validity between the CFCS and subscales of the CPCHILD-DV and FOCUS-34, along with moderate to strong correlations between functional communication tools and the C-BiLLT. The CFCS provides a valid classification of functional communication abilities in children with CP. However, the CFCS is less suited to determining more detailed individual communication goals, measuring (small) changes in functional communication over time or evaluating speech and language therapy. Therefore, in addition to the CFCS, we recommend use of other functional communication tools such as the CPCHILD-DV and FOCUS-34, and the FOCUS-34 is particularly recommended for toddlers. When discrepancies are found between communicative abilities and spoken language comprehension, especially in children aged 4 years and older, we strongly advise the use of standardized assessments to investigate language comprehension (Pennington et al., 2020) and functional communication in more detail.

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COMPETING INTERESTS

The authors state that they had no financial or non-financial competing interests to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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