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Communication behaviours of children with cerebral palsy who are minimally verbal

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Abstract

Background: There is a lack of population-based studies exploring the communicative behaviours of minimally verbal children with cerebral palsy (CP), with factors associated with superior and poorer communication outcomes unknown. This study aimed to examine the communication behaviours of minimally verbal children with CP recruited from a representative community sample, and to identify factors associated with communication outcomes.

Methods: Twenty minimally verbal children aged 5-6 years, recruited through the Victorian Cerebral Palsy Register, completed the Communication and Symbolic Behaviour Scales–Developmental Profile (CSBS-DP). Linear regressions examined child-related and environmental factors associated with communication outcomes.

Results: CSBS-DP total raw scores ranged from 0-113. Strengths were the use of conventional gestures and understanding of language. Challenges were noted in using sequential action schemes during play. Communication typically served to regulate the behaviour of others. All participants demonstrated reduced functional communication (Communication Function Classification System levels III-IV). In the multivariable regression model adjusted for cognition, poorer communication skills were associated with Manual Ability Classification System levels IV-V (p=0.004).

Conclusions: Whilst some children with CP who are minimally verbal use a variety of communication functions, significant functional limitations may be apparent. Severe upper limb impairment may provide an early indication of greater communication difficulties.

Key messages

- Children with cerebral palsy (CP) who are minimally verbal demonstrate considerable variation in communication skills, from those who communicate at a pre-intentional level to those who communicate using various modes and functions.
- Severe upper limb impairment is a potential early indicator of poorer communication outcomes.
- Development of standardised communication assessments appropriate for school-aged children with CP who are minimally verbal is needed to improve understanding of this population's communicative behaviours.

Introduction

Approximately a quarter of Australian children with cerebral palsy (CP) are non-vocal or minimally verbal (Mei et al., 2016), with worldwide prevalence figures ranging from 16-32% (Nordberg, Miniscalco, Lohmander, & Himmelmann, 2013; Sigurdardottir & Vik, 2011). The inability to verbally express basic needs places profound challenges on children, significantly impacting their activity and participation (Mei et al., 2015). Yet few studies have explored in detail the communication behaviours of minimally verbal children with CP, limiting our fundamental understanding of their communication development.

The communicative functions of non-vocal children with CP have predominately been described in clinical samples during parent-child interactions. Findings have revealed that non-vocal children with CP are largely passive communicators who seldom initiate requests and use a small range of communicative functions (Pennington & McConachie, 2001). Whilst children have intent to communicate (Singh, Iacono, & Gray, 2014), their messages are mostly responsive communicative acts (Pennington & McConachie, 1999). Parents often control interactions, resulting in an asymmetry in turn taking (Pennington & McConachie, 1999). Although communication during typical interactions is considered more naturalistic than structured assessments, they may potentially underestimate the abilities of non-vocal children given that communication partners often dominate interactions.

Communication is a multimodal process for non-vocal children. Communication modes include vocalisation, eye gaze, body posture, facial expression, gesture, and augmentative and alternative communication (AAC). Children adapt their use of these depending on the communication context, demands and partner, although natural modes (e.g., vocalisation, eye gaze) are typically preferred (Falkman, Dahlgren Sandberg, & Hjelmquist, 2002). Children often favour modes most available to them according to their physical capabilities, leading to significant variation in their communication characteristics (Singh et al., 2014). Although it is known that children with CP use multiple communication modes, the frequency of occurrence for each mode is yet to be explored using a population-based sample.

Beyond the characterisation of communication, a number of risk factors for communication impairment have been found. Risk factors for the absence of speech have been reported in relation to aetiology (cortical/subcortical and basal ganglia lesions) and CP presentation (e.g., non-spastic motor types, greater motor impairment and limb involvement) (Himmelmann, Lindh, & Hidecker, 2013; Sigurdardottir & Vik, 2011; Zhang, Oskoui, & Shevell, 2015). Yet factors associated with superior and poorer communication outcomes for non-vocal children have not been established. Identifying these subgroups is crucial to understanding the progression and predictors of longitudinal communication outcomes, and factors potentially impacting on treatment outcomes.

The lack of population-based studies describing the communicative behaviours of minimally verbal children with CP has critical impacts. The reliance of clinical samples may under or over represent the reported range and types of communicative behaviours. Thus, knowledge of the full range of presentations, including key communicative strengths and weaknesses, may be limited. Here, we used a structured face-to-face assessment to identify communication behaviours used by minimally verbal children with CP recruited from a population-based registry. We also explored factors associated with communication to identify those at greater risk of poorer communication outcomes.

Methods

Participants

Participants were identified through the Victorian Cerebral Palsy Register (VCPR) using previously described methods (Mei, Reilly, Reddihough, Mensah, & Morgan, 2014; Mei et al., 2016). All children born between August 2005 and August 2007 were eligible. Eighty-four representative participants were recruited (Mei et al., 2016), of whom 20 were minimally verbal and included here (see Table 1 for participant characteristics). Participants communicated via unaided (e.g., eye gaze, gesture; 17/20) and aided methods (e.g., communication book, electronic device; 12/20).

Table 1

Measures

Communication

Communication was assessed using the Communication and Symbolic Behaviour Scales – Developmental Profile (CSBS-DP) Behaviour Sample (Wetherby & Prizant, 2002), a commonly used tool for identifying delays in social and expressive communication, and symbolic functioning. Whilst the CSBS-DP is standardised for children aged 6-24 months, it can be used with those up to 6 years who are functioning within this range.

Participants also completed standardised receptive and expressive language assessments – the Preschool Language Scale-4 (PLS-4) and Peabody Picture Vocabulary Test-4 (PPVT-4) – which include normative data for children aged 5 and 6 years. Group scores are reported elsewhere (Mei et al., 2016) and individual scores are included as supplemental material.

Participants were evaluated across the six CSBS-DP sampling opportunities that are designed to elicit communication. Three composite scores and seven cluster scores are derived measuring emotion and eye gaze, communication and gestures (social composite); sounds and words (speech composite); and understanding and object use (symbolic composite). Composite scores are combined to obtain a total score. The frequency and method of communication acts (i.e., behaviour regulation, social interaction, joint attention; see Table S1 for definitions, supplemental material) were recorded for the sampling opportunities. Participants could use any method of communication during the assessment, including AAC. A parent/carer was present during the assessment and could interpret the participant's communication if needed.

As participants were outside of the CSBS-DP's normative age range, only raw scores are reported. Maximum raw scores attainable are shown in Tables 2 and 3. Approximate age equivalent scores were calculated using the age bracket where the normative mean corresponded to the participant's raw score.

Assessments were completed by CM, with video recordings scored by BF. Inter-rater reliability was performed by a second rater (MH) who independently scored 15% of the sample selected at random. Pairwise correlations revealed excellent agreement between raters (1.000 for CSBS-DP social, speech, symbolic and total composite scores).

Associated factors

To explore factors impacting on communication, data related to child and environmental factors were obtained. Environmental factors included socioeconomic status and parental level of education. Child-related factors included: CP motor type and distribution, gross and fine motor function, functional communication, oromotor performance, epilepsy, birth weight, gestational age, plurality, and the presence of vision, hearing and cognitive impairment. Functional impairments in gross motor, fine motor and communication were classified using the GMFCS (Palisano et al., 1997), Manual Ability Classification System (MACS, Eliasson et al., 2006), and Communication Function Classification System (CFCS, Hidecker et al., 2011). Cognitive status for 14 participants was available from data collected by the VCPR, with impairment defined as an IQ <70. Non-verbal cognition in a further participant was measured using the Columbia Mental Maturity Scale (Burgemeister, Blum, & Lorge, 1972). Cognitive status was unknown for 5 participants. Oromotor performance was examined using the Early Motor Control Scales (EMCS, Hayden, Wetherby, Cleary, & Prizant, 2010), which includes a sub-scale relating to motor speech function.

Statistical Analysis

CSBS-DP raw scores were analysed descriptively. Univariate linear regressions explored the association between cognition (explanatory variable) and CSBS-DP item and cluster scores (outcome variable). Univariate and multivariable linear regressions examined the association between CSBS-DP total scores (outcome variable) and the child and environmental factors described above (explanatory variable). Regressions were adjusted for cognition given the known association between communication and cognition. Reported regression coefficients represent the mean difference in CSBS-DP scores according to one unit difference in the corresponding explanatory variable. Linear regression analyses were considered appropriate for the sample size (Austin & Steyerberg, 2015). Factors univariately associated with CSBS-DP total scores were further examined to determine their relationship with the remaining composite scores (social, speech and symbolic). Variables showing significant associations were included in the multivariable model that involved a backward selection process, where insignificant variables were eliminated until only significant factors remained. Statistical significance was set at $p<0.05$.

Results

Communication behaviours: CSBS-DP

CSBS-DP total scores ranged from 0-113 (Table 2; see Tables S2 and S3 for individual participant scores, supplemental material). Two participants demonstrated no intentional communication. Strengths were noted in the social (M=24.8, SD=20.0) and symbolic composites (M=15.0, SD=16.0) in comparison to the speech composite (M=7.9, SD=8.9). Most participants (13/20, 65%) demonstrated overall communication skills (i.e., CSBS-DP total score) equivalent to a 12-14-month old level (Figure 1). One participant demonstrated communicative abilities equivalent to a two-year-old. A slightly higher proportion of participants demonstrated a 21-24-month age equivalence in symbolic functioning (5/20, 25%) compared to social communication (4/20, 20%) and speech ability (1/20, 5%) (Figure 1).

Table 2/Figure 1

Analysis of CSBS-DP items indicated strengths in the comprehension of objects, people and body parts (M=7.6, SD=9.4), and the use of conventional gestures (M=6.9, SD=4.5). As expected, the use of words was challenging for all participants (M=1.5, SD=2.1). In instances where words were produced, these commonly reflected functional words communicated using key word sign (e.g., ‘more,’ ‘finished’). Difficulty was noted in producing sequential action schemes during play for all participants (M=0.6, SD=1.1), despite some participants (n=11) having a variety of individual actions in their inventory (M=3.1, SD=3.2). This indicates that participants performed actions (e.g., drinking, mixing) in isolation but seldom used them in combination. Reduced shared positive affect was the only item significantly associated with cognitive impairment (p=0.023, Table 3).

Table 3

Communication Functions and Modes

The mean number of communication acts used by participants was 11.7 (SD 12.4). Communication acts were used for regulating behaviour (75%, 15/20), social interaction (45%, 9/20), and initiating joint attention (40%, 8/20) (Table 4). Behaviour regulation accounted for 77% of the total communication acts produced (Table 4). This included requesting and protesting objects/actions, respectively used by 75% (15/20) and 15% (3/20) of participants.

Less than a quarter of all communication acts served to facilitate social interaction (21%) or joint attention (20%) (Table 4). Social interaction acts were used to request social routines (30%, 3/20), request comfort (20%, 4/20), greet (20%, 4/20), call (15%, 3/20), show off (15%, 3/20), and request permission (5%, 1/20). All instances of joint attention were used to comment on an object/action (40%, 8/20) rather than request information, which was not used by participants.

Gesture and vocalisation were the most common communication modes (Table 4). Although participants were able to communicate via AAC during the CSBS-DP, AAC devices were used between (not during) scoring opportunities and were therefore not recorded. Gesture was typically used to facilitate behaviour regulation acts while vocalisation often supported social interaction. Eye gaze and key word sign were less frequent and were most often used for joint attention and behaviour regulation, respectively.

Table 4

Factors associated with CSBS-DP scores

The univariate linear regression revealed that lower CSBS-DP total scores were associated with MACS levels IV-V (R^2 62%), GMFCS level V (R^2 61%), EMCS score (i.e., oromotor function; R^2 43%), vision impairment (R^2 39%), and CFCS level V (R^2 30%) (Table 5). These variables (except CFCS) remained significant when controlled for cognition.

With the exception of vision and MACS level IV, the above variables (including CFCS) were univariately associated with the social, speech and composites (Table 6). Vision impairment and MACS level IV were respectively not associated with the speech and symbolic composites. When controlled for cognition, all variables remained significant. All factors that were not significantly associated with CSBS-DP total scores (Table 5) were also not associated with the social, speech and symbolic composites. The only exception was quadriplegia, which was associated with the speech composite (regression coefficient=-18.2, 95% CI=-34.5, -1.9, p=0.031), although significance was not maintained when adjusted for cognition.

Tables 5-6

All significant factors that were associated with CSBS total scores when adjusted for cognition were entered in the multivariable model, which included cognition as a covariate.

In this model, only MACS levels IV (regression coefficient=-58.3 95% CI=-87.3, -29.4, p=0.004) and V (regression coefficient=-65.3; 95% CI=-98.1, -32.6, p=0.004) were associated with lower CSBS-DP total scores. That is, more severe fine motor impairments were associated with poorer communication competency.

Discussion

We present a detailed report of communication in minimally verbal children with CP drawn from a representative community-based cohort. Participants demonstrated considerable variation in communication skills, from those who communicated at a pre-intentional level to those who communicated using various modes and functions. This highlights the importance of a thorough clinical assessment to determine individual strengths and weaknesses. Whilst a variety of communication functions were evident in some participants, findings at a group level highlight potential communicative restrictions experienced by this population.

Despite the general high degree of variability, participants displayed discernible strengths in communicating via conventional gestures, aligning with reports that gesture is one of the most common communication methods used by non-vocal children with CP (Falkman et al., 2002). Language comprehension was a further strength, supporting evidence that non-vocal children may demonstrate little to no impairment in receptive language (Geytenbeek, Vermeulen, Becher, & Oostrom, 2015). This is contrary to significant receptive language deficits in the current sample previously reported based on the PLS-4, an assessment of receptive and expressive language with a normed sample that includes children from birth to 6 years of age (Mei et al., 2016). This suggests that commonly used age-appropriate standardised language assessments, such as the PLS-4, which require a fine motor or verbal response, may underestimate the receptive language of minimally verbal children with CP, or that upon more thorough investigation, children may demonstrate weaknesses in receptive language. For example, the CSBS-DP assesses comprehension via one-stage commands for a series of common and proper nouns that are likely to be familiar to the child. Therefore, a higher score on the CSBS-DP may have potentially overestimated participants' receptive language development. It is also possible that the CSBS-DP underestimated the receptive language skills of two participants who reached the maximum raw score attainable for this item. This is also applicable to other CSBS-DP items where one or more participants reached the maximum. Although this indicates the possibility of a ceiling effect, communication competency was found to be considerably low based on the PLS-4 (Mei et al., 2016), with all participants obtaining an expressive communication standard score of 50.

Whilst particular strengths were noted (independent of cognition), findings here indicate some differences between the communicative strengths of children with and without motor disabilities. For instance, children without motor impairments demonstrate higher rates of communication and gaze shifts (Eadie et al., 2010). The low occurrence of these may have impacted participants' use of joint attention and ability to initiate and engage in social interactions, and may reflect poor head control, posture, visual attention, and the cognitive demands of the task (Arens, Cress, & Marvin, 2005). The relatively low use of gaze shifts reinforces findings of reduced face-to-face contact between children with CP and their mothers (Hanzlik, 1990), and the seldom use of gaze shifts by children with developmental disabilities at risk of being non-vocal (Arens et al., 2005). These areas highlight key targets for clinical management. A further area of difficulty was combining action schemes during play, which could represent the increased motor complexity required to perform consecutive actions.

Regarding regression analyses, individual factor models controlled for cognition revealed that poorer communication skills were associated with reduced oromotor control, GMFCS level V, MACS levels IV-V, and vision impairment. Whilst the CFCS did not remain significant when controlled for cognition, all participants showed functional communication limitations, although it is uncertain whether this was impacted by a lack of access to AAC. In the multivariable model, only MACS levels IV-V were associated with communication, indicating that children with better upper limb motor control were more likely to have better communication skills. This may reflect children with greater motor control of the arms and hands being increasingly able to produce gesture, the most common method of communication used by participants. Clinically, the early identification of severe motor impairment may indicate greater communication difficulties, with early intervention targeting children's functional communication and ability to communicate via multiple methods. Although the GMFCS did not remain significant in the multivariable model, our univariate results are consistent with previous findings where greater communication deficits are associated with severe gross motor impairment (Parkes, Hill, Platt, & Donnelly, 2010).

Further factors have previously been associated with communication impairment, including cognitive, hearing and vision impairment. Here however, only vision impairment was univariately associated with social communication. The association between epilepsy and CSBS-DP total score trended towards significance, supporting previous reports of epilepsy contributing to communication impairment associated with CP (Parkes et al., 2010). Birth factors such as plurality, gestational age and birth weight were also not significantly associated with communication abilities. This largely replicates previous research, with the exception of gestational age, where an increased risk of non-vocal status following term birth has been reported (Sigurdardottir & Vik, 2011). Regarding environmental factors, socioeconomic status and parental level of education were not associated with communication abilities. Maternal level of education has, however, been associated with communication in older children with CP (Voorman, Dallmeijer, Van Eck, Schuengel, & Becher, 2010), possibly suggesting that the impact of parental education increases with age.

Our results are limited by the relatively small sample size, which may have resulted in reduced power to identify significant factors, particularly within the multivariable regression. This also may have impacted clinically meaningful effects reaching statistical significance (e.g., epilepsy). The study was also limited in that the CSBS-DP standard scores could not be computed. This reflects the absence of standardised child-completed assessments appropriate for the sample's age and level of physical, cognitive and communication functioning. Development of appropriate standardised measures for children with movement disorders would enhance understanding of communication development for this population.

Conclusions

Minimally verbal children with CP exhibit considerable variation in communication abilities at ages 5-6 years. Language comprehension and conventional gestures were areas of communicative strength independent of cognitive impairment. The presence of severe upper limb impairment may provide an early indicator of greater communication difficulties. Further research is needed to explore how communication skills evolve and impact quality of life and participation for this population. Of interest would be to determine whether areas of strength and weakness identified here longitudinally predict communication outcomes and whether therapy targeting these specific areas results in greater improvements in communication. Further research is also needed to confirm factors associated with higher and lower levels of communication impairment to improve early identification and management.

This may reside in studies investigating the link between the nature and location of brain injury and communication impairment. Lastly, the reductions in functional communication observed across all participants highlights the importance of addressing this area early during management and the need to develop and implement evidence-based intervention programmes and AAC systems that enable children to independently and effectively communicate.

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Table 1. Participant characteristics (n=20)

Participant characteristic	n (%)
Gender (female)	10 (50)
CP motor type	
Dyskinetic	1 (5)
Spastic	9 (45)
Hypotonic	3 (15)
Mixed	7 (35)
CP distribution	
Quadriplegia	17 (85)
Diplegia	2 (10)
Left hemiplegia	1 (5)
GMFCS	
II	2 (10)
III	1 (5)
IV	10 (50)
V	7 (35)
MACS	
I	1 (5)
II	3 (15)
III	5 (25)
IV	5 (25)
V	6 (30)
CFCS	
III	9 (45)
IV	7 (35)
V	4 (20)
Autism (n=16)	0 (0)[a]
Vision impairment	9 (45)
Hearing impairment	3 (15)
Cognitive impairment (n=15)	11 (73)[a]
Epilepsy	11 (55)
Twin birth	3 (15)

Premature birth (<37 weeks' gestation)	8 (40)
Birth weight	
Extremely low (<1000g)	3 (15)
Very low (>1500g)	2 (10)
Low (>2000g)	1 (5)
Normal (≥2500g)	14 (70)
Socio-economic status	
High	8 (40)
Medium	11 (55)
Low	1 (5)
Parental Level of Education	
<13 years	4 (20)
13 years	6 (30)
Degree/postgraduate	8 (40)
Unknown	2 (10)

Note: CFCS: Communication Function Classification System. GMFCS: Gross Motor Function Classification System. MACS: Manual Ability Classification System. Dominant motor type in mixed cases were spastic (6/7) and ataxic (1/7). Vision impairment defined as blindness (<6/60 vision) or a reduction in visual acuity requiring corrective lenses. Hearing impairment defined as hearing loss >40dB in the less affected ear or bilateral deafness (>70dB in the less affected ear). The Socio-Economic Index for Areas (SEIFA) Index of Relative Socio-Economic Disadvantage was used to provide an indication of socio-economic status (Australian Bureau of Statistics, 2011).

[a] Cognitive status unknown for 5 participants. Presence/absence of autism not reported for 4 participants.

Table 2. Summary of cluster and composite raw scores on the CSBS-DP Behaviour Sample and their association with cognition

Performance on CSBS-DP (composite and cluster scores)				Association between CSBS-DP cluster scores and the presence of cognitive impairment (univariate linear regression)		
Communication Scale	Maximum Score	Mean (SD)	Range	Coefficient (95% CI)	p	R^2
Social Composite	64	24.8 (20.0)	0-58			
Emotion and eye gaze	18	7.1 (6.5)	0-18	-5.5 (-13.5, 2.5)	0.160	14.6
Communication	24	9.7 (8.5)	0-23	-7.4 (-17.4, 2.5)	0.131	16.7
Gestures	22	8.0 (5.6)	0-19	-4.5 (-12.1, 3.2)	0.230	10.9
Speech Composite	54	7.0 (8.9)	0-26			
Sounds	26	4.6 (6.1)	0-20	-3.4 (-11.9, 5.0)	0.397	5.6
Words	28	2.3 (3.4)	0-9	0.0 (-4.4, 4.5)	0.983	0.0
Symbolic Composite	53	15.0 (16.0)	0-42			
Understanding	24	7.6 (9.4)	0-24	-5.0 (-16.7, 6.8)	0.377	6.0
Object Use	29	7.5 (7.7)	0-20	-2.2 (-12.2, 7.8)	0.642	1.7
Total Score	171	46.7 (42.8)	0-113			

Note: Maximum score = maximum score achievable on scale, SD = standard deviation, Mean = average score. Cognitive impairment was based on data collected by the Victorian Cerebral Palsy Register (n=14), with impairment defined as an IQ <70, or performance on the Columbia Mental Maturity Scale (n=1).

Table 3. Summary of raw scores on the CSBS-DP Behaviour Sample items and their association with cognition

	Performance on CSBS-DP			Association between items and the presence of cognitive impairment (univariate linear regression)		
Item	Maximum Score	Mean (SD)	Range	Coefficient (95% CI)	p	R^2
1. Gaze shifts	6	1.5 (2.2)	0-6	-1.3 (-4.2, 1.5)	0.344	6.9
2. Shared Positive Affect	6	2.2 (2.3)	0-6	-3.0 (-5.5, -0.5)	0.023	33.8
3. Gaze/point following	6	3.3 (2.7)	0-6	-1.2 (-4.8, 2.4)	0.477	4.0
4. Rate of Communicating	6	3.2 (2.4)	0-6	-1.8 (-4.8, 1.3)	0.235	3.8
5. Behaviour regulation	6	3.3 (2.3)	0-6	-2.0 (-4.6, 0.6)	0.123	17.3
6. Social interaction	6	1.7 (2.2)	0-5	-1.5 (-4.1, 1.1)	0.240	10.4
7. Joint attention	6	1.4 (2.2)	0-6	-2.2 (-4.8, 0.4)	0.094	20.1
8. Inventory of conventional gestures	16	6.9 (4.5)	0-14	-2.7 (-9.0, 3.6)	0.376	6.1
9. Distal gestures	6	1.0 (1.7)	0-5	-1.8 (-4.0, 0.5)	0.112	18.2
10. Syllables with Consonants	6	1.6 (2.1)	0-6	-1.7 (-4.5, 1.1)	0.209	11.8
11. Inventory of Consonants	20	3.0 (4.3)	0-16	-1.7 (-7.8, 4.3)	0.550	2.8
12. Words	6	1.5 (2.1)	0-6	-0.0 (-3.0, 3.0)	0.987	0.0
13. Inventory of words	8	0.8 (1.3)	0-4	0.1 (-1.4, 1.6)	0.923	0.1
14. Word combinations	6	0 (0)	0	-	-	-
15. Inventory of word combinations	8	0 (0)	0	-	-	-
16. Language comprehension	24	7.6 (9.4)	0-24	-5.0 (-16.7, 6.8)	0.377	6.0
17. Inventory of action schemes	12	3.1 (3.2)	0-8	-1.3 (-5.3, 2.7)	0.483	3.9

18. Action schemes towards others	6	1.7 (1.8)	0-5	-0.5 (-3.0, 1.9)	0.652	1.6
19. Sequential action schemes	6	0.6 (1.1)	0-4	-8.0 (-2.3, 0.7)	0.261	10.0
20. Stacks tower of blocks	5	2.0 (2.2)	0-5	0.5 (-2.5, 3.4)	0.747	0.8

Note: Words score included those expressed through key word sign. Points were awarded for stacking blocks with or without assistance. Maximum score denotes the highest score achievable on the item. SD: standard deviation. Cognitive impairment was based on data collected by the Victorian Cerebral Palsy Register (n=14), with impairment defined as an IQ <70, or performance on the Columbia Mental Maturity Scale (n=1).

Table 4. Frequency and method of communication acts

	Frequency of individual communication acts			Method of communication used for communication acts (%)			
Communication act	Participants displaying communication act n (%)	Frequency Mean, (SD)	Percent of total communication acts Mean (SD)	Gesture	Vocalisation	Eye gaze	Words (signed)
Behaviour regulation	15/20 (75)	7.1 (5.9)	77 (23.4)	65	21	2	12
Social interaction	9/20 (45)	2.3 (3.3)	21 (6.4)	42	40	11	7
Joint attention	8/20 (40)	2.3 (4.3)	20 (4.6)	44	34	21	1
All communication acts	-	-	-	56	28	8	8

Note: SD = standard deviation. Gestures included giving, showing, nodding and shaking head, pushing and pulling, waving and pointing. Words included ‘more,’ ‘finished,’ ‘home,’ ‘good,’ and ‘help’ produced using key word sign. Gesture and words were recorded every instance they were observed.

Table 5. Univariate linear regression analysis of association between child and environmental variables and CSBS-DP Behaviour Sample total raw scores

Variable	Coefficient (95% CI)	p	R^2
Gender (male)	15.8 (-24.7, 56.3)	0.424	3.6
CP motor type			
Spastic	Reference	-	
Mixed	-14.2 (-63.4, 34.9)	0.548	2.5
Dyskinetic	-12.7 (-115.49, 90.2)	0.797	
Hypotonic	-2.3 (-67.4, 62.7)	0.940	
CP distribution			
Left hemiplegia	Reference	-	
Diplegia	0.5 (-94.6, 95.6)	0.991	33.7
Quadriplegia	-68.0 (-147.4, 12.4)	0.093	
GMFCS			
II	Reference	-	
III	18.5 (-57.5, 94.5)	0.613	60.5
IV	-31.9 (-80.0, 16.2)	0.179	
V	-85.1 (134.8, -35.3)	0.002	
MACS			
I	Reference	-	
II	-49.7 (-122.4, 23.1)	0.166	62.3
III	-31.2 (-100.2, 37.8)	0.351	
IV	-76.2 (-145.2, -7.2)	0.033	
V	-106.7 (-174.7, -38.6)	0.004	
CFCS			
III	Reference	-	

IV	-21.2 (-61.3, 19.0)	0.281	30.4
V	-61.7 (-109.5, -13.9)	0.015	
Epilepsy	-36.9 (-74.2, 0.3)	0.052	19.4
Cognitive impairment	-28.2 (-83.4, 26.9)	0.289	8.6
Vision impairment	-52.0 (-84.5, -19.4)	0.004	38.5
Hearing impairment	-9.8 (-67.5, 47.8)	0.724	0.7
EMCS Motor Speech score	2.6 (1.1, 4.1)	0.002	42.9
Birth weight			
Normal (≥2500g)	Reference	-	
Low (>2000g)	-49.4 (-137.3, 38.5)	0.251	26.1
Very low (>1500g)	44.1 (-20.1, 108.3)	0.165	
Extremely low (<1000g)	-31.1 (-85.1, 22.9)	0.240	
Gestation (preterm)	18.0 (-23.2, 59.2)	0.371	4.5
Plurality	26.2 (-30.1, 82.6)	0.341	5.0
Socioeconomic status			
High	Reference	-	
Medium	15.4 (-27.8, 58.6)	0.462	4.9
Low	34.5 (-64.2, 133.2)	0.471	
Parental level of education			
<13 years	Reference	-	
13 years	41.0 (-14.9, 96.9)	0.139	18.2
Degree/postgraduate	42.9 (-10.1, 95.9)	0.105	

Note: CFCS: Communication Function Classification System. EMCS: Early Motor Control Scales. GMFCS: Gross Motor Function Classification System. MACS: Manual Ability Classification System.

Coefficient = regression coefficient. Regression coefficients represent estimated mean differences. R^2 = R squared value. CI = confidence interval.

Table 6. Univariate linear regression analysis of significant associated factors and CSBS-DP Behaviour Sample composite raw scores

	Social Composite			**Speech Composite**			**Symbolic Composite**		
Associated factor	Coefficient (95% CI)	p	R^2	Coefficient (95% CI)	p	R^2	Coefficient (95% CI)	p	R^2
GMFCS V	-39.3 (-60.8, -17.7)	0.001	47.5	-18.6 (-31.1, -6.1)	0.006	42.4	-27.1 (-47.4, -6.9)	0.012	53.2
MACS									
IV	-34.2 (-64.9, -3.5)	0.031	65.9	-16.4 (-32.2, -0.6)	0.043	54.1	-25.6 (-54.2, 3.0)	0.076	53.7
V	-53.7 (-83.9, -23.4)	0.002		-17.0 (-32.6, -1.4)	0.034		-36.0 (-64.2, -7.8)	0.016	
CFCS V	-29.3 (-51.5, -7.1)	0.013	31.4	-10.8 (-21.1, -0.5)	0.040	25.7	-21.6 (-40.0, -3.1)	0.024	26.4
EMCS Motor Speech score	1.1 (0.3, 1.8)	0.007	34.4	0.6 (0.3, 0.9)	0.001	48.2	0.9 (0.4, 1.5)	0.003	39.8
Vision impairment	-27.0 (-41.1, -13.0)	0.001	47.5	-6.2 (-14.2, 1.9)	0.125	12.6	-18.8 (-31.2, -6.4)	0.005	35.9

Note: CFCS: Communication Function Classification System. EMCS: Early Motor Control Scales. GMFCS: Gross Motor Function Classification System. MACS: Manual Ability Classification System.

Coefficient = regression coefficient. Regression coefficients represent estimated mean differences. R^2 = R squared value. CI = confidence interval.

Figure Legend

Figure 1. Participant age equivalents on the CSBS-DP Behaviour Sample. Age equivalents determined using the age bracket where the normative mean corresponded to the raw score of the participant. M = months.