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Assessment of social function in four year old children with cerebral palsy

Emily McFadd, M.S., CCC-SLP^{*,†} and Katherine C. Hustad, Ph.D., CCC-SLP^{*,†}

^{*}Department of Communicative Disorders, University of Wisconsin – Madison

[†]Waisman Center, University of Wisconsin – Madison

Abstract

Objective—To determine whether scores from the Social Function domain of the Paediatric Evaluation of Disability Inventory (PEDI) would reflect differences among speech-language profile groups for children with cerebral palsy (CP).

Methods—Thirty-four children with CP participated (mean age = 54.4 months). PEDI Social Function raw scores, developmentally stratified skill levels, and types of skills mastered at a 75% criterion level were examined.

Results—Significant differences were observed in Social Function scores overall and within early and age-appropriate skills among all profile groups with one exception. Skill mastery varied based on profile group and on developmental age category of each skill.

Conclusion—The PEDI appears to capture language delay in children with CP, but it may not be sensitive to the impact of speech intelligibility deficits on social function. Findings call for the development of a new tool that more accurately assesses communicative activities and participation in children with CP.

Keywords

dysarthria; language disorders; communication

Introduction

Children with cerebral palsy (CP) experience a range of impairments that can impact overall body function and participation in daily life. CP is an umbrella term for a group of chronic, non-progressive disturbances of movement and posture that occur in the developing fetal or infant brain. The motor disorders of CP are often accompanied by impairments of sensation, perception, cognition, communication, and behaviour; by epilepsy, and by secondary musculoskeletal problems [1]. Recent data from a large sample in Europe indicate that nearly 60% of children with CP may have some type communication impairment [2]. While there is a wealth of research describing and classifying gross motor [3-7] and fine motor [8-11] development in children with CP, classification of speech, language and cognitive deficits in children with CP has only recently emerged [12,13].

Communication ability in children can be viewed on a number of different levels. These levels are best illustrated by the World Health Organisation's (WHO) International

Contact Author: Emily McFadd M.S., CCC-SLP 1500 Highland Ave. Madison, WI 53705 mcfadd@wisc.edu 608-263-5822 (voice) .

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Classification of Functioning, Disability and Health Children and Youth Version (ICF)[14]. The ICF-CY model is a 'biopsychosocial' model of health condition (disorder or disease) with three linking elements: 1.) body structure and function, 2.) activity and 3.) participation. Environmental and personal factors are recognised as facilitating or enhancing the levels of body structures and functions, activities, and participation. These elements join together to encompass major aspects of an individual's experience of health condition [14]. CP can affect several different body structures and functions related to communication, resulting in impairments in expressive and receptive language, cognition, and speech motor control. Standardised tests and/or instrumental measures are often used to characterise impairments in body structures and function associated with speech and language.

The therapy room setting allows the speech-language pathologist to evaluate an individual's capability to complete specific communicative activities in an optimal environment, since it is typically quiet and adequately-lit, and the SLP is a familiar partner who is invested in what the client has to communicate. We can measure communicative activities by determining the effectiveness of an individual's ability to speak, use communication devices and techniques, read and write. Speaking ability in particular can be characterised at the level of activities using measures of intelligibility, which describe the extent to which a listener can decipher a message produced by a speaker [15]. When obtaining measures of intelligibility, the communicative context is typically highly-controlled with standardised materials and procedures [16]. Thus, it is important to go beyond the level of communicative activities and consider the range of factors involved in natural communication contexts that impact an individual's engagement in life situations.

Communicative participation has been recognised as an important domain of outcomes in speech-language pathology [17] and has long been regarded as the ultimate goal of augmentative and alternative communication (AAC) interventions [18]. Communicative participation describes the nature and extent of involvement in social situations in daily life which takes place for a defined social goal (e.g., making new friends), for a function or role (e.g., school-related), or in a particular context (e.g., in a restaurant) [19]. It is difficult to directly assess communicative participation because it is heavily influenced by partners and environmental contexts. Furthermore, communicative participation occurs in real life, frequently in less optimal settings. The difficulty associated with measuring communicative participation may explain why most clinical measures of communication in individuals with disabilities focus on impairments at the level of body structures and functions and to a lesser extent on activities [16].

It is important to note that the levels of the ICF model are categorical, rather than hierarchical. For example, an individual may have moderate dysarthria, but given adequate environmental supports, such as an alphabet board, and favourable personal factors, such as strong motivation to communicate effectively using all possible modalities, he/she may not experience limitations in activities or participation. Therefore, it is not always the case that results from an outcome measure targeting a single component of the ICF model will reflect an individual's experience at different levels. For this reason, characterization at multiple levels of the model is critical to ensure that therapeutic interventions target challenges across all levels of the experience of disability.

ICF and Communication in Children with CP

Hustad, Gorton, & Lee [12] described four preliminary speech-language profile groups among young children with CP based primarily on the speech-language impairments (body structures and functions) measured in a cohort of 34 children. The proposed profile groups included: children who have no speech motor involvement (group NSMI), children who have speech motor involvement and typical language/cognition (group SMI-LCT), children

who have speech motor involvement and impaired language/cognition (group SMI-LCI), and children who are unable to produce functional speech (anarthria) and have impaired language abilities or unknown abilities based on clinical assessment (group ANAR). Of their sample, 24% of the children were placed group NSMI, 26% of the children were placed in group SMI-LCT, 18% were placed in group SMI-LCI, and 32% of the children were placed in group ANAR.

Extending this work to the level of activities, a recent study of speech intelligibility in four year old children with and without CP examined intelligibility as measured by orthographic transcription via naïve listeners [13]. The study sample included a group of typically developing children and a subset of the children reported on in Hustad et al.[12], including all those from groups NSMI, SMI-LCT, and SMI-LCI. Descriptive results revealed differences in intelligibility between all four groups of children, with typically developing children having higher intelligibility scores than all groups of children with CP. Surprisingly, children in group NSMI had reduced intelligibility as compared to typically developing children, suggesting that these children may have subtle speech production or expressive communication differences. Differences between children in groups SMI-LCT and SMI-LCI were not significant, though intelligibility scores for group SMI-LCT were about 20% higher than group SMI-LCI, suggesting the possibility that language impairment may contribute to reductions in intelligibility. Hustad et al. [13] propose that differences in impairment-based speech-language profile groups between children with and without dysarthria can also be found in measures of speech activities (i.e. intelligibility). Overall, children who had dysarthria (SMI-LCT and SMI-LCI) had noticeably reduced speech intelligibility as compared to their typically developing peers and their peers who had CP but no clinical evidence of speech motor or language involvement, highlighting the need for motor speech interventions and AAC systems and strategies.

Findings from a recent study of a sample of children with CP determined that 95% of children who had clinical speech and/or language impairments would benefit from some form of AAC because they were unable to meet all of their communication needs through speech alone [20]. However, in the study sample, only 57% of the children were receiving AAC services in their school setting. AAC systems and strategies provide an important pathway to enhance communication development and social participation for any child who cannot use speech to meet all communication needs [18]. It is troubling that many children with CP did not receive a school-based AAC intervention during such a crucial time for communication and social development.

The social challenges of children with CP have received increasing attention in the literature. Studies suggest that school-aged children with CP may experience more peer rejection, fewer friendships, greater victimization, or greater social isolation than typically developing peers [21,22]. Whittingham, Fahey, Rawicki, and Boyd [23] propose that overall social development may be related to gross motor ability in preschool children, with children with more severe motor impairment experiencing greater social difficulties. Other studies propose that the presence of speech motor impairments and /or reduced speech intelligibility may impact relationships with parents. Dickinson et al. [24] found that children with CP who had speech motor impairments had poorer relationships with their parents than children with CP who did not have speech motor impairments. Similarly, Pennington and McConachie [25] suggest that children with CP who had significant intelligibility problems showed a different pattern of communicative interaction with their parents than children who did not have reduced intelligibility. Collectively, findings seem to indicate that children with CP can experience difficulties with social participation that may be related to communication problems. However, the relationship between social

functioning and the variety of communication impairments in children with CP is not well understood.

Assessment of Activities/Participation

Liptak et al. [26] suggest that studies of children with CP should employ disease-specific measures that have been designed to be sensitive to the unique characteristics of the population such as motor limitations and mobility challenges. One such measure, Communication Function Classification System, seeks to characterise communication activities/participation in children with CP [27]. The CFCS was designed to be used in parallel with the Gross Motor Function Classification System (GMFCS) [5] and the Manual Abilities Classification System (MACS) [8] and consists of five levels of functioning related to communication effectiveness and efficiency of an individual as a sender and receiver in interactions [27]. The CFCS provides a global rating of communication in children with CP, but unlike the GMFCS, the current form does not consider the impact of development on communication effectiveness throughout childhood. An age-cohort study of the CFCS has been proposed to determine the impact of age effects on the stability of the CFCS, but has not yet been conducted [27].

The Paediatric Evaluation of Disability Inventory (PEDI) [28] has been widely used to examine various aspects of everyday functioning in children with CP [23,29-31], developmental disabilities [32] and traumatic brain injury [33-35]. The PEDI is a standardised instrument for evaluating functional capabilities of young children under 7 years, 6 months of age and for children with disabilities whose functional skills are expected to fall below the 7 years, 6 months developmental level [28]. The PEDI Functional Skills domain provides indices of capability, assessing what a child can do in his or her daily environment through examination of three content areas: self-care, mobility, and social function [28]. The PEDI queries 65 developmentally-stratified social function skills that relate to functional comprehension, expression, the integration of communication and other cognitive skills, and skills necessary for participation in community settings [28]. For the present study, Social Function scores were of particular interest as this PEDI domain purports to capture communicative activities [36].

In an effort to characterise social functioning of children with CP and relate it to recent work examining speech activities (speech intelligibility) and impairments in the same children, the present study examined the following questions:

1. Are overall scores from the Social Function domain of the PEDI consistent with the impairment-level and the activity-level differences observed among the speech-language profile groups reported by Hustad and colleagues [12,13]?
2. Are there differences among speech-language profile groups on PEDI Social Function scores within developmentally stratified skill levels (i.e. early-emerging, age-level, and late-emerging skills)?
3. Are there differences among speech-language profile groups on PEDI Social Function scores with regard to attainment of 'mastery' of different skills among profile groups?

Because of the important contribution of expressive communication to social functioning, we hypothesised that we would observe significant social function differences among the four speech-language profile groups. We expected that children without speech-language impairments (group NSMI) achieving high Social Function scores and the children who are unable to speak (group ANAR) achieving the lowest Social Function scores. The PEDI is considered a measure of activities within the ICF framework; therefore we expected that findings would be similar to those described by Hustad et al. [13] in their study of

intelligibility, also considered a measure of activities. Specifically, we expected that the Social Function scores of children in group NSMI may not meet age expectations, given that these children do have reduced speech intelligibility, which is likely to be a key factor in social functioning. Further, we expected that the two different groups of children with speech motor involvement (SMI-LCT and SMI-LCI) would have lower Social Function scores than children in group NSMI because of the severity of their intelligibility reductions. Though Hustad et al. [13] did not find significant differences between children in groups SMI-LCT and SMI-LCI on speech intelligibility scores, we expect to find differences in PEDI scores between these groups, with children in group SMI-LCI achieving lower scores, as the additional burden of language impairment in this group is likely to have a negative impact on functional communication activities that are more broad based than measures of speech intelligibility. We expect that children in group ANAR would experience the greatest social activity limitations as speech and/or some form of expressive communication ability is crucial for social functioning.

Methods

Participants

This study examined data from the PEDI collected from the same children who participated in a related study by Hustad et al. [12]. All children were participating in a prospective 4-year longitudinal study of communication development in children with CP involving collection of behavioural and questionnaire data that target speech and language development. All participants included in this study had a medical diagnosis of CP, were seen for a data collection session at an average age of 54 months, had parents who were able to complete the PEDI questionnaire for the 54 month data collection session, and had normal hearing per audiological screening or formal audiological test report. A total of 34 children participated in this study. Demographic information is listed in Table 1. The children in the sample had a wide range of motor impairments, anatomical involvement, functional gross motor skills, and visual impairments. The mean age across children was 54.4 (+ 1.8) months. The sample had 18 boys (mean age 54.6 (+ 1.6) months) and 16 girls (mean age 54.3 (+ 1.9) months). Children in this study were classified into impairment profile groups based on the presence of speech-motor involvement and language/cognitive involvement [12].

Materials and procedures

Parents were sent a packet of questionnaires, including the PEDI, before the behavioural communication assessment visit closest to 54 months of age. Typically, the PEDI is administered either by a clinician or educator, or by parent report in the form of a structured interview. However, the authors of the PEDI suggest that parent report can be used without a structured interview as an alternative administration protocol [28]. Previous work examining social function in children with CP has also used the PEDI in a parent questionnaire format [23]. Parents were asked to complete the form independently as time constraints did not allow for us to administer the PEDI as a structured interview. For the Functional Skills domain, parents rated their child as either 'able' (1 point) or 'unable' (0 points) to complete tasks or engage in the activities described in 65 different individual items.

Mean raw scores and individual item responses on the Social Function – Functional Skills domain of the PEDI were examined for each child within each profile group. In order to analyse group performance and differences from a developmental perspective, PEDI Social Function items were sorted into three categories: early-emerging, age-level, and late-emerging skills. These categories were identified through use of developmental norms presented in the PEDI manual, describing the 6-month age range in which 90% of typically developing children are expected to master each skill. Categories were defined as follows:

early-emerging skills were those that were mastered between birth and 3;0 years; age-level skills were those that were mastered between 3;6 years and 5;0 years; and late-emerging skills were those that were mastered between 5;6 years and 7;0 years. There were 33 early-emerging skills, 19 age-level skills, and 13 late-emerging skills.

To evaluate mastery of individual skills, descriptive analyses were used. Specifically, for each individual question within the Social Function domain of the PEDI, the percent of children within each profile group who performed that skill was examined. The individual items that 75% of children performed within each speech-language profile group were identified as 'mastered' items. The number, nature, and developmental level of items mastered at the set criteria level were then examined within each of the profile groups.

Design & Analysis

This study employed a four-way between subjects design, with each of the four communication profile groups treated as an independent variable. The following levels of analyses were completed: (1) examination of profile group differences across Social Function raw scores; (2) examination of profile group differences within the early-emerging, age-level, and late-emerging skills; (3) examination of descriptive differences among profile groups for the items that children mastered on the Social Function domain of the PEDI. Because sample sizes for the four profile groups were small, non-parametric analyses using the Mann-Whitney U statistic were performed to evaluate pair-wise difference between groups for each set of analyses. The type I error rate was controlled for multiple comparisons using the Bonferroni procedure. For each of the two families of tests, an alpha of .05 was partitioned evenly among tests. For group differences across Social function scores, 6 tests were performed; an alpha of .0083 or less was required for significance. For examination of group differences within skill levels, 6 tests were performed within each skill level for a total of 18 tests; an alpha level of .0027 or less was required for significance.

Results

Differences in Overall Scores

Mean Social Function domain raw scores for each profile group are shown in Figure 1. The highest possible PEDI Social Function raw score was 65. Descriptive results revealed the expected pattern, with children without speech-language impairments (group NSMI) achieving the highest Social Function scores and the children who are unable to speak (group ANAR) achieving the lowest Social Function scores. Statistical results examining pair-wise differences between groups across all items comprising the social function domain of the PEDI revealed that the difference between Groups NSMI and SMI-LCT was not significant. However, the following differences were significant: NSMI and SMI-LCI ($z = -2.86$; $p = .003$); NSMI and ANAR (-3.64 ; $p < .001$), SMI-LCT vs. SMI-LCI (-2.77 ; $p = .003$), SMI-LCT vs. ANAR (-3.77 ; $p < .001$), SMI-LCI vs. ANAR (-3.21 ; $p < .001$).

Differences in Developmentally Stratified Skill Levels

The percentage of Social Function skills within the three developmentally-stratified skills levels performed by each profile group are displayed in Figure 2. Within the early-emerging skills, the same pattern of results as those observed for the overall data was evident. Group NSMI and group SMI-LCT performed the highest percentages of early-emerging skills and group ANAR performed the lowest percentage of early-emerging skills. The difference between groups NSMI and SMI-LCT was not significant; however, the differences between groups NSMI vs. SMI-LCI ($z = -3.15$; $p < .001$), NSMI vs. ANAR ($z = -3.66$; $p < .001$), SMI-LCT vs. SMI-LCI ($z = -3.22$; $p < .001$), SMI-LCT vs. ANAR ($z = -3.78$; $p < .001$), and SMI-LCI vs. ANAR ($z = -3.32$; $p < .001$) were significant.

Within the age-level skills, again, the same pattern of results as those observed for the overall data was evident. Again, the difference between groups NSMI and SMI-LCT was not significant. The results from groups SMI-LCI and ANAR followed the expected pattern, with group ANAR performing the lowest percentage of skills. The differences between NSMI vs. SMI-LCI ($z = -2.61$; $p < .01$), NSMI vs. ANAR ($z = -3.65$; $p < .001$), SMI-LCT vs. SMI-LCI ($z = -3.74$; $p < .005$), SMI-LCT vs. ANAR ($z = -3.78$; $p < .001$), and SMI-LCI vs. ANAR ($z = -3.29$; $p < .001$) were significant.

A stair-step pattern was evident within the late-emerging skills. Overall, children in our sample performed few late-emerging skills, which was expected given the chronological age of the children. Children in group NSMI performed the highest percentage of late-emerging skills and children in group ANAR performed less than 5% of the late-emerging skills. Within late-emerging skills, a different pattern of significant group differences emerged. The differences between Groups NSMI vs. SMI-LCT, NSMI vs. SMI-LCI, SMI-LCT vs. SMI-LCI and SMI-LCI vs. ANAR were not statistically significant. However, the differences between Groups NSMI vs. ANAR ($z = -3.76$; $p < .001$), and SMI-LCT vs. ANAR ($z = -3.42$; $p < .001$) were significant.

Mastery of Skills

Mastery results for early-emerging, age-level, and late-emerging items are displayed in Figure 3. Children in group NSMI mastered 33 of the 33 early-emerging items, 14 of the 19 age-level items, and 4 of the 13 late-emerging items at the 75% criteria level. Children in group SMI-LCT mastered 32 of the 33 early-emerging items, 16 of the 19 age-level items, and none of the late-emerging items at the 75% criteria level. Children in group SMI-LCI mastered 20 of the 33 early-emerging items, 4 of the 19 age level items and none of the late-emerging items at the 75% criteria level. Children in Group ANAR mastered 5 of the 33 early-emerging items and none of the age-level or late-emerging items at the 75% criterion level.

Discussion

This study examined differences in PEDI Social Function scores for four year-old children with CP who were classified into four speech-language profile groups, as described by Hustad et al. [12]. There were four key findings from this study. First, results showed that all children in the sample had social function limitations as measured by the PEDI, including those children without documented speech-language impairments. Second, activity-level performance on the PEDI did not seem to be affected by intelligibility differences for some children. Third, activity-level performance on the PEDI did seem to be affected by differences in language abilities. Finally, while the PEDI is oriented towards early-emerging social function skills, it may have limited sensitivity to the nonverbal / non-speech communication modalities used by children in group ANAR. Each of these will be discussed below.

Social Function Limitations for All Children

In general, Social Function raw scores revealed a pattern of greater social function limitations for children with more severe communication impairments. This pattern was expected as previous research indicates that children with speech-language impairments do experience social participation difficulties that may be related to their underlying impairments [21,22,24,25,37]. This study provides evidence of need for speech-language interventions that target social communication activities across environments and partners. Further, findings provide some support for the somewhat controversial notion that performance of activities may be closely linked to underlying impairments. Previous

research indicates that the relationship between gross motor impairments and activities in children with CP is complex and is affected by the interaction between personal and environmental factors [29,38]. We expect that communicative impairments and activities have a similarly complex relationship, with strong influences from personal and environmental factors.

Intelligibility Deficits and Social Function Skills

Children with no speech motor involvement (NSMI) and children who had motor speech involvement and typical language comprehension abilities (SMI-LCT) did not differ from one another with regard to their overall PEDI scores, or their scores on early-emerging, age-level, or late-emerging skills. This was surprising because children in group SMI-LCT had documented reductions in speech intelligibility relative to children in group NSMI [12]. According to Yorkston et al. [15], intelligibility is defined as the extent to which a listener can decipher a message produced by a speaker and considered an overall measure of speech activity. Reductions in speech intelligibility can lead to negative social consequences [21,22,24,25,37] and improving intelligibility is often a primary treatment focus [15]. The finding that children in groups NSMI and SMI-LCT did not differ significantly in their overall PEDI scores, in light of previous reports on the social impact of reduced speech intelligibility, suggests that the Social Function domain may not be sensitive to speech intelligibility deficits. Examination of the individual items comprising the PEDI Social Function domain reveals that very few items actually require intelligible speech to complete. Those items that do rely on intelligible speech do not query the extent to which others are able to understand the child's productions. For example, one item queries whether the child can state his/her address. If a child can, in fact, state his/her address, parents may have provided an affirmative response to this question even though it may be difficult to understand the child's words. In this situation, the binomial response required for each item on the PEDI may limit its sensitivity to gradations of 'success'. Further, because of the complexity of communication and the extent to which it is affected by partners and contexts, Social Function domain responses from parents may reflect a biased view. In our example, an affirmative response from parents may reveal their perception of success, which may be different than more global communicative success across partners and contexts.

Children in groups NSMI and SMI-LCT mastered nearly all early skills as expected given their chronological age. Children in both groups mastered similar numbers of age-level skills (about three quarters of the possible skills). It is noteworthy, however, that children in these groups did not master all of the age-level skills as would be expected based on their chronological age. This is particularly surprising in the case of group NSMI, which was comprised of children without any speech motor involvement. Informal examination of the age-level items not mastered by group NSMI revealed that these children experience challenges on six items related to peer interaction, personal safety, and community function. Mastery data from group NSMI provide further support for previous findings regarding social challenges in children with CP [21,22] and suggest that other factors beyond speech and language abilities may be impacting Social Function scores of children in our sample.

Sensitivity to Language Impairments

Results of the present study suggest that activity-level performance on the PEDI is sensitive to language deficits that were identified in children comprising group SMI-LCI and that children in this group may also have other deficits related to social function beyond their documented language impairments. Specifically, examination of the 24 items that were not mastered by group SMI-LCI but were mastered children without language impairment (group SMI-LCT) revealed that 7 of the 24 Social Function items that were not mastered by children in group SMI-LCI targeted language comprehension or expression specifically.

Interestingly, 17 of the 24 items that were not mastered by children in group SMI-LCI focused on skills related to play, problem-solving, or intellectual development. Results of the present study suggest that children in group SMI-LCI also, most likely, had other developmental delays, beyond their documented language delays, that impact engagement in communicative activities. Results support the need for multifaceted speech and language therapy approaches in children with CP [39].

Orientation toward Early-Emerging Skills

One observation that emerged from the analysis of developmentally-stratified skill levels was that the PEDI Social Function domain had more questions targeting early-emerging skills (defined as skills that emerge between birth and 3;0 years old) than any other skill level. While this earlier orientation may be useful for assessment of children who are chronologically or developmentally younger, it may potentially result in an inflated Social Function score for some children. Descriptive statistics showed that children in each group performed more early-emerging skills than age-level or late-emerging skills. However, it is difficult to interpret this observation in a developmental context because of the relative paucity of higher level skills.

Early-emerging skills were the only items that children in all four groups mastered at a 75% criterion level, although it is noteworthy that children in group ANAR only mastered 5 early-emerging skills. The finding that children in group ANAR had mastered so few skills is surprising, since additional early-emerging skills were deliberately added in the design of the PEDI to better capture the functioning of children with severe disabilities. Though children in group ANAR, by definition, could not use speech to communicate, they do engage in social interaction, communicating using modalities such as eye gaze, facial expression, referential pointing, and gross vocalizations. The very limited number of items that children in this group mastered suggests that the PEDI may have limited sensitivity to use of nonverbal / non-speech communication modalities, despite the orientation toward early-emerging social function skills.

Limitations

The PEDI was designed to be administered in the form of an interview with a trained clinician/researcher and a parent. In this study, all PEDI forms were administered as parent questionnaires. As the parents of our participants represent a range of cultural backgrounds and socio-economic levels, it is possible that some parents may not have fully understood the PEDI form. In addition, the relatively small number of participants in this study and the small number of children within each profile group limit generalization of findings. Conclusions should be drawn with caution. Additionally, improvements to the PEDI presently under development include computerised administration, an expanded item bank, and refinement of response scales [40-42]. Continued developments of the PEDI, particularly expansion of the item bank, show promise in addressing some of the issues raised within this study.

Summary

The purpose of this project was to characterise the social functioning of children with CP within the four speech and language profile groups identified by Hustad et al. [12] and to determine if the PEDI would capture similar differences previously observed for speech intelligibility in the sample. Overall, children with CP had reduced activity-level performance as measured by the PEDI and this was generally consistent with impairment profiles. PEDI social function scores were not consistent with intelligibility profiles of the group, which is known to be a measure of speech activities. Findings call for the creation of a new developmentally-sensitive tool that more accurately isolates communicative activities

and participation for children with CP who do and do not have communication disorders. Children with CP experience unique challenges related to communicative activities and participation [21,22,24,25,37], a condition-specific measure is needed to provide insight about the impact of multiple partners, environments, and communication modalities, including AAC systems, on their lives.

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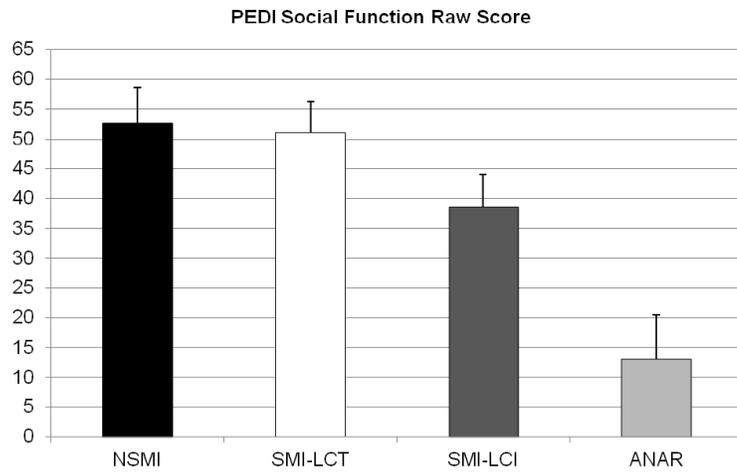


Figure I. Mean PEDI Social Function Raw Score by group. Error bars represent standard deviation.

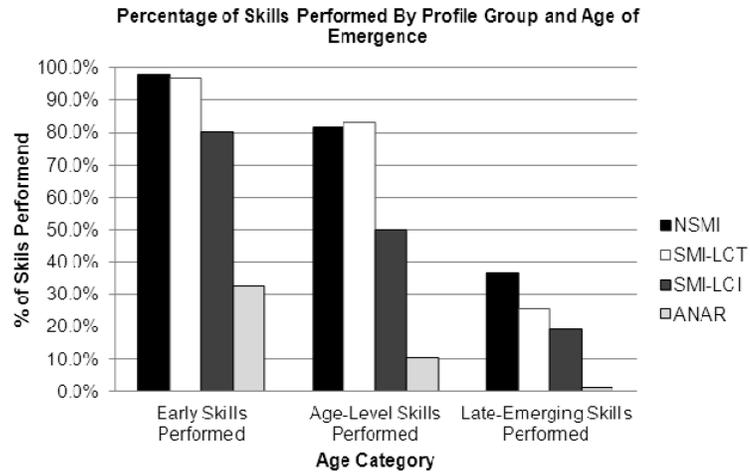


Figure II. Percentage of skills performed by children in each profile group within developmentally-stratified skill levels.

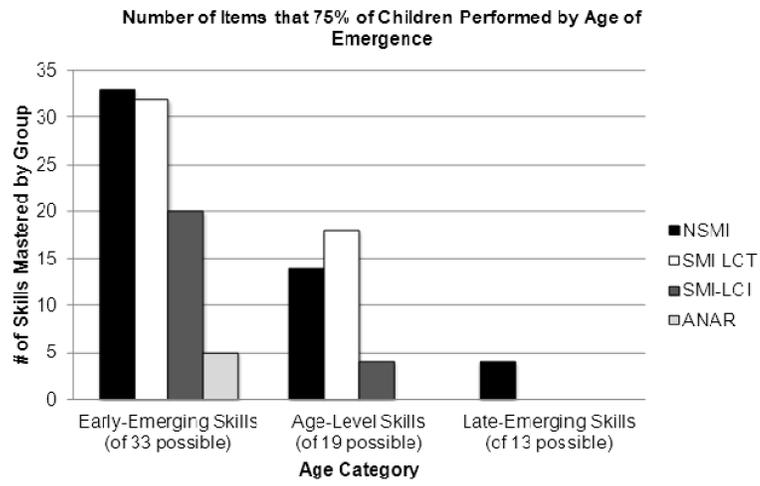


Figure III. Number of items mastered by 75 of children in each profile group within developmentally-stratified skill levels. R01DC009411.

TABLE I

Demographic information for participants

	Group NSMI	Group SMI-LCT	Group SMI-LCI	Group ANAR	Total
n	8	9	6	11	34
Mean Age (SD)	54.7 (1.1)	53.5(1.7)	54.9(1.8)	54.7(2.1)	54.45
Mean GA at birth in weeks	33	33	32	37	33.75
Born at >38 weeks	2	2	2	7	13
Born at < 38 weeks	4	3	4	3	14
Not reported	2	4	0	1	7
Male:female ratio	5:3	2:7	3:3	8:3	18:16
Distribution					
Diplegia	4	2	1	0	7
Hemiplegia (left)	3	1	0	0	4
Hemiplegia (right)	0	1	1	0	2
Quadriplegia	0	2	2	8	12
Not reported	1	3	2	3	9
GMFCS Level					
Level I	2	1	0	0	3
Level II	6	4	2	1	13
Level III	0	2	2	0	4
Level IV	0	2	0	4	6
Level V	0	0	2	6	8
AAC system in place	0	1	0	5	6
Cortical visual impairment	0	0	0	3	3
Corrected vision	0	2	4	5	11

Note: GA = gestational age; GMFCS = Gross Motor Function Classification System