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Alignment of classification paradigms for communication abilities in children with cerebral palsy

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Abstract

Aim—We examined three communication ability classification paradigms for children with cerebral palsy (CP): the Communication Function Classification System (CFCS), the Viking Speech Scale (VSS), and the Speech Language Profile Groups (SLPG). Questions addressed inter-judge reliability, whether the VSS and the CFCS captured impairments in speech and language, and whether there were differences in speech intelligibility among levels within each classification paradigm.

Method—80 children (42 males) with a range of types and severity levels of CP participated (mean age, 60 months; SD 4.8 months). Two speech-language pathologists classified each child via parent-child interaction samples and previous experience with the children for the CFCS and VSS, and uisng quantitative speech and language assessment data for the SLPG. Intelligibility scores were obtained using standard clinical intelligibility measurement.

Results—Kappa values were .67 (95% CI [.55, .79]) for the CFCS, .82 (95% CI [.72, .92]), for the VSS, .95 (95% CI [.72, .92]) for the SLPG. Descriptively, reliability within levels of each paradigm varied, with the lowest agreement occurring within the CFCS at levels II (42%), III (40%), and IV (61%). Neither the CFCS nor the VSS were sensitive to language impairments captured by the SLPG. Significant differences in speech intelligibility were found among levels for all classification paradigms.

Interpretation—Multiple tools are necessary to understand speech, language, and communication profiles in children with CP. Characterization of abilities at all levels of the ICF will advance our understanding of the ways that speech, language, and communication abilities present in children with CP.

Keywords

dysarthria; speech; language; intelligibility; communication development

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Communication difficulties are one of the most common deficits observed in individuals with cerebral palsy (CP) (1) and can be related to impairments in speech motor control, cognition, language, and sensation / perception, or a combination of these. However, systematic prospective research efforts aimed at understanding the specific nature of communication abilities and the impact of development have lagged far behind the study of motor skills. The development and validation of research-based tools for classifying communication problems in individuals with CP has been identified as a high priority (2, 3). Toward this end, recent efforts have focused on classifying overall communication (4, 5) and functional speech abilities (6, 7) in individuals with CP at the level of activities and participation within the International Classification of Functioning, Disability and Health (ICF). For example, the Communication Function Classification System (CFCS) (4) seeks to classify overall communication effectiveness in everyday situations based on the individual's ability to act as both a sender and receiver of information, regardless of modalities used. The CFCS was developed to mirror the Gross Motor Function Classification System (GFMCS) (8) and thus has 5 levels. However, the CFCS was designed to be applied to individuals across all ages without regard for developmental variables, thus it would be expected that children might advance through CFCS levels as their development progresses.

The Viking Speech Scale (VSS) (6) is a four level rating scale developed to characterize the functionality of speech (speech intelligibility) in daily life. Because children with CP frequently experience dysarthria (7), and dysarthria is almost always associated with reduced speech intelligibility, the quantification of intelligibility deficits is critical to characterize how well speech functions as a communication modality. Such information is also useful for intervention decision making, particularly with regard to the potential need for augmentative and alternative communication (AAC) systems. Intelligibility is most commonly measured clinically through direct assessment of speech (9), however if tools such as the VSS or the CFCS are sensitive to intelligibility deficits, this could provide important information that adds to the usefulness of these tools.

Both the CFCS and the VSS were designed to be used by a range of professionals, including speech language pathologists, as well as family members. Both are rating scales that require subjective judgment to assign levels and can be employed without clinical assessment or direct observation of the person with CP, and thus have utility for registries and surveillance studies. However, studies have reported variability in reliability for both the VSS (6) and the CFCS (4, 10). It is noteworthy that the CFCS is in widespread use, often as the sole measure of communication abilities in individuals with CP (see 11, 12), making the issue of reliability a particularly important one.

While the CFCS and the VSS provide important information regarding functional communication, characterization of impairment-level speech and language abilities is also essential to begin to understand how different impairment profiles might lead to different activity and participation classifications and to begin to develop data-based interventions that improve long term outcomes (13). A prospective approach to classification that considers underlying speech and language impairment at the level of body functions and structures as well as speech intelligibility at the level of activities has been described by Hustad and colleagues (13) who empirically identified four speech/language profile groups based on

behavioral speech and language assessment data. The speech language profile group (SLPG) paradigm separates children based on the presence or absence of speech motor involvement, and the presence or absence of language / cognitive involvement. The resultant model comprises four speech and language impairment profiles (13). Strong reliability of clinician classification into profile groups was reported in the original paper (13); however larger scale reliability studies have not been conducted. Table 1 summarizes each of the three classification systems and their respective levels.

In the present study, our aim was to examine the clinical application of three classification paradigms (CFCS, VSS, SLPG) with regard to: 1.) reliability, 2.) agreement between scales, specifically whether classification levels of the VSS and CFCS, designed to capture intelligibility and functional communication, respectively, also detected underlying speech and language impairments as classified by the SLPG, 3.) whether speech intelligibility differed among classification levels within each of the three classification paradigms.

Method

Participants

Eighty children with CP participated in this study. All children were involved in a larger prospective longitudinal study on communication development in children with CP. Children were recruited through local and regional neurology and physiatry clinics in the upper midwestern region of the United States. Recruitment efforts sought to capture a representative sample of children with CP that was not biased for or against the presence of speech or language problems. Inclusion criteria for the larger study required that children: 1.) have a medical diagnosis of CP; and 2.) have hearing abilities within normal limits as documented by either formal audiological evaluation or distortion product otoacoustic emission screening. For the present study, we selected children from the larger cohort reflecting an equal representation of our previously described speech language profile groups (SLPG) (13). Approximately 20 children from each SLPG who had completed a data collection session between the chronological ages of 50 and 72 months of age were randomly selected for inclusion in the present study. Children with no speech motor involvement (NSMI) had no clinical evidence of speech or language impairment. Children with speech motor involvement and typical language comprehension abilities (SMI-LCT) had clinical evidence of dysarthria as described in our previous work (see Hustad and colleagues, 2010) and receptive language skills on standardized tests that were within one standard deviation from the mean. Children with speech motor involvement and language comprehension impairment (SMI-LCI) met the same criteria for speech motor involvement, but had standardized receptive language scores below one standard deviation from the mean. Children who were unable to speak were classified as anarthic (ANAR). We defined anarthria as the ability to produce fewer than 5 words or word approximations using natural speech (following our earlier work, Hustad and colleagues, 2010). Children in the ANAR group had a range of language abilities, with all children having language impairment as indicated by standardized test scores. Note, however, that all but one child in the ANAR group had GMFCS levels of IV or V, making standardized language testing, which relies heavily on motor skills to manipulate objects and / or point to pictures, very difficult. All

children in the ANAR group used other modes to communicate, with 13 of 20 children having augmentative and alternative communication (AAC) systems in place.

Collectively, children in the sample were representative of the upper-midwest portion of the United States with regard to socioeconomic status and race. All children were from homes where American English was the primary language.

Children in this study were born in the United States between 2001 and 2009. The mean age across all children was 60 months (SD 5.8 months). The sample comprised 42 males; 38 females. Table 2 presents demographic characteristics of children, including medical diagnoses, and GMFCS (14) rating. Table 3 presents demographic characteristics of children by speech language profile group (SLPG).

Materials and Procedures

For the larger study, the evaluation protocol was administered by a research speech-language pathologist in a sound-attenuating room. The protocol included administration of a standard assessment battery focused on speech production, language comprehension, and spontaneous communication in a parent-child interaction. During the parent-child interaction, children were permitted to use any and all of their communication tools (including augmentative/alternative communication systems for those who had them). The same testing room, stimulus materials, and assessment tools were employed for each child. The play-based data collection sessions lasted approximately two hours; all children tolerated this without difficulty. All sessions were audio and video recorded with professional-quality recording equipment.

For the present study each child was classified using the CFCS (4), the VSS (6), and the SLPG (13) paradigms by two licensed and certified speech-language pathologists with extensive expertise working with children who have CP. Experts made ratings independently of one another on all children. Both individuals reviewed published materials (including on-line tools) to learn how to assign classifications following established guidelines. To assign VSS and CFCS classifications, experts viewed a 10-minute video sample of each child interacting with a parent. To assign SLPG classification, experts utilized prospectively obtained speech and language evaluation data including clinical findings related to oral motor, speech motor, and language testing results. Note that both experts had professional experience collecting speech and language assessment data from the children in the sample. Thus, their professional knowledge of each child's speech, language and communication skills exceeded that which was presented on the videotaped samples that they viewed when making ratings. This type of knowledge among raters is consistent with published reports describing use of both the VSS and the CFCS. Further, we would expect this inter-personal knowledge of the children to have a similar impact on classifications for all three paradigms because it affords clinically relevant information at all levels of the ICF model.

Following initial classifications by both expert raters, children who did not receive the same rating by both individuals were classified by consensus. This was done for each of the three

classification paradigms to obtain a single final expert classification for each child using each paradigm.

For children who were able to produce speech, intelligibility scores were obtained using a standard intelligibility measurement procedures (9). Specifically, listeners made orthographic transcriptions of audio recordings from each child producing stimuli ranging from 1- 7 words in length from the Test of Children's Speech (TOCS+) (15), which is a set of single words and sentences that systematically vary in length and are developmentally appropriate for children.

A total of two different listeners heard each child who was able to produce the TOCS + (58 children), for a total of 116 listeners. Intelligibility was scored as the percent of words identified correctly by each listener, averaged across the two listeners per child. Across all children who could produce the TOCS+, the correlation between the intelligibility scores of the first and second listener was .936, with the average difference between listeners being less than 1%, indicating a high level of agreement between pairs of listeners who heard the same child.

Statistical analysis

To address reliability of judgments made by two expert raters in placing children into classification groups for each of the three classification systems, we completed two sets of analyses: 1.) descriptive inter-rater agreement (not corrected for chance), measured as the percent of agreements divided by the total number of judgments; 2.) Cohen's Kappa statistics to examine inter-rater agreement (corrected for chance) within each classification system.

To address how well the VSS and the CFCS captured impairments across both speech and language domains (identified in the SLPG levels), we completed two sets of analyses: 1.) cross tabulation to examine the distributions of CFCS against SLPG, and VSS against SLPG and identify overlap among classification categories across classification paradigms; and 2.) non-parametric correlation coefficients (Kendall's Tau) between classifications using each paradigm.

Finally to examine whether there were differences in children's intelligibility among levels of each classification system for the children who were able to speak, we completed two sets of analyses: 1.) analysis of variance within in each classification paradigm; and 2.) pairwise follow-up contrasts within each classification system.

Results

Reliability of classification

Within level inter-rater consistency is shown in Table 4. Overall the two expert raters assigned CFCS ratings to children with 75% consistency. Within level inter-rater consistency ranged from 40% for level 3 to 100% for level V. Cohen's Kappa for the CFCS was .67, 95% CI [.55, .79].

The two expert raters assigned VSS ratings to children with 85% consistency. Results indicate that agreement on the VSS ranged from 74% for level III, to 95% for level I. Cohen's Kappa for the VSS was .816, 95% CI [.72, .92].

Inter-rater consistency for the SLPG was 96%. Within level inter-rater consistency ranged from 95% for level II to 100% for all other levels. Cohen's Kappa for the SLPG was .95, 95% CI [.89, 1.0].

Classification of impairment profiles

Descriptive cross tabulation results between the CFCS, VSS and SLPG ratings are provided in Table 3. For the CFCS, level I captured all children without speech motor impairment (SLPG level I) as well as six children who had speech motor involvement (SLPG level II); thus, CFCS level I did not separate children with speech impairment from children without speech impairment. Level II of the CFCS captured only children with speech motor impairment (SLPG levels II and III), but did not differentiate between those with and without language impairment. CFCS level III had the fewest children in the entire study. Only children with speech motor involvement and intact language skills (SLPG level II) were classified as CFCS level III. CFCS level IV captured children with speech motor involvement, regardless of language abilities (SLPG levels II and III), and also captured 7 children who were anarthric (SLPG level IV), thus did not differentiate between children who could and could not produce speech. Finally CFCS level V captured primarily children who were anarthric (SLPG level IV), but one child with speech motor involvement and language difficulties (SLPG level III) was also classified in this group. The correlation between CFCS ratings and SLPG ratings was .825 (Kendall's Tau).

For the VSS, results suggested that level I captured only children who did not have speech motor involvement (SLPG level I). VSS level II captured only children who had speech motor impairment, but did not differentiate between those with and without language difficulties (SLPG levels II vs. III). Level III captured primarily children with speech motor involvement who could talk (SLPG levels II and III), but two children who were anarthric (SLPG level IV) were also classified as VSS level III. Finally, VSS level IV captured only children who had anarthria (SLPG level IV); however, 2 children in SLPG level IV who were anarthric were rated VSS level III. The correlation between VSS ratings and SLPG ratings was .89 (Kendall's Tau).

Intelligibility differences

Within each of the classification paradigms, overall ANOVA results revealed significant differences in intelligibility between groups containing children who could speak (for SLPG $F_{2,54} = 39.49$, $p<.001$; for CFCS $F_{4,52} = 50.46$, $p<.001$; and for VSS $F_{2,54} = 56.41$, $p<.001$). Note that none of the children in SLPG IV (ANAR) were able to produce enough speech to measure intelligibility. Pairwise comparisons examining differences between levels (See Table 4) showed that all levels were significantly different within the VSS and the SLPG. For the CFCS all pairwise contrasts for intelligibility were also significant except for the difference between levels II and III.

Discussion

This study examined three different communication classification paradigms for children with CP, the CFCS, the VSS, and the SLPG. Each paradigm purports to capture somewhat different aspects of communication ability at different levels of the ICF model. Eighty children with CP who were 5 years old participated in this study. Two speech-language pathologists classified children using each of the three paradigms. We examined inter-rater agreement (reliability) for each paradigm; the extent to which the VSS and the CFCS captured impairments in speech and language as indicated by SLPG classification; and whether the levels within each of the three classification paradigms revealed differences in speech intelligibility as measured by direct clinical assessment.

Results showed that there was variability in the reliability among the three classification systems. The CFCS was the least reliable with an agreement level (uncorrected for chance) of 75% between two expert raters and a Kappa value of .67. This result is consistent with findings from the earliest reports of the CFCS (4), reflecting an “adequate” Kappa value (16). Note however, that a recent study showed that inter-rater reliability of the CFCS improved considerably after an extensive web-based training program (10). In the present study, further descriptive exploration of inter-rater agreement revealed that there were differences in agreement within levels of the CFCS. Specifically, within levels II, III, and IV expert raters generally had much lower agreement (42%, 40%, and 61%, respectively) than those observed for levels I and V (96% and 100% respectively). This finding is consistent with other studies where inter-rater agreement tends to be better at extreme ends of a rating scale (see for example (14)). In the present study one reason may relate to the finding that the CFCS was generally not sensitive to language abilities based on our cross tabulation analysis with the SLPG. Specifically, levels II, III, and IV of the CFCS comprised children with speech motor impairment with and without co-occurring language impairment (SLPG levels II and III) as well a few children who were unable to speak (level IV). Although the CFCS does not seek to capture underlying problems such as speech or language impairment, these abilities clearly impact an individual’s success as both a sender and receiver of information and have critical implications for intervention. Results of this study also showed that intelligibility scores were significantly different among levels of the CFCS for all but levels II vs. III (note that level V did not have enough children who could speak to be included in pairwise comparisons). This finding suggests that the CFCS may be sensitive to speech intelligibility, though not as sensitive as the VSS. Collectively, results may indicate that refinements in the CFCS to enhance differentiation among levels II, III, and IV are warranted. One approach may be to consider factoring functional language abilities into the different levels of the classification system, which would also have the added benefit of informing potential intervention directions.

The VSS was considerably more reliable than the CFCS, with an overall uncorrected agreement between experts of 85% and a Kappa value of .819, which is considered to be very good (16). This finding may suggest that rating one parameter, functional speech, is more straightforward (thus more reliable) than rating the more complicated construct of overall functional communication in both sender and receiver roles. Within levels, reliability of the VSS was generally consistent, with agreement ranging from 75% to 95%. Level III

had the lowest agreement, followed by level II, again suggesting that individuals falling in the mid-range of the scale were more difficult to classify, even for expert raters. As with the CFCS, the VSS did not appear to differentiate among children with speech motor impairment who did and did not have co-occurring language impairment (SLPG levels II and III). This is not surprising given that the explicit purpose of the VSS is to characterize functional speech (i.e. speech intelligibility). Findings from intelligibility data showed significant differences among levels for all children who were able to speak (note that level IV was comprised of children who were unable to produce functional speech). This finding supports the validity of the VSS, demonstrating that it successfully separates children into groups that have significantly different intelligibility scores as measured empirically.

The SLPG showed the best inter-rater reliability of the three paradigms, with 96% uncorrected agreement between raters and a Kappa value of .95. This high level of inter-rater reliability is likely directly related to the method through which classifications were made (i.e. via consideration of empirical speech/language data). Thus, subjectivity was considerably reduced for SLPG classification relative to the CFCS and VSS. It is also noteworthy that our group developed the SLPG and thus has more experience with it than with other classification tools. Within levels of the SLPG, the lowest inter-rater agreement level was II (SMI-LCT), which had 95% agreement. Interestingly, disagreement at this level centered around how to classify children with borderline language abilities. We considered scores that were below one standard deviation from the mean to reflect impaired language. In other contexts, such as qualifying for school based services in the US, cutoff scores of 1.5 or even 2 standard deviations are required for a child to be considered “impaired”. Use of different criteria could result in improved agreement as to whether test scores are indicative of impairment. As with the VSS, intelligibility scores were significantly different among groups of children who were able to talk (note that group IV was comprised of children with anarthria). One interesting finding was that children with speech motor involvement and language impairment (SMI-LCI) had lower intelligibility scores (by about 20%) than those with speech motor impairment who did not have language impairment (SMI-LCT), highlighting the importance of language abilities to speech production. The interaction between speech motor and language deficits is extremely complicated and not well understood. However, further investigation is clearly warranted to begin to elucidate the ways in which speech and language abilities and deficits influence each other and jointly affect functional speech, language, and communication abilities and subjective ratings of these abilities.

Overall, results of this study show that there are differences in inter-rater reliability of the three communication classification systems when expert speech-language pathologists classified children with CP. Particularly noteworthy was the low agreement levels for the CFCS within levels II, III, and IV. Results further indicate that neither the CFCS nor the VSS were sensitive to the presence of language impairments in children with CP. Although neither scale purports to capture language abilities, language skills play a crucial role in overall communication ability, and likely interact in important ways that require further investigation with speech intelligibility. Finally, there was general consistency among the classification systems with regard to how well they separated children based on speech intelligibility scores. Results of this study highlight the notion that multiple tools are

necessary to comprehensively describe speech, language, and communication profiles in children with CP. Measures at the level of activities and participation are not sufficient in and of themselves to fully characterize the range of abilities relating to speech, language, and communication in children with CP, nor do they serve to direct intervention in the absence of an understanding of the associated underlying impairments. However, there are a variety reasons that speech, language, and communication classification may be of interest, for example surveillance studies involving retrospective data analysis from registries. Given the paucity of data on speech, language, and communication in CP relative to the large body of knowledge regarding motor skills, tools such as the CFCS and the VSS provide a valuable starting place for a more thorough exploration of the range of strengths and challenging facing individuals with CP.

This study had several key limitations. Perhaps most importantly, there were a relatively small number of participants. All children were the same age, which is attractive from the perspective of controlling for developmental variables; however, generalization of findings to children of other ages must be made with caution. Future studies should seek to examine the age continuum of children with CP to begin to understand the impacts of development on speech, language, and communication abilities and on the longitudinal stability of classification paradigms.

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What this paper adds

- Different tools for classifying communication abilities in children with CP at 5 years of age vary in their reliability. Reliability of classification within levels II, III, and IV of the Communication Function Classification System (CFCS) was problematic, suggesting refinement in application of the CFCS may be necessary.
- Language is an essential facet of communication and has an important impact on functional communication. Neither the CFCS nor the VSS purport to describe language ability, and neither definitively captured language impairment relative to the SLPG, which employs language ability as a differentiating feature among classification levels.
- All three classification paradigms, the CFCS, the VSS, and the SLPG showed differences among at least some levels in speech intelligibility as measured directly using standard clinical tools, suggesting that severity is captured by each paradigm.

Table 1

Description of levels within the Viking Speech Scale (VSS), Communication Function Classification System (CFCS), and the speech language profile groups (SLPG).

Classification System	Description of Levels
CFCS	**Level I** – Effective sender/receiver with both unfamiliar/familiar partners
	Level II – Effective sender/receiver with both unfamiliar/familiar partners but the pace of conversation is slower
	Level III – Effective sender/ receiver with familiar partners only; not effective with unfamiliar partners
	Level IV – Inconsistent sender and/or receiver with familiar partners; not effective with unfamiliar partners
	Level V – Seldom effective sender/receiver with familiar partners; not effective with unfamiliar partners
VSS	**Level I** – No speech motor disorder
	Level II – Speech motor disorder but usually understandable to unfamiliar listeners
	Level III – Speech motor disorder but not usually understandable to unfamiliar listeners out of context
	Level IV – No understandable speech
SLPG	**NSMI** – No speech motor involvement
	SMI-LCT – Speech-motor involvement and age-appropriate language and/or cognitive skills
	SMI-LCI – Speech-motor involvement and impaired language and/or cognitive skills
	ANAR – Unable to produce speech

Table 2

Demographic characteristics of children with CP.

	Number of participants
Sex	
Male	42
Female	38
GMFCS	
I	38
II	7
III	5
IV	15
V	15
Type of CP	
Spastic bilateral	36
Spastic unilateral	24
Dystonic	5
Choreo-Athetotic	0
Ataxic	3
Unknown	12
Vision	
Within normal limits	42
Corrected	24
Uncorrected	3
CVI	6
Other	5

Table 3

Demographic characteristics of children by speech language profile group (SLPG)

	SLPG 1 (No speech motor involvement)	SLPG 2 (Speech motor involvement – Language comprehension typical)	SLPG 3 (Speech motor involvement – Language comprehension impaired)	SLPG 4 (Anarthria)
Mean Age (SD)	59.8 (6.5)	60.0 (5.9)	59.1 (5.2)	61.2 (5.6)
Male: Female ratio	13: 7	9:12	7: 12	13:7
Type of CP				
Spastic bilateral	7	7	8	14
Spastic unilateral	10	9	5	0
Dystonic	0	0	3	2
Choreo-Athetotic	0	0	0	0
Ataxic	0	3	0	0
Unknown	3	2	3	4
GMFCS				
I	18	13	7	0
II	2	0	4	1
III	0	3	1	1
IV	0	5	5	5
V	0	0	2	13
Standard Language comprehension score (SD)	108.6 (18.2)	102.3 (14.7)	77.7 (5.4)	58.3 (7.1)
Speech intelligibility score (SD)	79.1 (10.3)	45.2 (23.5)	22.4 (20.0)	NA
Mean Utterance length	4.18 (.44)	3.42 (.86)	2.21 (.90)	NA

Table 4

Cross tabulation results showing distributions of VSS against SLPG and CFCS against SLPG.

			VSS						CFCS					
			1	**2**	**3**	**4**	**Total**		**1**	**2**	**3**	**4**	**5**	**Total**
SLPG	1: NSMI	Count	20	0	0	0	20	Count	20	0	0	0	0	20
		% within VIKING	100.0%	0.0%	0.0%	0.0%	25.0%	% within CFCS	76.9%	0.0%	0.0%	0.0%	0.0%	25.0%
	2: SMI-LCT	Count	0	16	5	0	21	Count	6	7	5	3	0	21
		% within VIKING	0.0%	69.6%	26.3%	0.0%	26.3%	% within CFCS	23.1%	58.3%	100.0%	13.0%	0.0%	26.3%
	3: SMI-LCI	Count	0	7	12	0	19	Count	0	5	0	13	1	19
		% within VIKING	0.0%	30.4%	63.2%	0.0%	23.8%	% within CFCS	0.0%	41.7%	0.0%	56.5%	7.1%	23.8%
	4: ANAR	Count	0	0	2	18	20	Count	0	0	0	7	13	20
		% within VIKING	0.0%	0.0%	10.5%	100.0%	25.0%	% within CFCS	0.0%	0.0%	0.0%	30.4%	92.9%	25.0%
Total		Count	20	23	19	18	80	Count	26	12	5	23	14	80
		% of Total	25.0%	28.8%	23.8%	22.5%	100.0%	% of Total	32.5%	15.0%	6.3%	28.8%	17.5%	100.0%

Note that column totals reflect the number of children classified in each VSS category and each CFCS category. Row totals reflect the total number of children classified in each SLPG category. Row/column coordinates show the number of children within each SLPG category who were classified in each of the VSS and CFCS categories

Table 5

Summary data associated with classification using the VSS, the CFCS, and the SLPG.

	Number of participants	Inter-rater agreement	Cohen's Kappa	Intelligibility
CFCS				
I	26 (32%)	25/26 (96%)		75.93% (SD 11.68)
II	12 (15%)	5/12 (42%)	Overall = .670	47.13% (SD 16.75)
III	5 (6%)	2/5 (40%)	95% CI = .55 - .79	34.92% (SD 16.13)
IV	23 (29%)	14/23 (61%)		14.92% (SD 12.39)
V	14 (18%)	14/14 (100%)		7.81% (SD NA)
		Overall = 75%		
VSS				
I				
II	20 (25%)	19/20 (95%)		78.68% (SD 10.27)
III	23 (29%)	19/23(83%)	Overall = .816	47.49% (SD 20.31)
IV	19 (24%)	14/19 (74%)	95% CI = .72 - .92	17.87% (SD 16.96)
	18 (22%)	16/18 (89%)		Unable to speak
		Overall = 85%		
SLPG				
I: NSMI				
II: SMI-LCT	20 (25%)	20/20 (100%)		78.68% (SD 10.27)
III: SMI-LCI	21 (26%)	19/21 (95%)	Overall = .950	45.16% (SD 23.50)
IV: ANAR	19 (24%)	19/19 (100%)	95% CI = .89 – 1.0	24.64% (SD 19.29)
	20 (25%)	20/20 (100%)		Unable to speak
		Overall = 96%		

Table 6

Pairwise follow-up contrasts examining differences in intelligibility scores between groups within each classification paradigm.

Contrast	Mean difference	95% CI		Std. Error	Observed p-value
		Lower bound	Upper bound		
SLPG					
I vs. II	33.53	19.19	47.87	5.80	≤.001*
I vs. III	54.04	38.65	69.44	6.23	≤.001*
II vs. III	20.52	5.29	35.75	6.17	≤.005*
VSS					
I vs. II	31.19	18.67	43.71	5.07	≤.001*
I vs. III	60.81	46.55	75.08	5.77	≤.001*
II vs. III	29.62	15.74	43.49	5.62	≤.005*
CFCS					
I vs. II	28.80	17.47	40.14	4.69	≤.001*
I vs. III	41.01	21.35	60.66	6.05	≤.001*
I vs. IV	61.01	52.45	69.56	4.05	≤.001*
II vs. III	12.20	-7.89	32.31	8.82	.187
II vs. IV	32.21	19.84	44.57	5.86	≤.001*
III vs. IV	20.00	.38	39.62	7.99	≤.047*