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Construct Validity of The Viking Speech Scale

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Abstract

Objective: The Viking Speech Scale (VSS) reliably classifies the speech performance of children with cerebral palsy. This paper aims to establish the construct validity of the VSS by testing the extent to which percentage intelligibility in single word speech and connected speech predicts VSS rating.

Patients and Methods: This is a secondary analysis of two sets of anonymised data collected for previous research. The full dataset comprised 79 children with cerebral palsy from the US (43) and the UK (36): (43 boys, 36 girls); mean age 7.2 years (SD 3.3). Single word intelligibility was measured using the TOCS+ words for US children and Children's Speech Intelligibility Measure for the UK children. Connected speech intelligibility was measured from a subset of repeated sentences in TOCS+ for US children and picture description for the UK children. We used ordinal logistic regression to examine prediction of VSS rating by percentage single word and connected speech intelligibility scores in both samples.

Results: Percentage single word intelligibility and connected speech intelligibility predicted VSS rating in univariate and multivariate regression models for both the US and UK samples.

Conclusion: Intelligibility predicts VSS for both single words and connected speech, establishing the construct validity of VSS.

Keywords

Cerebral palsy; dysarthria; intelligibility; classification; children; Viking Speech Scale

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Cerebral palsy is the most common cause of motor disorder in childhood [1]. Cerebral palsy frequently affects children's oromotor system, leading to the motor speech disorder dysarthria [2,3]. Children with dyskinetic forms of cerebral palsy (choreo-athetosis and dystonia) are more likely to have dysarthria, and to have more severe speech impairment, than children with spastic type cerebral palsy [4,5], although they may share many perceptual speech characteristics [6]. Reduced intelligibility is a hallmark feature of dysarthria and can have significant negative impacts on the ability to communicate functionally and social participation [7–11].

Improved intelligibility is often a primary goal of speech therapy for children with dysarthria [12], and recent studies have shown promising results for improving speech intelligibility in children with cerebral palsy following intervention [13]. Quantification of intelligibility can assist in decisions about type of intervention. For example, children with low levels of intelligibility may be recommended augmentative and alternative communication (AAC) systems to either supplement or replace verbal communication; children who use speech as their main means of communication may be offered intervention to improve intelligibility [14]. Intelligibility measures may also be used to monitor progress in treatment, and providing an index of severity [15–17].

Intelligibility can be measured in a number of different ways that vary in complexity and practicality from a clinical perspective. Subjective measures require listeners to quantify their perception of a speaker's intelligibility by assigning a number to, or scaling what they heard [18–20]. Objective measures involve transcription (usually orthographic), or forced-choice recognition of words by listeners, typically yielding a percent of words identified correctly relative to the target words that the speaker intended to produce [21–23]. An advantage to objective measurement is that quantification is straightforward: lexical units are either correct or incorrect.

In addition to differing in the method of listener response, objective measures of intelligibility also vary in how speech is elicited. Clinically, it is most ecologically valid to estimate how intelligible speech is in real-life interactions. However, conversational speech is rarely used in objective measurement because of lack of control over linguistic features (e.g. grammatical complexity, length of utterance, and vocabulary), and lack of control of acoustic features of the environment (e.g. background noise). In addition, the behaviour of communication partners during interaction varies widely; thus, comparison across time and between speakers almost impossible. Methods have been employed to reduce variability, but each brings its own limitations in generating an estimate of intelligibility in daily conversation. Some assessments require children to repeat spoken models provided by the tester [24] or stored audio recordings. In repetition tasks the target word is known to the assessor and listeners' perceptions can be accurately judged as correct or incorrect. Stored audio models also have the benefit of providing a standard model across speakers and time [25]. However, repetition does not necessarily involve lexical retrieval and children's repetitions may differ from their usual speech patterns. Other measures use picture naming or picture description [16,17] to ensure lexical retrieval and the use of stored speech motor programmes. Picture naming involves both lexical generation, usual speech pattern and a known target. Picture description involves the spontaneous generation of narrative speech and assessors transcribing the words they hear. A challenge with this approach is that the target words produced by children are unknown by assessors and thus there is not a reliable standard against which to compare whether transcriptions were correct or incorrect. However, a method to work around this limitation involves a second step in which the understanding of spontaneously produced speech is checked with the child by repeating the utterances and having the child confirm its accuracy to create a gold standard against which listeners' transcriptions are compared. Whilst the speech generated may closely approximate usual speech patterns used outside the assessment environments, the gold standard transcriptions assessors generate may not be totally accurate, even if children confirm them. Thus, each method of speech elicitation for intelligibility testing has pros and cons. Currently, there is no consensus on the best method and researchers differ in the tasks they select. Most researchers do however, measure the intelligibility of single words and connected speech. Single words can be selected for diagnostic intelligibility, showing which phonemes can be produced in each word/syllable position under 'ideal' breath support conditions [26]. They also allow us to examine decoding that relies solely on bottom up processing by listeners. Connected speech can be decoded using both bottom up and top down processing, and allows us to examine the effects of breath control and prosody on intelligibility.

Although objective methods of intelligibility measurement provide the most accurate estimate of the proportion of words that listeners understand they are not always feasible clinically because they require considerable time and resources. Recently, Pennington and colleagues developed the Viking Speech Scale (VSS), to classify the speech of children with cerebral palsy for epidemiological and intervention research and clinical practice [27,28]. The VSS was designed to be used by a range of professionals, including speech and language therapists, as well as family members. It is an ordinal rating scale that can be employed without clinical assessment or direct observation of the person with cerebral palsy, and thus is very efficient to administer. The VSS has four levels ranging from Level I in which speech is not affected, to level IV in which the child has no understandable speech (Table 1) [29]. In addition to summarising the intelligibility of the children's speech, the VSS also provides some descriptors of the perceptual characteristics of speech that may be heard at each level of the scale. The scale's content validity, inter-rater agreement and test-retest reliability have been established with parents and health professionals [28]. The scale was judged to be easy to use by parents, speech and language therapists and other healthcare professionals from direct observation and from written case-notes [28]. Its strong content validity, reliability and ease of use suggest that the VSS may provide a quick and easy method to rate intelligibility of children with cerebral palsy. However, the construct validity of the scale as an intelligibility measure has yet to be established. In the present study, we sought to determine the extent to which percentage intelligibility, as the gold standard intelligibility measure, predicts VSS level. Because each method of intelligibility testing has its own limitations in reflecting intelligibility in daily life conversation, we examined the relationship between VSS level and percentage intelligibility measured from both single words and connected speech, and elicited in repetition and picture description tasks.

Method

This study is a secondary analysis of anonymised data collected in research conducted in the U.S. and the U.K. by the authors. East of Scotland Research Ethics Service REC 2 and University of Wisconsin – Madison Institutional Review Board approved the study. Children aged 16 years and above and the parents of younger participants provided written consent for their anonymised data to be used.

Participants

Anonymised research records were searched to select children who were aged 4 – 18 years inclusive, had cerebral palsy, came from households in which English was spoken (confirmed by parents/care givers) and had provided speech recordings containing single words and connected speech samples for previous research and whose research records showed demographic and linguistic data.

UK sample.—UK participants had taken part in dysarthria intervention and were classified by local speech and language therapists as having mild – severe dysarthria associated with cerebral palsy [16,17,30]. The UK sample comprised 36 children (22 boys; 14 girls) aged 5–18 years (mean age 10.6, SD 3.7 years).

US sample.—US participants were part of a longitudinal study of communication development in cerebral palsy [31]. The sample for the present study included children with cerebral palsy who had clinically confirmed dysarthria as well as children with cerebral palsy who had no evidence of speech disorder. The US sample comprised 43 children (21 boys; 22 girls) aged 4–6 years (mean age 5.1; SD 0.9 years). (Table 2)

Descriptor Measures

Children with a diagnosis of cerebral palsy vary widely in terms of their development and levels of functioning [32]. To provide a rounded picture of children's characteristics and identify any differences between the UK and US samples, we extracted data relating to children's motor disorder, cognition, speech and language for the study from their research records. We classified type of cerebral palsy according to the Surveillance of Cerebral Palsy in Europe [33], using the categories spastic, dyskinetic and ataxic. Where more than one motor disorder was identified, with no predominant type, children were classified as having mixed type cerebral palsy. We also included children with a diagnosis of Worster Drought syndrome, a subtype of cerebral palsy affecting the corticobulbar tract [34].

We rated children's gross motor performance using the Gross Motor Function Classification System (GMFCS) [35], a five level ordinal scale in which level I is scored if children walk at home, school, outdoors and in the community; can climb stairs without the use of a railing; and run and jump, but with limited speed, balance and coordination. Level V on GMFCS indicates that children are transported in a manual wheelchair in all settings and have limited ability to maintain antigravity head and trunk postures and control leg and arm movements. Speech and language therapists who had worked with children over at least one full day, and who had discussed their skills and difficulties in activities of daily living with their parents in research assessments, classified children's function. This level of knowledge has been shown to be sufficient for accurate GMFCS ratings [36].

We estimated children's nonverbal cognition with IQ bands of <50; 50–70; >70 from adaptive functioning (learning and socialisation with friends of similar age), following the protocol used in the Study of Participation of Children with Cerebral Palsy Living in Europe [37] developed in consultation with clinical psychology input and information taken from the British Institute of Learning Disabilities [37]. In this system children who are judged to learn as well as other children similar in age and who have friends of similar age are likely to have IQ above 70. Children who have difficulties in learning skills in all areas of development and whose skills are similar to much younger children are judged to have IQ below 50. And those who require help to acquire new skills, to understand abstract or complex ideas, and who find it easier to make friends with and relate to children younger than themselves, but do not fit the descriptions above, are likely to have IQ between 50 and 70.

We determined mean length of utterance in words (MLU) from spontaneous language samples recorded during research visits, which were transcribed verbatim by research speech and language therapists in the UK, and were estimated by speech and language therapists in the US. We capped MLU at 7 for this study. We did this on the basis of normative data indicating that mean length of utterance in words for typically developing 9 year olds is approximately 5 words [38]. Systematic data for children over 9 years have not been published; however, since our sample included children up to 18 years we extended expectations for MLU up to 7 words.

The General Oromotor Control section of the Verbal Motor Production Assessment for Children (VMPAC) [39] provided a percentage score for ratings of children's oromotor tone, respiration/phonation, oromotor reflexes and chewing and swallowing functions. The VMPAC was used as a measure of overall oromotor function and underlying neurological involvement of the cortico-bulbar tract.

Independent Variables

We extracted data on children's percentage intelligibility in single words and connected speech. Measures were somewhat different across the two samples. Specific measures of intelligibility for each sample were as follows.

US sample intelligibility measurement—In the US sample, single words and connected speech were elicited using the TOCS+ stimuli [25]. Elicitations were obtained by having children repeat a core of words and sentences that included 33 single words, ten 2-word sentences, ten 3-words sentences, ten 4-word sentences, and so on up to sentences that were 7 words in length. TOCS+ words and sentences were designed to be lexically and phonetically appropriate for children, and have been frequently used in research focused on childhood dysarthria [40–42]. If a child repeated all the words for at least 5 of the 10 sentence stimuli for a given sentence length, then the child's productions of the corpus of sentences for that length were included in data analyses. Nine children were unable to produce more than single word utterances; those children did not contribute speech samples to the connected speech data pool. For the remaining children, the average utterance length was 5.6 (SD = 1.9); range = 2–7 words. For both single word and connected speech samples, 3 different listeners per child (for a total of 129 listeners) heard target words and phrases, and then transcribed the words they heard orthographically. Mean percentage of words perceived correctly across listeners was calculated for each child in single words and connected speech.

UK sample intelligibility measurement—Intelligibility of children in the UK sample was measured from single words elicited using the Children's Speech Intelligibility Measure (CSIM) [24] and connected speech elicited through picture description [16,17]. The CSIM contains lists of 50 words which children repeat after a model from the tester. There are 200 lists within the assessment, which are balanced in length and articulatory complexity. It is a forced choice test, in which listeners select the word they have heard from a list of 12 phonetically similar foils. Different CSIM lists were allocated to each child. Connected speech was elicited in picture description. We used four sets of cartoon sequences / pictures, which were randomly allocated to children. To generate a gold standard against which intelligibility could be tested, children described an individual picture and the research therapist repeated the child's production to check they had understood the child's speech correctly before transcribing the utterance. Listeners were presented with phrases from the connected speech sample and transcribed the words they heard in each phrase. Each phrase comprised a single intonation phrase (e.g. 'There's a leak in the roof.' 'And then he gets the book.'). Phrases ranged in length from 1 to eleven words (mean = 5.7 words; SD = 2.9). Each child's single word and connected speech samples were heard by three different unfamiliar listeners (108 listeners in total)). Mean percentage of words perceived correctly across listeners was calculated for each child in each condition. Further details on intelligibility testing procedures for the UK sample can be found elsewhere [43,44].

Dependent Variable

Research speech and language therapists classified each child's speech using the full descriptors of the VSS [27]. Therapists classified children in the samples they worked with; thus, a US therapist classified US children and a UK therapist classified UK children on the VSS. Therapists assigned classifications at the end of the data collection in their respective research studies, from observations of children's interactions with their family and research staff and clinicians with whom they were unfamiliar. Previous research has shown the VSS test-retest and inter-rater agreement to be high [27,28] and so no reliability checks were completed in the present study.

Analysis

We used descriptive statistics to examine the characteristics of children in the UK and US samples and tested the difference between the two samples using chi square and Wilcoxon rank sum tests for categorical and continuous variables respectively.

To test if VSS levels were predicted by percentage intelligibility scores, we first examined the median and range of percentage intelligibility scores of children assigned to each VSS level using box and whisker plots. Because we aimed to examine the ability of both single word and connected speech intelligibility to predict VSS level independently and together, we also assessed the difference between children's single word and connected speech intelligibility using paired t tests.

We tested the strength with which percentage single word and connected speech intelligibility scores predicted VSS level using univariate ordinal logistic regression, conducting separate analyses for each sample. We then entered both single word and connected speech intelligibility into multivariate ordinal regression models for each sample. to examine the effect of both measures of intelligibility on VSS. As nine participants in the US sample did not contribute to the connected speech data, multivariate regressions for the US data comprised a sample of 34 children. Results are presented as odds ratios (OR) with corresponding 95% confidence intervals (95% CI). All analyses were undertaken using the statistical software package Stata 14.

Results

Differences between UK and US groups of children

Overall, children from the UK were older ($z = 6.83$, $p < 0.001$), had lower connected speech intelligibility ($z = -2.69$, $p = 0.007$) and lower VSS scores (X^2 24.35, $p < 0.001$) than children from the US. The samples also differed in spread of the types of motor disorders (X^2 17.18, $p = 0.001$); the UK group contained relatively more children with dyskinesia than the US group and also contained children with Worster Drought syndrome (Table 2). Children in the UK sample had higher intelligibility in single words than connected speech ($t=4.4$; $p<0.001$). No differences were observed between the intelligibility of US children in single words and connected speech.

Prediction of VSS score by percentage intelligibility

VSS scores ranged from I to IV, although VSS ratings of I and IV were less common. Ratings of I occurred only in the US sample, and ratings of IV occurred only in the UK sample for connected speech. The boxplot in Figure 1 shows single word intelligibility findings by country and by VSS level. Figure 2 shows analogous data for connected speech intelligibility. Descriptive results show that the median percentage intelligibility score reduced with increasing VSS level. However, in both UK and US data for single word and connected speech there was overlap in scores between VSS levels, especially in the UK sample. The widest variation in intelligibility scores was observed for VSS levels II and III. Visual inspection of the descriptor data for the outliers in each VSS level for each data set revealed that five of the eight children who had lower intelligibility in single words or connected speech levels in VSS II and III had dyskinesia (3 UK and 2 US) and one who had the highest level of single word intelligibility in VSS level III in the UK sample also had dyskinesia. No other distinguishing features were noted.

In both the UK and US data, single word intelligibility and connected speech intelligibility strongly predicted VSS level when considered as single predictors, with reductions in percent intelligibility was associated with an increase in VSS level (Table 3). In the multivariate models, single word intelligibility in the UK sample significantly predicted VSS when connected speech was held constant. Neither single word nor connected speech intelligibility independently predicted VSS in the US sample when the other was held constant, suggesting colinearity between the variables.

Discussion

In this study we sought to examine the validity of the VSS relative to well established measures of speech intelligibility involving listener transcription of children's speech or a forced choice listening task. A key question in this study was how well VSS levels could be predicted from speech intelligibility scores. To address this question, we treated single word intelligibility and intelligibility of connected speech separately for each of the two data sets that differed in important ways. In particular, the UK data were from older children with cerebral palsy, and all children had dysarthria, thus three of four levels of the VSS were represented (Levels II, III, IV). US data were from younger children with cerebral palsy, who overall had less severe motor disorders; some children in this sample did not have clinical evidence of dysarthria, and three of four levels of the VSS were represented (Levels I, II, and III). In spite of these differences, both single word intelligibility and connected speech intelligibility independently predicted VSS levels for each of the two data sets with higher intelligibility scores associated with lower (better) VSS ratings, indicating less severe speech involvement.

At face value, our results provide support for the construct validity of the VSS. However, examination of Figures 1–2 suggests that there was variability among children with regard to the range of intelligibility scores, especially for VSS levels II and III. This variation is consistent with previous work on the VSS as well as similar kinds of measures for characterizing functional gross motor ability [45] and functional communication ability [46]. The wide variation in intelligibility within levels may be related to the characteristics of the sample, including sample size; the characteristics on which therapists are basing their judgements; chance; or a combination of such factors. The children in the samples varied in their functional profiles, as seen in the descriptor measures in Table 2. With our small samples it was not possible to test the influence of individual characteristics on VSS rating and further research is required to investigate if individual or groups of factors other than intelligibility are associated with VSS level. It is noteworthy, however, that several of the children who had the lowest levels of intelligibility in VSS level II and III had dyskinesia. This motor disorder leads to the presence of involuntary movements, which are produced particularly on intention, and abnormal postures [33]. It has also been observed that the speech of adults with dyskinetic type cerebral palsy varies in the duration between phonemes, possibly because of extraneous movements, but that individual phonemes within words may be articulated consistently [47,48]. Therapists in our study rated children's performance on the VSS from observation, and may have been influenced by seeing children's unintentional movements. Such distractions may not have interfered the listeners in the objective intelligibility measures, where audio data only were presented. The reliance on different features may therefore account for some degree of 'mismatch' between VSS assignment and intelligibility for these children.

Also relating to salient features is the fact the VSS has descriptors of perceptual characteristics of children's speech for each level in addition to the headline referring intelligibility. Therapists, with their expert knowledge of speech production and impairment, may have influenced by the perceptual characteristics of the VSS more than parents or other health professionals, hence the wider variation seen here than in the original development of the VSS [27]. Cognitive interviewing would be required to ascertain which characteristics in the level descriptors are most influential for groups of VSS raters.

Finally, the variability in intelligibility scores within VSS levels may be an artefact of the small sample size, where outliers are influential. We also relied on a small number of listeners to calculate mean percentage intelligibility, whereby one high or low intelligibility score can shift the mean percentage intelligibility considerably (intelligibility in both samples was calculated from three listeners). It should be noted that two UK children were assigned to level IV and were completely unintelligible in connected speech but listeners were able to perceive some single word speech correctly. This may be by chance, from the forced choice method of single word intelligibility testing, but may also indicate highly perceptive listeners hearing that individual. Further examination of the variation in intelligibility of speakers assigned to the individual levels of the VSS is warranted. Nevertheless, the overall consistency in findings between the two samples is a promising finding and suggests that individual VSS levels may reflect definable ranges of intelligibility scores.

When we examined prediction of VSS level using both single word and connected speech intelligibility at the same time, we again found that that intelligibility was predictive of VSS level for both samples. This finding logically follows our other results showing that each measure independently predicted VSS for each of the two samples. However, we found that single word intelligibility in the UK sample significantly predicted VSS level when connected speech was held constant, but this was not the case for the US sample where both connected speech and single word intelligibility had confidence intervals crossing one. This finding suggests colinearity between the variables, especially for the US sample. The finding that the particular measure of intelligibility (single word vs. connected speech) differed when simultaneously regressed onto VSS for the two samples may be due to methodological differences between the way that the two sets of samples were collected and quantified. Specifically, the US sample employed utterance repetition for both single word and connected speech; and orthographic transcription for both types of samples. In contrast, the UK sample employed spontaneous productions for connected speech samples; and forced choice responses for single words. These methodological differences may have resulted in differences in speech production features for children with cerebral palsy, with those in the UK having a larger linguistic load associated with production of spontaneous speech. Further, studies involving forced choice or closed set intelligibility methods have generally yielded higher intelligibility score than those using open set or transcription approaches [49]. However, the generally consistent findings across the two samples in spite of differences in age, severity, and methodology provide strong support for the validity of the VSS.

Differences between the samples in prediction of VSS level from combined intelligibility scores may also be associated with the severity of speech motor impairment between the groups. The UK sample had more severe impairments than the US sample as observed in the VSS and lower intelligibility scores. Furthermore, the US sample had similar percentage intelligibility in both single words and connected speech; whereas children in the UK sample were generally easier to understand in single words. Similar reduced levels of intelligibility in connected speech have been observed in previous studies of speakers with severe dysarthria [50]. It is possible that for the UK sample, who all had dysarthria, single word intelligibility is a marker for severity of speech impairment and predicts connected speech intelligibility. Further research, with a larger sample of children with wide ranging severities of impairment and intelligibility is required to examine this relationship.

Limitations and Future Directions

There are several important limitations to the present study. In this study, we used two small data sets, one from the US and one from the UK, which were both collected for other studies; we conducted a secondary analysis of these data. Estimates of the reliability of the descriptor measures was not available for the subsets of data. Data sets from the two countries differed in several ways including the age of participants and presence of motor speech disorder. In addition, there were differences in how intelligibility was measured between children from the US and children from the UK. Future research should seek to control these kinds of measurement differences, which may account for the relatively large variability within VSS levels observed in the present study. Similarly, we had few children who were rated as VSS I, and all were from the US sample of children. We also had few children who were rated as VSS IV, and most were from the UK sample. Future validation efforts should seek to ensure that all VSS levels are similarly represented in the sample.

Clinical implications

In spite of the limitations of the present study, our findings were consistent across the two international samples, and provide promising data to support the notion that the VSS is related to percentage intelligibility as measured from audio-recordings. With its high degree of reliability, the VSS may provide a quick and efficient means for clinicians to characterize speech intelligibility in children with cerebral palsy, but further, larger scale research is required to identify the full range of children's speech characteristics that lead to individual VSS level assignment.

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References

1. Oskoui M, Coutinho F, Dykeman J, Jetté N, Pringsheim T: An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. Developmental Medicine & Child Neurology 2013;55:509–519. [PubMed: 23346889]
2. Nordberg A, Miniscalco C, Lohmander A, Himmelmann K: Speech problems affect more than one in two children with cerebral palsy: Swedish population-based study. Acta Paediatrica, International Journal of Paediatrics 2013;102:161–166.

3. Australian Cerebral Palsy Register Group: Report of the Australian Cerebral Palsy Register 2016. Birth Years 1993–2009. Syndney, Aus, Cerebral Palsy Alliance and CP Register, 2016,

4. Bax M, Tydeman C, Flodmark O: Clinical and MRI Correlates of Cerebral Palsy: The European Cerebral Palsy Study. JAMA 2006;296:1602–1608. [PubMed: 17018805]

5. Love RJ: Childhood motor speech disability, ed 2 Boston, Allyn & Bacon, 2000.

6. Workinger MS, Kent RD: Perceptual analysis of the dysarthrias in children with athetoid and spastic cerebral palsy; in Moore CA, Yorkston KM, Beukelman DR (eds): Dysarthria and Apraxia of Speech: Perspectives on Management. Baltimore, Paul Brookes, 1991, pp 109–126.

7. Dang VM, Colver A, Dickinson HO, Marcelli M, Michelsen SI, Parkes J, Parkinson K, Rapp M, Arnaud C, Nystrand M, Fauconnier J: Predictors of participation of adolescents with cerebral palsy: A European multi-centre longitudinal study. Research in Developmental Disabilities 2015;36:551–564.

8. Colver A, Rapp M, Eisemann N, Ehlinger V, Thyen U, Dickinson HO, Parkes J, Parkinson K, Nystrand M, Fauconnier J, Marcelli M, Michelsen SI, Arnaud C: Self-reported quality of life of adolescents with cerebral palsy: A cross-sectional and longitudinal analysis. The Lancet 2015;385:705–716.

9. Michelsen SI, Flachs EM, Damsgaard MT, Parkes J, Parkinson K, Rapp M, Arnaud C, Nystrand M, Colver A, Fauconnier J, Dickinson HO, Marcelli M, Uldall P: European study of frequency of participation of adolescents with and without cerebral palsy. European Journal of Paediatric Neurology 2014;18:282–294. [PubMed: 24412031]

10. Fauconnier J, Dickinson HO, Beckung E, Maas E, Marcelli M, McManus V, Michelsen SI, Parkes J, Parkinson KN, Thyen U, Arnaud C, Colver A: Participation in life situations of 8–12 year old children with cerebral palsy: Cross sectional European study. BMJ 2009;338:1458–1471.

11. Mei C, Reilly S, Reddihough D, Mensah F, Green J, Pennington L, Morgan AT: Activities and participation of children with cerebral palsy: parent perspectives. Disability & Rehabilitation 2015;37:2164–2173. [PubMed: 25586796]

12. Ansel BM, Kent RD: Acoustic-phonetic contrasts and intelligibility in the dysarthria associated with mixed cerebral palsy. Journal of Speech and Hearing Research 1992;35:296–308. [PubMed: 1573870]

13. Pennington L, Parker NK, Kelly H, Miller N: Speech therapy for children with dysarthria acquired before three years of age. Cochrane Database of Systematic Reviews 2016:Art. No.: CD006937. DOI: 006910.001002/14651858.CD14006937.pub14651853.

14. NICE: Cerebral palsy in under 25s: assessment and management NICE guideline [NG62]. London, National Institute of Health and Care Excellence, 2017,

15. Yorkston KM, Beukelman DR, Strand E, Bell K: Management of Motor Speech Disorders in Children and Adults (2nd edition). Austin, TX, Pro-Ed, 1999.

16. Pennington L, Roelant E, Thompson V, Robson S, Steen N, Miller N: Intensive dysarthria therapy for younger children with cerebral palsy. Developmental Medicine & Child Neurology 2013;55:464–471. [PubMed: 23441834]

17. Pennington L, Miller N, Robson S, Steen N: Intensive speech and language therapy for older children with cerebral palsy: a systems approach. Developmental Medicine & Child Neurology 2010;52:337–344. [PubMed: 19758364]

18. Platt LJ, Andrews G, Young M, Quinn PT: Dysarthria of adult cerebral palsy: I. Intelligibility and articulatory impairment. Journal of Speech and Hearing Research 1980;22:28–40.

19. Darley F, Aronson A, Brown J: Clusters of deviant speech dimensions in the dysarthrias. Journal of Speech and Hearing Research 1969;12:462–496. [PubMed: 5811846]

20. Weismer G, Laures JS: Direct magnitude estimates of speech intelligibility in dysarthria: Effects of a chosen standard. Journal of Speech, Language, and Hearing Research 2002;45:421–433.

21. Yorkston K, Beukelman D: A comparison of techniques for measuring intelligibility of dysarthric speech. Journal of Communication Disorders 1978;11:499–512. [PubMed: 739065]

22. Yorkston K, Beukelman D: A clinician-judged technique for quantifying dysarthric speech based on single-word intelligibility. Journal of Communication Disorders 1980;13:15–31. [PubMed: 7354139]

23. Tikofsky RS, Tikofsky RP: Intelligibility as a measure of dysarthric speech. Journal of Speech and Hearing Research 1964;7:325–333. [PubMed: 14239011]
24. Wilcox K, Morris S: Children's Speech Intelligibility Measure. San Antonio, Harcourt Assessment, 1999.
25. Hodge M, Daniels J, Gotzke CL: TOCS+ Intelligibility Measures [computer software]. Edmonton, Canada, University of Alberta, 2009,
26. Miller N: Measuring up to speech intelligibility. International Journal of Language & Communication Disorders 2013;48:601–612. [PubMed: 24119170]
27. Pennington L, Virella D, Mjøen T, da Graça Andrada M, Murray J, Colver A, Himmelmann K, Rackauskaite G, Greitane A, Prasauskiene A, Andersen G, de la Cruz J: Development of The Viking Speech Scale to classify the speech of children with cerebral palsy. Research in Developmental Disabilities 2013;34:3202–3210. [PubMed: 23891732]
28. Virella D, Pennington L, Andersen GL, Andrada MdG, Greitane A, Himmelmann K, Prasauskiene A, Rackauskaite G, De La Cruz J, Colver A: Classification systems of communication for use in epidemiological surveillance of children with cerebral palsy. Developmental Medicine & Child Neurology 2016;58:285–291. [PubMed: 26272847]
29. Pennington L, Mjøen T, da Graça Andrada M, Murray J: The Viking Speech Scale, 2011,
30. Smith J, Balaam M, Brittain K, Kelly H, Parker N, Stockwell K, Pennington L: Acceptability of intensive speech therapy delivered via Skype to children with dysarthria and cerebral palsy: International Cerebral Palsy Conference. Stockholm, 2015,
31. Hustad KC, Gorton K, Lee J: Classification of speech and language profiles in 4-year-old children with cerebral palsy: A prospective preliminary study. Journal of Speech, Language and Hearing Research 2010;53:1496–1513.
32. Brown JK, Eunson P: Heterogeneity in cerebral palsy; in Bax M, Gillberg C (eds): Comorbidities in Developmental Disorders. London, MacKeith Press, 2011, pp 9–29.
33. SCPE: Surveillance of cerebral palsy in Europe: a collaboration of cerebral palsy surveys and registers. Surveillance of Cerebral Palsy in Europe (SCPE). Developmental Medicine & Child Neurology 2000;42:816–824. [PubMed: 11132255]
34. Clark M, Carr L, Reilly S, Neville BGR: Worster-Drought syndrome, a mild tetraplegic perisylvian cerebral palsy. Brain 2000;123:2160–2170. [PubMed: 11004132]
35. Palisano RJ, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B: Development and reliability of a system to classify gross motor function in children with cerebral palsy. Developmental Medicine & Child Neurology 1997;39:214–223. [PubMed: 9183258]
36. Palisano R, Rosenbaum P, Bartlett D, Livingston M: Gross Motor Function Classification System Expanded and Revised Toronto, CanChild Centre for Childhood Disability Research, McMaster University, 2007.
37. BILD BIoLD: Information about learning disabilities, BILD, 2018, 2018,
38. Rice ML, Smolik F, Perpich D, Thompson T, Rytting N, Blossom M: Mean length of utterance levels in 6-month intervals for children 3 to 9 years with and without language impairments. Journal of Speech, Language and Hearing Research 2010;53:333–349.
39. Hayden D, Square P: Verbal motor production assessment for children. San Antonio, Harcourt Assessment, 1999.
40. Hodge MM, Gotzke CL: Construct-related validity of the TOCS measures: comparison of intelligibility and speaking rate scores in children with and without speech disorders. J Commun Disord 2014;51:51–63. [PubMed: 25069811]
41. Hodge M, Gotzke CL: Criterion-related validity of the Test of Children's Speech sentence intelligibility measure for children with cerebral palsy and dysarthria. Int J Speech Lang Pathol 2014;16:417–426. [PubMed: 25011401]
42. Darling-White M, Sakash A, Hustad KC: Characteristics of speech rate in children with cerebral palsy: A longitudinal study. Journal of Speech, Language, and Hearing Research 2018;61:2502–2515.
43. Miller N, Pennington L, Robson S, Roelant E, Steen N, Lombardo E: Changes in Voice Quality after Speech-Language Therapy Intervention in Older Children with Cerebral Palsy. Folia Phoniatrica et Logopaedica 2013;65:200–207. [PubMed: 24503934]

44. Pennington L, Lombardo E, Steen N, Miller N: Acoustic changes in the speech of children with cerebral palsy following an intensive program of dysarthria therapy. International Journal of Language & Communication Disorders 2018;53:182–195. [PubMed: 28714530]

45. Eliasson AC, Krumlinde-Sundholm L, Rosblad B, Beckung E, Arner M, Ohrvall AM, Rosenbaum P: The Manual Ability Classification System (MACS) for children with cerebral palsy: scale development and evidence of validity and reliability. Developmental Medicine & Child Neurology 2006;48:549–554. [PubMed: 16780622]

46. Hustad KC, Oakes A, McFadd E, Allison KM: Alignment of classification paradigms for communication abilities in children with cerebral palsy. Dev Med Child Neurol 2016;58:597–604. [PubMed: 26521844]

47. Platt LJ, Andrews G, Howie PM: Dysarthria of adult cerebral palsy: II. Phonemic analysis of articulation errors. Journal of Speech & Hearing Research 1980;23:41–55. [PubMed: 7442183]

48. Platt LJ, Andrews G, Young M, Quinn PT: Dysarthria of adult cerebral palsy: I. Intelligibility and articulatory impairment. Journal of Speech & Hearing Research 1980;23:28–40. [PubMed: 7442182]

49. Clopper CG, Pisoni DB, Tierney ATJ: Effects of open-set and closed-set task demands on spoken word recognition. Journal of the American Academy of Audiology 2006;17:331–349. [PubMed: 16796300]

50. Hustad KC: Effects of speech stimuli and dysarthria severity on intelligibility scores and listener confidence ratings for speakers with cerebral palsy. Folia Phoniatrica et Logopaedica 2007;59:306–317. [PubMed: 17965573]

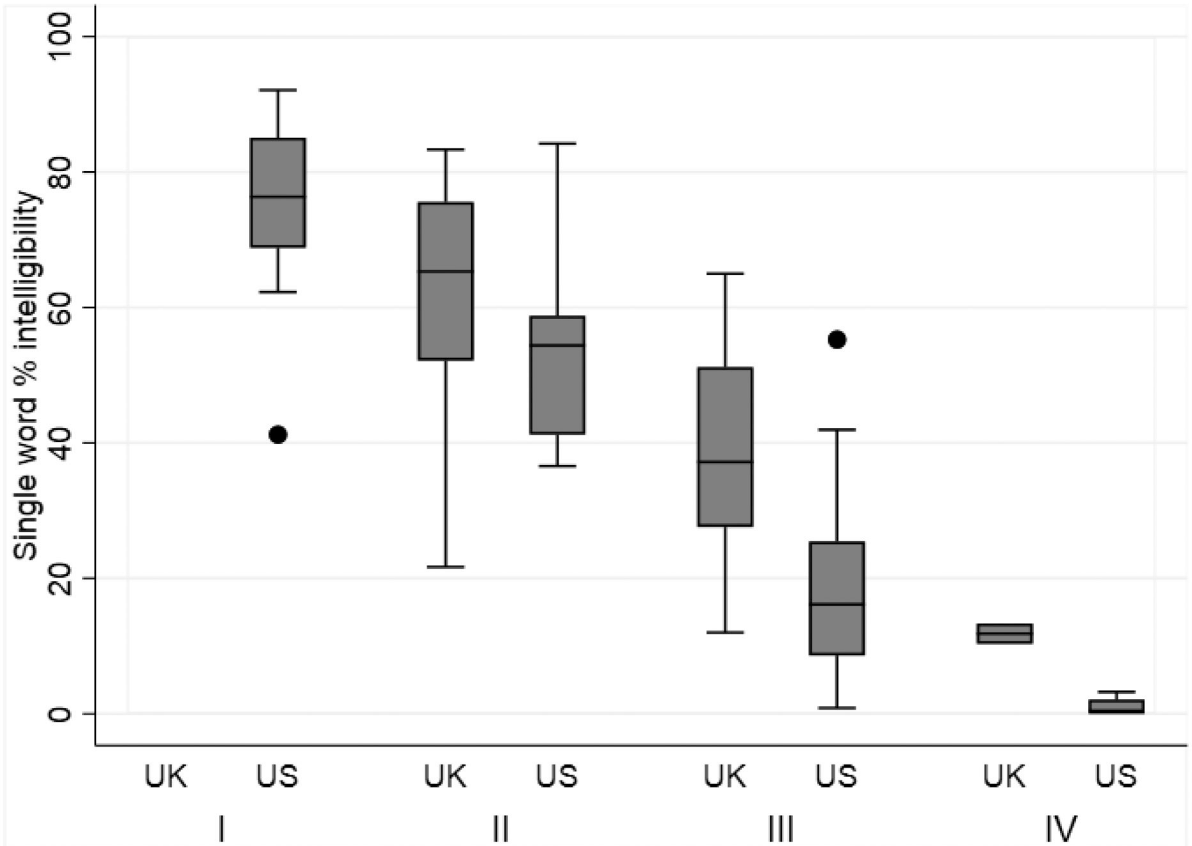

Figure 1.
Boxplots of VSS level by single word intelligibility score by country of origin for children with cerebral palsy

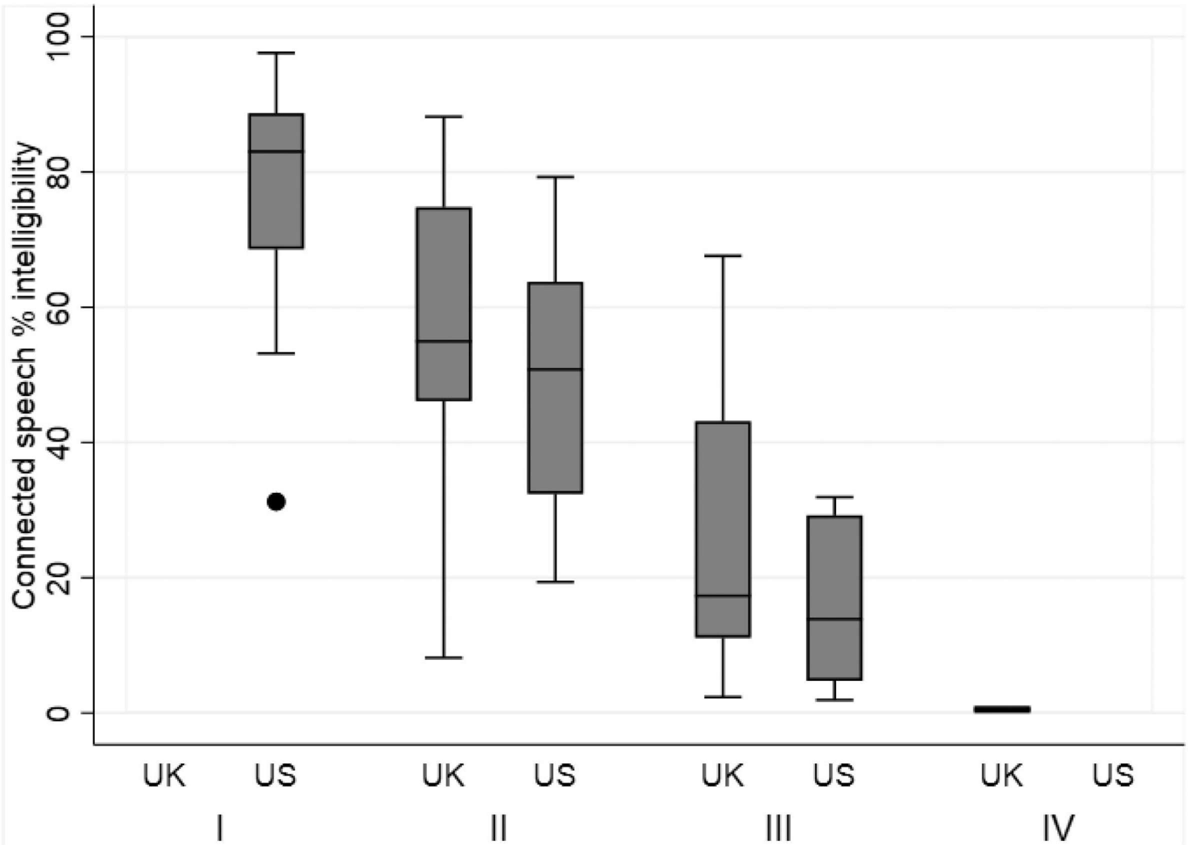

Figure 2.

Boxplots of VSS level by connected speech intelligibility score by country of origin for children with cerebral palsy

Table 1.

The Viking Speech Scale

Level	Headline descriptor	Speech characteristics
I	**Speech is not affected by motor disorder**	Following the usual pattern of speech development. Immaturities may be present, similar to other children of their age/developmental level.
II	**Speech is imprecise but usually understandable to unfamiliar listeners**	Speech is affected by motor disorder. Speech is usually understandable but is not following the usual pattern of development and does not sound like children of their age/developmental level.
III	**Speech is unclear and not usually understandable to unfamiliar listeners out of context**	Speech is severely affected by their motor disorder at multiple levels (e.g. breath control, vocal cord movement/voice, articulation). The severe difficulties in controlling each level act together to make the children's speech very difficult to understand without contextual cues.
IV	**No understandable speech**	

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Table 2.

Characteristics of children with cerebral palsy by country cohort.

Characteristic	Full sample (n=79)	US participants (n=43)	UK participants (n=36)
Age in years median (range)	7.2 (4–17)	5.0 (4–7)	12 (5–17)**
M:F	43:36	21:22	22:14
CEREBRAL PALSY type			
Spastic	56	35	21*
Dyskinetic	10	1	9
Mixed	2	1	1
Worster- Drought	3	0	3
Ataxic	4	2	2
Unknown	4	4	0
GMFCS			
I	24	17	7
II	16	9	7
III	9	3	6
IV	22	11	11
V	8	3	5
Cognition (estimated IQ)			
>70	43	26	17
50–70	36	17	19
MLU in words median (range)	5 (0–7)	6 (0–7)	6 (2–8)
VMPAC General Oromotor median % (range)	66.4 (0–100)	67.5 (20–100)	67.5 (0–100)
Single word intelligibility mean % (SD)	48.1 (25.9)	50.3 (28.2)	44.3 (20.5)
Connected speech intelligibility mean % (SD)	46.5 (29.5)[¥]	52.9 (31.3)[¥]	35.8 (25.5)*
VSS			
I	15	15	0**
II	29	13	16
III	29	11	18
IV	6	4	2

Difference between US and UK samples p<0.01*, p<0.001** calculated using chi square for categorical variables and Wilcoxon Rank Sum test for continuous variables

[¥] 34 of 43 US children provided data for connected speech analysis. Full sample =70 for connected speech.

Table 3.

Univariate and multivariate prediction of Viking Speech Scale by percentage intelligibility of single words and connected speech, for each sample

Variable	Univariate analysis				Multivariate analysis			
	VSS UK		VSS US		VSS UK		VSS US	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Single word percentage intelligibility	0.90**	0.85, 0.95	0.87**	0.83, 0.92	0.91*	0.84, 0.99	0.93	0.85, 1.01
Connected speech percentage intelligibility	0.94**	0.90, 0.97	0.91**	0.87, 0.96	0.99	0.93, 1.05	0.95	0.89, 1.01

*p<0.05,

**p<0.001