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How Well Do Communication Profiles at 2 Years of Age Predict Outcomes at 9–10 Years of Age in Children With Cerebral Palsy?

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ABSTRACT

Purpose: Early identification of diverging developmental trajectories is important to optimize communication interventions for children with cerebral palsy (CP). The aim of this study was to examine if communication profiles at 2 years of age predicted speech, language, and communication outcomes at 9–10 years of age in children with CP.

Method: Twenty-three children with CP (M_{age} = 9;10 [years;months]) participated in the study comprising of three mutually exclusive 2-year speech-language profiles: not yet talking (*n* = 10), emerging talkers (*n* = 9), and established talkers (*n* = 4). Using generalized linear regression and Kruskal–Wallis rank sum tests, we examined if 2-year speech-language profiles predicted speech, language, and communication outcomes at 9–10 years of age. Outcomes at 9–10 years of age were obtained from classification systems, spontaneous language samples, elicited speech tasks, and parent report.

Results: Based on 2-year speech-language profiles, we found significant differences in speech, language, and communication outcomes at 9–10 years of age. Specifically, children who were not talking at 2 years of age had more restricted outcomes than children who were emerging or established talkers at 2 years of age.

Conclusion: Our study's results provide preliminary evidence that early communication interventions can and should be differentiated based on communication abilities at 2 years of age to maximize later communication outcomes for children with CP.

Cerebral palsy (CP) is the most common motor disability in children, with an estimated prevalence of one in 345 children in the United States (Durkin et al., 2016). While motor impairments are hallmark features of CP, estimates suggest that 85% of children also experience communication impairments, ranging in severity from mild to profound (Mei et al., 2020). Specifically, estimates suggest that 80% of children with CP have disordered speech production, with around 50% of children having dysarthria (Mei et al., 2020; Nordberg et al., 2013). In addition, three out of five children have a language impairment, either receptive and/or expressive, and approximately 24% of children are nonspeaking (Mei et al., 2016). These speech and language impairments negatively impact communication in children with CP (Kristoffersson et al., 2020). Communication impairments, in turn, have adverse effects on social and educational experiences as well as quality of life throughout the lifespan (e.g., Alghamdi et al., 2017; Mei et al., 2015). Thus, it is critical to identify speech, language, and communication challenges early and understand the developmental trajectories to ensure timely access to developmentally appropriate interventions to maximize communication outcomes for children with CP.

Speech, Language, and Communication Development in CP

Many children with CP are delayed in their early speech and language. Children with CP who do not have

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speech–motor impairment (SMI) demonstrate earlier and greater intelligibility growth as well as higher intelligibility outcomes compared to children with SMIs, both in single-word intelligibility (SWI) and connected speech (Hustad, Sakash, Natzke, et al., 2019; Mahr et al., 2020). Furthermore, the presence of a language comprehension impairment, in addition to SMI, is associated with greater reductions in intelligibility and outcomes at 8 years of age (Mahr et al., 2020). Additionally, children with SMI showed an average delay in language comprehension of 6 months compared to children without SMI (Hustad et al., 2018). Moreover, children with anarthria (i.e., inability to produce more than five words or word approximations due to neurological impairment affecting the speech–motor system) showed limited developmental change in language comprehension over time using motor-based behavioral assessments (Hustad et al., 2018). Collectively, results suggest that early outcomes for both language comprehension and speech intelligibility are highly predictive of later outcomes. Specifically, language comprehension at 18 months predicts outcomes at 4 years, and speech intelligibility at 2 years predicts outcomes at 8 years (e.g., Hustad et al., 2018; Hustad, Sakash, Natzke, et al., 2019; Hustad et al., 2020; Mahr et al., 2020).

Classifying Speech, Language, and Communication Development

Variability in speech, language, and communication abilities among individuals with CP necessitates the use of classification tools to enable the identification of subgroups with common features, examination of developmental trajectories, and prediction of outcomes. Additionally, classification tools provide a common language to describe similar profiles among children with CP, which has important clinical implications. Some existing classification systems are based on rating scales and can be made through caregiver reports or record reviews, while others are data based using direct observation.

Two commonly used rating scales are the communication function classification system (CFCS; Hidecker et al., 2011) and the Viking Speech Scale (VSS; Pennington et al., 2013). These classification tools require subjective judgment to assign ratings to individuals, and both scales are used in clinical and research settings (e.g., Choi et al., 2018; Hidecker et al., 2018; Hustad et al., 2016; Long et al., 2022). The CFCS is a five-level scale that rates global communication abilities based on the activity/participation levels in the World Health Organization International Classification of Functioning, Disability and Health. In contrast, the VSS solely focuses on speech and is used to describe the severity of functional speech challenges. The scale has four levels, and ratings are made with respect to the impact of reduced intelligibility on listeners.

Data-based classification systems can help reduce limitations such as subjectivity associated with rating scales. Our lab developed the speech-language profile groups (SLPGs), a data-based classification system that considers both speech and language abilities in children with CP, and these ratings are based on direct measurement (Hustad et al., 2010). With this approach, children are classified into one of four categories based on the presence or absence of SMI and language comprehension impairment. These groups are as follows: (a) no SMI (NSMI) and typical communication abilities, (b) SMI and typical language comprehension (SMI-LCT), (c) SMI and language comprehension impairment (SMI-LCI), and (d) those that are unable to produce more than five words or word approximations due to anarthria (anarthric [ANAR]).

While these three classification systems provide a framework for reducing heterogeneity among children with CP, a limitation is that they are challenging to use with children younger than 4 years of age reliably. This is due mainly to the difficulty differentiating typical from atypical speech development at young ages. Typical speech developmental trajectories vary greatly, and there is considerable overlap between features of SMI and features of speech–motor development (Hustad et al., 2021; Mahr et al., 2021; Schölderle et al., 2020). This is particularly true for children with mild SMIs (Hustad et al., 2014). Nonetheless, it is critical that we can reliably identify speech and language impairments before the age of 4 years to ensure timely access to speech-language interventions. Not only is it essential to identify those who require intervention at the earliest age possible to leverage critical periods of development, but we also need to ensure that children receive the services that they require to maximize their communication growth.

Toward this end, work from our laboratory has sought to differentiate atypical from typical speech development at the earliest age possible in children with CP (e.g., Hustad et al., 2014, 2023; Long & Hustad, 2023). Recently, in a large-scale study, we examined two data sets, one including neurotypical children and the other including children diagnosed with CP, to identify developmental cutoff thresholds. We found that children with a CP diagnosis and intelligibility scores below 40% at 3 years of age have an 80% probability of having an SMI (Hustad et al., 2023). Another work has sought to classify children's speech-language at 2 years of age (Hustad et al., 2014). This work has identified three distinct speech-language profiles: those not yet talking, emerging talkers, and established talkers. Like SLPGs, these profiles are data driven and based on direct observation and measurement. Furthermore, these 2-year speech-language profiles are predictive of communication at 4 years of age (Hustad et al., 2017). However, additional research is needed to determine if they predict outcomes past 4 years of age.

Communication Classifications to Inform Early Intervention Priorities

Even though children with CP are frequently delayed in their speech and language development and early outcomes are predictive of later performance, many children with CP are not receiving the speech and language therapy and communication support that they require (Hustad & Miles, 2010). Given that CP is such a heterogeneous population, identifying common developmental trajectories and when these trajectories diverge from typical age expectations is vital for intervention planning. There is extensive literature on early predictors of speech and spoken language in the broader developmental and/or intellectual disabilities (IDD) field. For example, frequency of canonical vocal acts, proto-declarative use, receptive language, and intentional communication predicts later spoken language (e.g., Brady et al., 2004; McDaniel et al., 2018; Yoder & Warren, 2004; Yoder et al., 1998). In addition, factors related to children's language environments (e.g., caregiver responsiveness; Brady et al., 2004; McDaniel et al., 2018; McDuffie & Yoder, 2010; Potter et al., 2024) are also highly predictive of later language outcomes in children with IDD. However, children with CP are often excluded from these studies. Given the unique gross motor and speech motor impairments associated with CP, we cannot assume that research on other IDD populations generalizes to children with CP. Therefore, examining communication development in children with CP is critical to identify distinct communication profiles that can guide intervention planning.

Given the high prevalence of SMIs in CP, incorporating augmentative and alternative communication (AAC) strategies into speech-language interventions is critical to maximizing communication success. Toward this end, Hustad and Miles (2010) described an AAC framework for considering the complementary roles of AAC and speech for children with CP. This framework has four categories as follows: (a) No AAC needed: All communication needs across partners and settings can be met by speech; (b) Speech is the primary mode of communication: AAC systems play a secondary supporting role; (c) Speech and AAC are both primary modes of communication: Whether speech or AAC is used varies depending on the partner and the setting; and (d) Comprehensive AAC systems are the primary mode of communication: For these children, AAC systems are required for nearly all communication interactions to enable social and educational participation. However, they may be able to produce some idiosyncratic words, vocalizations, intonation patterns, gestures, or facial expressions that familiar communication partners can interpret. These categories of AAC needs can be helpful for intervention planning; for example, children with anarthria will require comprehensive AAC systems to maximize their communication outcomes and increase social participation. In contrast, children with CP who have NSMI will be very unlikely to have any need for AAC. However, in some cases, they may still benefit from speech-language therapy but with a focus on language and communication. Identifying clinical benchmarks for speech and language development in CP will help determine how best to combine speech and AAC to maximize communication outcomes for children with CP.

To improve access and quality of early communication interventions for children with CP, we also need to understand who receives speech-language services and the kind of services they receive (e.g., inclusion of AAC). For example, the misalignment of services is often higher for children with milder speech impairments (Hustad & Miles, 2010; Koopmans et al., 2022). Additionally, many children with CP with reduced intelligibility do not have educational goals related to AAC and speech (Koopmans et al., 2022), even though they could benefit from AAC supports. Understanding how communication profiles are associated with speech-language interventions will help to identify barriers and solutions to improve communication interventions for children with CP. Identifying children's communication trajectories at the earliest age is critical for ensuring all children with CP can communicate to their fullest potential. Early classification findings, such as 2-year-old speech and language profiles from our earlier work, are a potential tool that could be used to inform intervention planning for children with CP. However, more research is needed to understand how predictive they are of long-term outcomes.

Study Purpose and Research Questions

The primary purpose of the current study was to examine if speech-language profiles at 2 years of age were associated with speech, language, and communication outcomes at 9–10 years of age. A secondary purpose was to examine whether these profiles were associated with AAC use and speech-language therapy at 9–10 years old. We addressed the following research questions:

- RQ1: Are speech-language profiles at 2 years of age associated with children's speech, language, and communication profiles at 9–10 years of age?
- RQ2: To what extent do speech and language profiles at 2 years predict speech and language outcome measures derived from language samples and speech intelligibility at 9–10 years of age?

- RQ3: At 9–10 years of age, which children receive speech-language services, and are there additional children who would benefit from speech-language services? To what extent is this related to their 2-year speech-language profiles?
- RQ4: At 9–10 years of age, which children have access to AAC strategies, and are there additional children who would benefit from AAC strategies? To what extent is this related to their 2-year speech-language profiles?

We hypothesized that speech-language profiles at 2 years of age would predict speech, language, and communication outcomes at 9–10 years of age based on prior longitudinal work examining speech and language in CP (e.g., Hustad et al., 2018, 2020; Mahr et al., 2020). Specifically, we hypothesized that children classified as established talkers at 2 years of age would be classified into more advanced speech profiles, have better language outcomes, and have higher intelligibility scores at 9–10 years of age compared to children classified as emerging talkers or not yet talking at 2 years of age. We hypothesized that 2-year speech-language profiles would predict who received speech-language therapy and had access to AAC strategies at 9–10 years of age based on prior work identifying associations between expressive language and AAC decisions (Smith & Hustad, 2015). However, due to the high prevalence of SMIs within CP, we did not expect that 2-year speech-language profiles would predict who would benefit from speech-language therapy and/or access to AAC strategies at 9–10 years of age.

Method

Participants

Participants for the current study were selected from a cohort of children with CP participating in a larger prospective longitudinal study of communication development. Children were born in the United States between 2000 and 2009. Recruitment occurred in two waves between 2005 and 2012 from local and regional medical centers providing pediatric specialty care in the upper Midwest region of the United States. After enrollment in the study, children were seen every 6 months until their eighth birthday and yearly thereafter. Inclusion criteria for the larger cohort required that children (a) have a medical diagnosis of CP, (b) have hearing abilities within normal limits as documented by either a formal audiological evaluation or a distortion product otoacoustic emission screening, and (c) be between the ages of 18 and 54 months old upon initial enrollment. Inclusion for the current study required the following: (a) included in Hustad et al. (2014) or had a data collection visit at 2 years of age, (b) completed a data collection visit between 108 and 124 months, and completed a caregiver–child interaction at this visit. Twenty-three children met the current study inclusion criteria. The mean age in months at 9–10 years was 118 months (*SD* = 3.79, range: 108–124 months). Table 1 presents participant demographic information. Of the 27 children included in the Hustad et al. study, 19 were still enrolled in the larger longitudinal study at 9–10 years of age. The remaining three children in the current study completed their 2-year timepoint after Hustad et al. was published.

Materials and Procedures

The Institutional Review Board for Social and Behavioral Sciences at the University of Wisconsin–Madison approved this study (Institutional Review Board

Table 1. Participant demographics (*n* = 23).

Demographics	*N* (%)
Child mean age (*SD*) in months; range	118 (3.39); 108–124
Child sex: female	10 (43)
Child ethnicity	
Hispanic/Latino	2 (7)
Non-Hispanic/Latino	20 (87)
Not reported	1 (4)
Child race	
Asian	1 (4)
Black	1 (4)
Black & White	1 (4)
Guatemalan	1 (4)
White	19 (83)
CP diagnosis	
Hypotonic	1 (4)
Mixed	1 (4)
Spastic	19 (83)
Unknown	2 (7)
GMFCS at 9–10 years of age	
I	4 (17)
II	7 (30)
III	4 (17)
IV	3 (13)
V	5 (22)
MACs at 9–10 years of age	
I	2 (7)
II	9 (39)
III	8 (35)
IV	2 (7)
V	2 (7)

Note. CP = cerebral palsy; GMFCS = Gross Motor Function Classification System; MACS = Manual Abilities Classification System.

2013–1258). Participants completed a battery of standard assessments administered by a certified speech-language pathologist (SLP) in a lab setting, assessing speech production, language comprehension, and spontaneous communication. Sessions lasted up to 2 hr, and the same testing room, stimulus materials, and assessment tools were used for each child. All children tolerated the play-based sessions without difficulty. Written informed consent or assent was provided on behalf of or by all participants.

Measures

VSS. The VSS (Pennington et al., 2013) was used to describe the severity of speech involvement at 9–10 years of age. Ratings are made based on how understandable a child is to unfamiliar conversation partners as indicated from perceptual impressions. Children's speech is classified as one of four mutually exclusive levels: (I) speech is not affected by motor disorder, (II) speech is imprecise but usually understandable to unfamiliar listeners, (III) speech is unclear and not usually understandable to unfamiliar listeners out of context, and (IV) no understandable speech. Two research SLPs (independent of the manuscript authors) independently rated each child following standard instructions for assigning VSS levels (Pennington et al., 2013). Agreement between the two raters was 87%, and disagreements were always within one rating level. Disagreements were resolved through consensus. We computed Cohen's kappa with squared weights, showing strong agreement (k = .95). This level of agreement is consistent with the literature (e.g., Long et al., 2022).

CFCS. The CFCS (Hidecker et al., 2011) was used to characterize functional communication abilities at 9–10 years of age. Ratings are made with respect to the effectiveness of a child's ability to send and receive information and consider all communication modalities a child uses. Ratings are made into one of five mutually exclusive levels: (I) a person independently and effectively alternates between being a sender and receiver of information with most people in most environments; (II) a person independently alternates between being a sender and receiver with most people in most environments, but the conversation may be slower; (III) a person usually communicates effectively with familiar communication partners, but not unfamiliar partners, in most environments; (IV) a person is not always consistent at communicating with familiar communication partners; and (V) a person is seldom able to communicate effectively even with familiar people. Two research SLPs (independent of the manuscript authors) independently rated each child following standard instructions for assigning CFCS levels (Hidecker et al., 2011). The two raters' agreement was 70%, and disagreements were always within one rating. Disagreements were resolved through consensus. Cohen's kappa with squared weights showed strong agreement (k = .90). Note that the discrepancy between the percent agreement and Cohen's kappa is due to the kappa being able to account for the degree of disagreement, which was always within one rating. While the interrater percent agreement is on the lower end, it is consistent with the literature (e.g., Koopmans et al., 2022).

SLPG. We used SLPG ratings (Hustad et al., 2010) to classify children's speech and language abilities based on the presence or absence of SMI and co-occurring language comprehension impairment at 9–10 years of age. Children were classified into one of four mutually exclusive groups: (a) NSMI, (b) SMI with language comprehension in the typical range (SMI-LCT), (c) SMI with language impairment (SMI-LCI), and (d) ANAR, defined as being able to produce fewer than five words or word approximations. Two research SLPs classified children following procedures from our previous work (Hustad et al., 2010, 2016; Soriano & Hustad, 2021). The classification agreement was 100% between the two SLPs.

Two-year-old SLPGs. Based on findings from Hustad et al. (2014), children were classified into one of three mutually exclusive speech-language profiles: (a) not yet talking, (b) emerging talkers, and (c) established talkers. For the 19 children included in Hustad et al. (2014), we used previously published classifications for analysis in the present study. Three of the remaining four children were included in Hustad et al. (2017), and their classifications published in the 2017 study are used here. For the remaining child, not included in Hustad et al. (2014 or 2017), two research SLPs (independent of the manuscript authors) independently classified the child at 2 years of age based on procedures outlined in Hustad et al. (2017). Agreement was 100%.

Test of Children's Speech. Using a standard elicitation procedure, children produced single-word and multiword utterances from the Test of Children's Speech (TOCS; Hodge et al., 2007). This measure assessed SWI and multi-word intelligibility (MWI).

To measure speech intelligibility, elicited productions of the TOCS words and sentences were recorded using a digital audio recorder for the 9- to 10-year-old visit. Orthographic transcriptions by two different in-person naive listeners per child were obtained for children's recorded productions (n = 46 listeners). Intelligibility scores were obtained by averaging the number of words transcribed correctly for the two listeners per child and then dividing by the total number of words produced by the child (see Hustad et al., 2016, 2020, for detailed description). Using an average-score, agreement-based, one-way random effects model, there was an excellent interrater agreement among SWI scores, intraclass correlation coefficient (ICC) (2) = .98, 95% confidence interval

(CI) [.93, .99]. The average of the absolute value of the difference between the two listeners for SWI was 0.06 (on a continuous scale ranging from 0–1, *SD* = 0.05). Likewise, there was excellent interrater agreement among MWI scores, ICC (2) = .98, 95% CI [.95, .99]. The average of the absolute value of the difference between the two listeners for MWI was 0.04 (*SD* = 0.05). We examined SWI separately from MWI because research has indicated important differences in these two measures for both typically developing children and children with dysarthria (Hustad et al., 2021; Mahr et al., 2020).

Caregiver communication questionnaire. Caregivers completed a researcher-developed questionnaire about their child's communication development at all visits. The current study used the following two yes/no questions: (a) "Does your child currently have an augmentative communication system (AAC)?" and (b) "Is your child currently receiving speech and language therapy?". While these questions do not provide detailed information about AAC systems and/or the primary focus of speech-language therapy, they capture the types of communication supports that children are/are not receiving on a global level.

Need for communication support and therapy. To identify who would benefit from receiving speech-language therapy and/or access to AAC strategies at 9–10 years of age, we made binary clinical judgments based on children's speech intelligibility data and SLPG ratings. At 9–10 years of age, typically developing children in the 5th percentile are expected to be 95% intelligible for multiword productions (Hustad et al., 2021). Reductions in speech intelligibility below 80% for children at this age indicate an impairment that likely has a significant impact on functional speech (e.g., Hustad, Sakash, Broman, & Rathouz, 2019; Natzke et al., 2020). Using this guideline, we determined that children with MWI and/or spontaneous speech intelligibility below 80% would benefit from access to AAC strategies in some capacity. Again, we determined the need for speech-language therapy based on binary clinical judgments, considering the presence/absence of an SMI. We used the SLPG ratings to determine this. Lastly, using caregiver responses to the caregiver communication questionnaire, we determined if children received speech-language therapy and/or had access to AAC strategies at 9–10 years of age.

Caregiver–child interactions. During each visit, children completed a caregiver–child interaction free-play session with their caregivers. A standard set of age-appropriate toys was made available for the observations, and caregivers were instructed to interact with their child as they typically would at home.

Trained research assistants transcribed caregiver–child interactions following the conventions of Systematic Analysis of Language Transcripts (SALT; Miller et al., 2011). Transcription was completed at the word level. Research assistants were undergraduate students in speech-language pathology. They completed the lab transcription training protocol, including the free self-paced online training on the SALT website. Next, they completed a standard parent–child interaction to practice SALT conventions. Lastly, they transcribed three practice parent–child interaction samples not part of the current data set to assess reliability. If reliability was not achieved (i.e., above 80%), more videos would be completed to achieve reliability. Both transcribers achieved reliability after completing three practice parent–child interaction videos.

Due to the heterogeneous nature of CP, children varied in their speech and communication abilities. Hence, we had to make several changes to the typical SALT conventions to accommodate dysarthric speech and varying communication abilities for the transcription process and for deriving variables from the transcript. First, children varied in the number of utterances they produced; many could not produce the standard set of 50. Therefore, we controlled for the duration of the sample; the first 10 min of each interaction were transcribed. We chose this number because it was the highest common denominator across recordings in the data set. Second, we also made several changes to how the language samples were transcribed to handle dysarthric speech; this included transcribers being able to gloss (i.e., use cues from a communication partner or video feed to determine what the child was saying) and transcribers were only allowed to listen to utterances/words up to three times before marking it as unintelligible. Third, we also made changes to the analysis set: Typically, the analysis set only contains complete and intelligible utterances. However, due to SMIs, children had a high number of partially intelligible utterances, and we wanted to fully capture their spoken language abilities within the context of these interactions; for most variables, we included intelligible and partially intelligible utterances in our analysis set. Specific information on how each variable was computed is described below.

We computed five variables from language transcripts. These are as follows: (a) We created an unintelligible segment (UN-S) code to calculate the number of UN-Ss that occurred within a partially intelligible utterance. These segments were composed of at least one unintelligible word. This variable was based on the entire transcript. (b) We computed the number of total words (NTW) the child produced. We calculated NTW by taking the NTW value from the entire transcript minus the number of UN-S and/or unintelligible utterance occurrences if present. These were not included since we could not determine if each instance of a code represents a single word or multiple words due to the dysarthric nature of children's speech. (c) The number of different words (NDW) produced was also calculated from the entire transcript by taking the NDW minus UN-S and/or unintelligible utterances if present. (d) The mean length in utterance–morpheme (MLUm) was calculated from the analysis set of complete and intelligible utterances. (e) Lastly, we calculated the % of intelligible utterances, defined as the number of complete and intelligible utterances divided by the total number of utterances multiplied by 100.

To ensure the reliability of the transcriptions and derived measures, we randomly selected 30% of interactions to be transcribed by a second transcriber. Reliability was determined by calculating the number of agreements over the total number of judgments for each variable of interest across children. Agreement was as follows: UN-S = 94% (80–100), NTW = 94% (88–100), NDW = 97% (89–100), MLUm = 95% (75–100), % intelligible utterances = 95% (88–100). We also calculated word-by-word agreement, and this was 86% (83–91).

Data Analysis

We used a combination of descriptive, nonparametric, and semiparametric analyses to describe and quantify the association between communication at 2 years and 9–10 years of age. All analyses were performed in R (Version 4.2.0; R Core Team). Given the ordinal structure of the data, we conducted Kruskal–Wallis rank sum tests to answer Research Questions 1, 3, and 4. Pairwise follow-up tests for significant differences were completed with the Dunn's test and Bonferroni adjustments for multiple comparisons. For our second research question, we conducted generalized linear regression (GLM) models with unspecified reference distributions (Rathouz & Gao, 2009) to examine if 2-year-old speech-language profiles predict speech and language outcome measures at 9–10 years of age. This semiparametric analysis was selected given its flexibility surrounding data assumptions and the estimation of the reference distribution being made from the data. We examined separate models for the following measures: SWI, MWI, % intelligible utterances, MLUm, NTW, and NDW. Two-year-old speech-language profiles were added to each model as a predictor, and we also included chronological age in months to control for the age range at 9- to 10-year-old visits. The not-yet-talking group served as the referent group. However, we also reran the models with established talkers as the referent group to test the differences between the emerging and established talkers. We used the gldrm package (Version 1.5; Wurm & Rathouz, 2018) to complete GLMs. We used the irr package (Version 0.84.1; Gamer et al., 2019) to complete ICC and Cohen's kappa reliability statistics.

Results

RQ1: Are Speech-Language Profiles at 2 Years of Age Associated With Children's Speech, Language, and Communication Profiles at 9–10 Years of Age?

Table 2 shows count data for speech, language, and communication classifications. Kruskal–Wallis rank sum tests were used to examine the relationship between 2-year speech-language profiles and three communication classification rating scales: VSS, CFCS, and SLPG.

VSS

The VSS was used to assess speech severity. We found a significant difference in VSS ratings at 9–10 years of age between the different 2-year speech and language profiles, $\chi^2(2) = 14.78$, $p = .001$. A pairwise post hoc Dunn's test with Bonferroni adjustments showed significant differences in VSS levels at 9–10 years of age between children who were classified at 2 years of age as not yet talking versus emerging talkers ($p = .001$) and between the not yet talking versus established talkers ($p = .018$). Specifically, children classified as not yet talking at 2 years of age had higher VSS ratings (indicating greater limitations in speech function) compared to those classified as emerging or established talkers at 2 years of age.

CFCS

The CFCS was used to assess children's overall communication effectiveness and considers all modes of communication (e.g., speech, eye contact, AAC) available to the child. We found a significant difference in CFCS ratings at 9–10 years of age between the different 2-year speech-language profiles, $\chi^2(2) = 13.68$, $p = .001$. A pairwise post hoc Dunn's test with Bonferroni adjustments showed there were significant differences in CFCS levels at 9–10 years of age between children who were classified at 2 years of age as not yet talking versus emerging talkers ($p = .003$) and between the not yet talking versus established talkers ($p = .014$). Specifically, children classified as not yet talking at 2 years of age had higher CFCS levels (indicating more restricted communication abilities) than those classified as emerging or established talkers.

SLPG

The SLPG was used to assess speech and language profiles. We found a significant difference in SLPG at 9–10 years of age between the different 2-year speech-language profiles, $\chi^2(2) = 12.01$, $p = .002$. A pairwise post

Table 2. Descriptives of speech, language, and communication outcomes at 9–10 years of age, based on 2-year-old speech-language profiles.

Variable results at 9–10 years of age	Two-year-old speech-language profile		
	Not yet talking (*n* = 10)	Emerging talks (*n* = 9)	Established talkers (*n* = 4)
	M (*SD*) unless otherwise noted	*M* (*SD*) unless otherwise noted	*M* (*SD*) unless otherwise noted
SWI			
Completed TOCS, *n*	3	9	4
Mean % intelligibility	46 (21)	72 (26)	82 (11)
MWI			
Completed TOCS: *n*	2	9	4
Mean % intelligibility	52 (17)	75 (30)	88 (10)
Longest TOCS completed	7 (1.58)	6.4 (1.71)	7 (1.44)
% Intelligible utterances (SALT)	20 (32)	80 (16)	80 (40)
Number of UN-S	0.9 (1.73)	8.44 (7.92)	12.75 (4.57)
MLUm – C&I	0.79 (1.10)	2.85 (0.69)	3.4 (0.59)
NDW – C&I	11.60 (25.81)	88.78 (46.21)	131.25 (15.17)
NDW – all utterances[a]	13.40 (29.16)	99.33 (52.35)	146.5 (15.5)
NTW – C&I	21.70 (51.18)	206.78 (179.44)	292.75 (49.61)
NTW – all utterances[a]	25.20 (59.71)	237.56 (214.06)	350.00 (60.55)
VSS rating (*n*)			
I	0	3	1
II	1	5	3
III	2	3	0
IV	7	0	0
CFCS rating (*n*)			
I	0	4	2
II	1	4	2
III	1	0	0
IV	5	1	0
V	3	0	0
SLPG (*n*)			
NSMI	0	2	2
SMI-LCT	1	3	1
SMI-LCI	2	4	1
ANAR	7	0	0

Note. SWI = single-word intelligibility; TOCS = Test of Childhood Stuttering; MWI = multi-word intelligibility; SALT = Systematic Analysis of Language Transcripts; UN-S = unintelligible segments; MLUm = mean length of utterance–morpheme; C&I = complete and intelligible utterances; NDW = number of different words; NTW = number of total words; VSS = Viking Speech Scale; CFCS = Communication Function Classification System; SLPG = speech language profile group; NSMI = no speech–motor impairment; SMI-LCT = speech–motor impairment and language comprehension intact; SMI-LCI = speech–motor impairment and language comprehension impairment; ANAR = anarthric.

[a]Count of words from all utterances minus unintelligible segments and/or unintelligible utterances.

hoc Dunn's test with Bonferroni adjustments showed there were significant differences at 9–10 years of age between children who were classified at 2 years of age as not yet talking versus emerging talkers (p = .012) and between the not yet talking versus established talkers (p = .013). Specifically, children classified as not yet talking at 2 years of age had SLPG ratings associated with greater impairment (e.g., most children were classified as ANAR) compared to those classified as emerging or established talkers.

RQ2: To What Extent Do Speech and Language Profiles at 2 Years of Age Predict Speech and Language Outcome Measures Derived From Language Samples and Speech Intelligibility at 9–10 Years of Age?

Means and standard deviations for speech and language outcomes are shown in Table 2. The GLM analyses testing the relationship between 2-year speech-language profiles and MLU-m, NDW, and NTW at

9–10 years of age revealed significant overall omnibus tests for all measures (see Table 3 for results for each model and Figure 1). Pairwise contrasts showed that children who were not yet talking at 2 years of age had, on average, significantly lower MLU-m and used fewer total and number different words at 9–10 years of age during caregiver–child interactions compared to emerging and established talkers. There were no significant differences between 2-year-old emerging talkers and established talkers at 9–10 years of age for MLU-m, NTW, and NDW (see Table 4 for full model results).Results of the GLM analyses testing the relationship between 2-year speech-language profiles and SWI at 9–10 years of age revealed an insignificant overall omnibus test. The same result was observed for MWI (see Table 3 and Figure 2). However, the GLM analyses testing the relationship between 2-year speech-language profiles and % intelligible spontaneous utterances from caregiver–child interactions at 9–10 years of age revealed a significant overall omnibus test. Pairwise contrasts showed that children who were not yet talking at 2 years of age produced, on average, significantly fewer spontaneous intelligible utterances at 9–10 years of age compared to those who were emerging and established talkers. There were no significant differences in the percent spontaneous intelligible utterances between emerging and established talkers (see Table 3 for full model results).

RQ3: At 9–10 Years of Age, Which Children Receive Speech-Language Services, and Are There Additional Children Who Would Benefit From Speech-Language Services? To What Extent Is This Related to Their 2-Year Speech-Language Profiles?

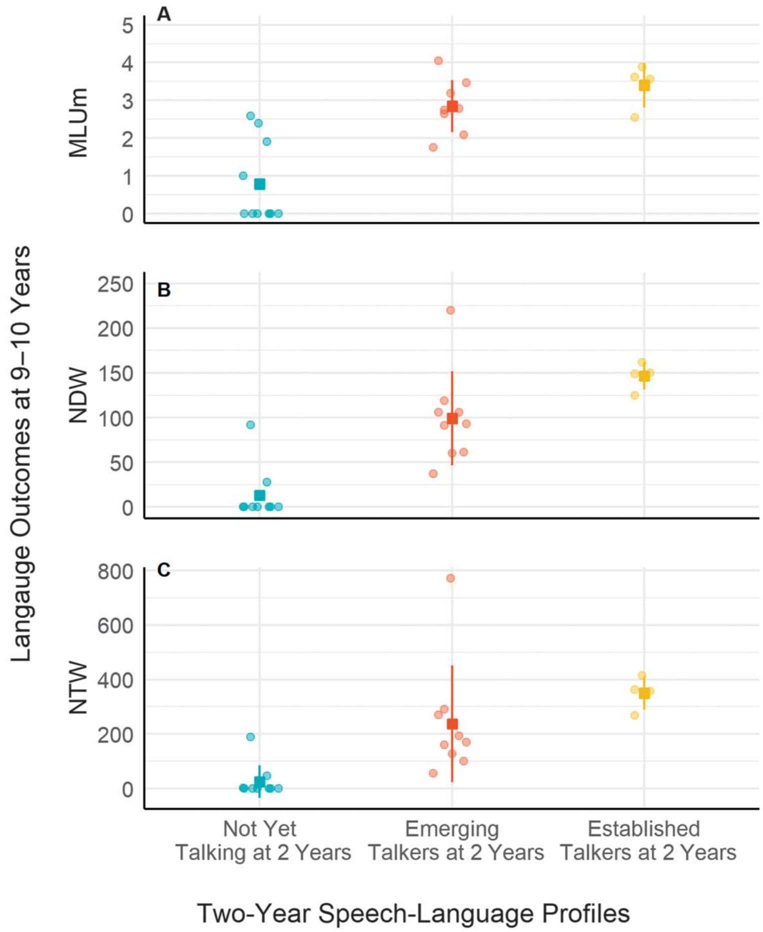
Table 4 displays individual data for those who received speech-language therapy and those who would benefit from such services, along with the relevant speech, language, and communication variables. There was a significant association between those who received speech-language services at 9- to 10-years of age and their 2-year-old speech-language profile, $\chi^2(2) = 9.35$, $p = .009$, with all 10 children who were not yet talking at 2 years of age receiving services, three of the nine emerging talkers receiving services, and two of the four established talkers receiving speech-language services. A pairwise post hoc Dunn's test with Bonferroni

Table 3. General linear regression analysis summary for 2-year-old speech-language profiles predicting speech, language, and communication outcomes at 9–10 years of age.

Variable	*B*	*SE*	*t*	*F*	*p*
Mean length of utterance–morpheme				9.86***	
Emerging talkers vs. not yet talking	2.31	0.34	6.90		.000
Established talkers vs. not yet talking	2.73	0.37	7.43		.000
Emerging vs. established talkers	–0.42	0.24	–1.79		.09
Age at 9- to 10-year visit	–0.10	0.013	–7.76		.000
Number of different words – all utterances				7.93**	
Emerging talkers vs. not yet talking	84.415	17.097	4.94		.000
Established talkers vs. not yet talking	131.685	25.193	5.23		.000
Emerging vs. established talkers	–47.270	27.903	–1.69		.11
Age at 9- to 10-year visit	1.602	0.934	1.73		.099
Number of total words – all utterances				7.18**	
Emerging talkers vs. not yet talking	214.63	55.03	3.90		.001
Established talkers vs. not yet talking	318.94	112.04	2.85		.010
Emerging vs. established talkers	–104.31	122.45	–0.85		.40
Age at 9- to 10-year visit	3.32	1.94	1.71		.10
Single-word intelligibility				1.67	
Multi-word intelligibility				1.22	
Percent intelligible utterances (SALT)				6.59**	
Emerging talkers vs. not yet talking	0.63	0.10	6.47		.000
Established talkers vs. not yet talking	0.62	0.12	5.66		.000
Emerging vs. established talkers	0.01	0.07	0.16		.871
Age at 9- to 10-year visit	–0.01	0.01	–1.10		.287

Note. Significant codes **.001 and ***.000. Degrees of freedom: for mean length of utterance–morpheme, number of different words, and number of total words: 3, 19; single-word intelligibility model: 3, 12; multi-word intelligibility model: 3, 11. Percent intelligible utterances: 3, 19. SALT = Systematic Analysis of Language Transcripts.

Figure 1. Language outcomes at 9–10 years of age. Circles represent individual data points, and squares represent the means for each group. Panel A displays mean length in utterance–morpheme (MLUm) at 9–10 years of age derived from caregiver–child interactions. Panel B displays number of different words (NDW) at 9–10 years of age derived from caregiver–child interactions. Panel C displays number of total words (NTW) at 9–10 years of age derived from caregiver–child interactions.



adjustments showed differences to be significant only for the not-yet-talking versus emerging-talkers groups (p = .008).

Two-year speech-language profiles were not significantly associated with who would benefit from receiving speech-language services at 9–10 years of age as determined by the presence/absence of SMIs, $\chi^2(2)$ = 4.99, p = .082. Most children across the 2-year speech-language profiles had an SMI (n = 19; see Table 4). Examining individual-level data in Table 4, we can see discrepancies between SMI status and speech-language therapy access. For example, child C18 does not have SMI based on the SLPG but was receiving speech-language therapy at 9–10 years of age. In contrast, children C19, C11, C08, C12, and C14 all have SMI based on the SLPG but were not receiving speech-language therapy at 9–10 years of age.

RQ4: At 9–10 Years of Age, Which Children Have Access to AAC Strategies, and Are There Additional Children Who Would Benefit From AAC Strategies? To What Extent Is This Related to Their 2-Year Speech-Language Profiles?

Table 4 displays individual-level data for those with access to AAC strategies who would benefit from AAC and the relevant speech, language, and communication variables. There was a significant association between those with access to AAC strategies at 9–10 years of age and their 2-year speech-language profile, $\chi^2(2)$ = 6.02, p = .049. Pairwise post hoc Dunn's test with Bonferroni adjustments showed no significant difference between groups.

Using the threshold of intelligibility below 80% to determine who would benefit from AAC strategies, we did not find

Table 4. Individual-level data for speech-language therapy and augmentative and alternative communication (AAC) strategies and relevant speech, language, and communication variables.

Child	SLT at 2 years of age	SLT at 9–10 years of age	Need SLT at 9–10 years of age[a]	AAC at 2 years of age	AAC at 9–10 years of age	Need AAC at 9–10 years of age[b]	SLPG	MWI	% intel SALT
Established talkers at 2 years of age									
C16	No	No	No	No	No	No	NSMI	100	82
C18	Yes	Yes	No	No	No	No	NSMI	93	85
C19	No	No	Yes	No	No	Yes	SMI-LCI	81	79
C17	No	Yes	Yes	No	No	Yes	SMI-LCT	78	76
Emerging talkers at 2 years of age									
C13	Yes	No	No	No	No	No	NSMI	99	85
C07	Yes	No	No	No	No	No	NSMI	98	99
C11	Yes	No	Yes	No	No	No	SMI-LCT	89	87
C08	Yes	No	Yes	No	No	No	SMI-LCT	93	84
C12	Yes	No	Yes	Yes	No	Yes	SMI-LCI	79	87
C15	Yes	Yes	Yes	No	No	Yes	SMI-LCI	67	75
C10	No	Yes	Yes	No	No	Yes	SMI-LCI	62	79
C9	Yes	Yes	Yes	No	No	No	SMI-LCT	86	86
C14	Yes	No	Yes	No	No	Yes	SMI-LCI	3	43
Not yet talking at 2 years of age									
C06	Yes	Yes	Yes	No	No	No	SMI-LCI	86	91
C03	Yes	Yes	Yes	No	No	Yes	SMI-LCI	52	46
C20	Yes	Yes	Yes	Yes	Yes	Yes	SMI-LCT	NC	49
C04	Yes	Yes	Yes	No	No	Yes	ANAR	NC	0
C21	No	Yes	Yes	No	Yes	Yes	ANAR	NC	11
C22	Yes	Yes	Yes	No	Yes	Yes	ANAR	NC	0
C23	Yes	Yes	Yes	No	Yes	Yes	ANAR	NC	0
C01	Yes	Yes	Yes	No	No	Yes	ANAR	NC	0
C02	Yes	Yes	Yes	No	No	Yes	ANAR	NC	0
C05	Yes	Yes	Yes	No	No	Yes	ANAR	NC	0

Note. SLT = speech-language therapy; SLPG = speech language profile group; MWI = multi-word intelligibility; SALT = Systematic Analysis of Language Transcript; NSMI = no speech–motor impairment; SMI-LCI = speech–motor impairment and language comprehension impairment; SMI-LCT = speech–motor impairment and language comprehension intact; NC = not completed; ANAR = anarthric.

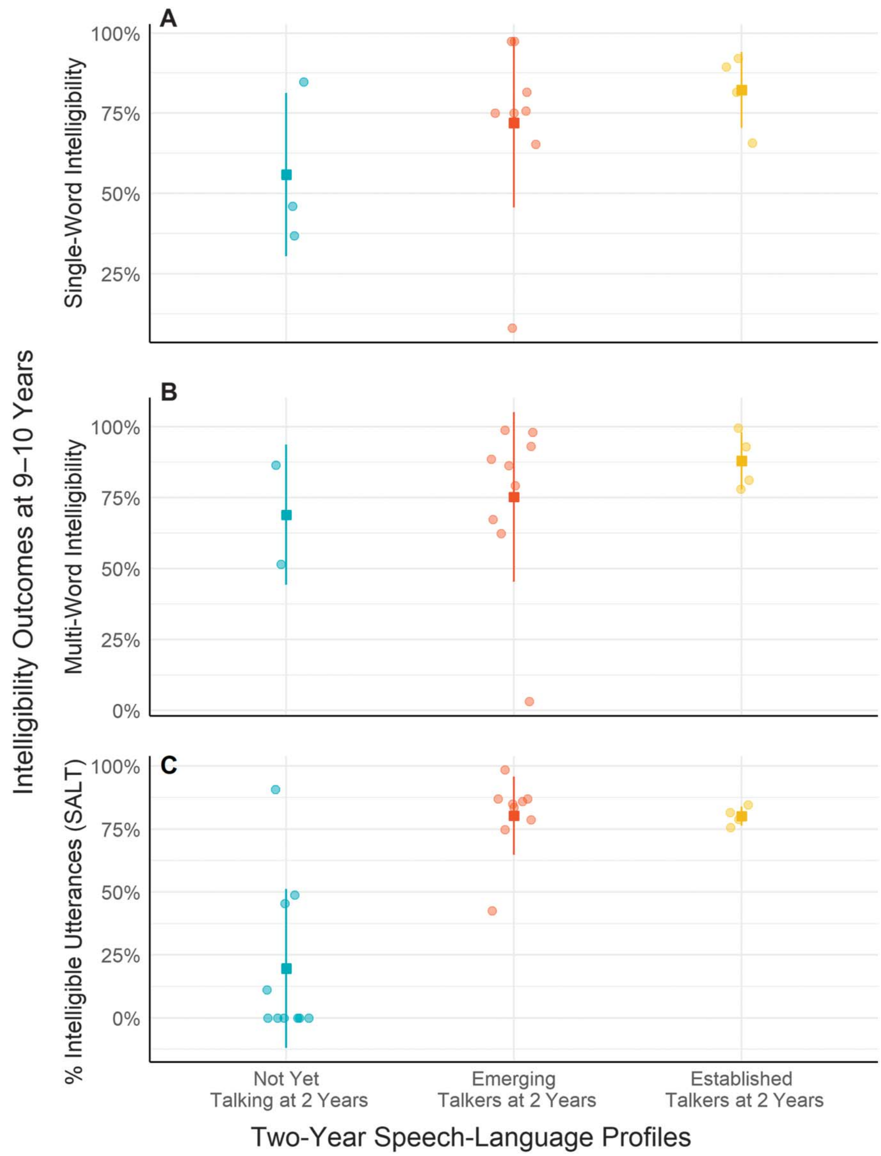
[a]Need for SLT determined by the presence of a speech–motor impairment. [b]Need for AAC strategies determined by MWI below 80%.

a significant association between who would benefit from AAC at 9–10 years of age and their 2-year speech-language profiles. Examining individual-level data in Table 4 shows discrepancies between intelligibility scores and who had access to AAC strategies. For example, child C14 was receiving speech-language therapy at 2 years of age, but at 9–10 years of age, despite having restricted intelligibility based on both spontaneous speech (i.e., % intel SALT = 43%) and elicited multi-word utterances (i.e., MWI = 3%), child C14 did not have access to AAC strategies and was not receiving speech-language therapy. Furthermore, only four of the 15 children in our sample who would benefit from AAC strategies had access to them.

Discussion

We were interested in understanding the extent to which 2-year-old speech-language profiles were associated with speech, language, and communication outcomes at 9–10 years of age in children with CP. We also examined whether early profiles were associated with AAC use and speech-language therapy at 9–10 years of age. Consistent with previous research demonstrating that early speech and language outcomes are highly predictive of later outcomes (e.g., Hidecker et al., 2018; Hustad et al., 2018; Hustad, Sakash, Natzke, et al., 2019; Long et al., 2022; Mahr et al., 2020; Pennington et al., 2020), we found significant differences in outcomes at 9–10 years of age based on children's 2-year speech-language profiles across all our research questions. Furthermore, while speech/language improves over time for many children with CP, our current results provide further evidence that there are distinct trajectories and speech-language profiles among children with CP (Hustad et al., 2010, 2014; Hustad, Sakash, Natzke, et al., 2019; Mahr et al., 2020). Collectively, these results indicate that early communication abilities are highly indicative of later ability

Figure 2. Speech intelligibility outcomes at 9–10 years of age. Circles represent individual data points, and squares represent the mean for each group. Panel A displays single-word intelligibility at 9–10 years of age. Note that only three children who were classified as not talking at 2 years of age were able to produce elicited single-word utterances at 9–10 years of age. Panel B displays multi-word intelligibility at 9–10 years of age. Note that only two children who were classified as not yet talking at 2 years of age were able to produce elicited multi-word utterances at 9–10 years of age. Panel C displays % intelligible utterances derived from the caregiver–child interaction at 9–10 years of age. SALT = Systematic Analysis of Language Transcripts.



profiles and thus can be used as evidence for treatment decision making focused on AAC and maximizing communication outcomes. We discuss our findings below and how they relate to clinical decision making for children with CP.

Speech, Language, and Communication Outcomes at 9–10 Years of Age in Children Who Were Not Talking at 2 Years of Age

We found that children with CP classified as not talking at 2 years of age had speech, language, and communication outcomes that were more restricted at 9–10 years of age than children with CP who were emerging or established talkers at 2 years of age. Specifically, we found that in relation to other speech, language, and communication profile groups, children not talking at 2 years of age had significantly reduced speech production abilities (indicated by higher VSS ratings; more severe) at 9–10 years of age. In particular, all children had evidence of reduced functional speaking ability, and most had very significantly reduced speech function (either speech that is unclear and not usually understandable to unfamiliar listeners (VSS III) or no understandable speech (VSS IV).

When considering the overall effectiveness of everyday communication using all modalities (indicated by CFCS ratings), we found that the majority of children who were not talking at 2 years had limited communication abilities (higher CFCS ratings; greater severity) at 9–10 years of age. Most children who were not talking at 2 years of age were either not always consistent in communicating with familiar partners (CFCS IV) or seldom able to communicate effectively even with familiar people (CFCS V) at 9–10 years of age.

Regarding impairment-based SLPGs, all children not talking at 2 years of age showed evidence of SMI (as indicated by SLPG) at 9–10 years of age. Most children were in the anarthria group, and the remainder had SMI, either with or without co-occurring language impairment (as indicated by SLPG). Previous work from our lab examined these children at 4 years of age to determine the predictiveness of 2-year speech-language profiles on communication outcomes at 4 years of age (Hustad et al., 2017). Results at 4 years of age showed that all children who were not yet talking at 2 years of age had significant speech and communication limitations as indicated by the SLPG at 4 years of age. Findings did not change between 4 and 9–10 years of age. However, it is critical to note that a lack of change in categorical classification does not mean children are not advancing in speech, language, and communication abilities. Indeed, children showed advancement in more refined measures.

When looking at speech and language outcomes obtained from language transcription analyses of spontaneous language samples (i.e., caregiver–child interaction), children who were not talking at 2 years of age were significantly less talkative (i.e., NTW) and less intelligible (i.e., % complete and intelligible spontaneous utterances) at 9–10 years of age compared to children who were emerging or established talkers at 2 years of age. Additionally, grammatical complexity and lexical diversity (i.e., MLU-m and NDW) were significantly lower compared to emerging or established talkers. Despite the limited growth compared to the emerging and established talkers, some children who were not talking at two demonstrated growth between 2 and 10 years of age. Specifically, at 2 years of age, during spontaneous language samples, children who were not yet talking did not produce any intelligible utterances or words (i.e., NTW and NDW = 0; Hustad et al., 2014). At 9–10 years, on average, 20% of utterances were intelligible; the group produced 22 words (NDW = 13) and had an MLU-m of 0.79. Notably, however, these group results are primarily driven by children with SMI but did not have anarthria and were therefore able to produce speech. Looking at Figure 1, we can see that for those classified as ANAR at 9–10 years of age, spontaneous language samples with a familiar communication partner did not capture spoken expressive language owing to barriers imposed by speech motor impairments. Measures that code for nonverbal communication, including turn-taking, nonlinguistic vocal behavior, and use of idiosyncratic gestures, may provide greater insight into communication development in children with anarthria. For example, McFadd and Hustad (2020) found that ANAR children used a combination of nonlinguistic vocalizations and gestures to communicate, neither of which was captured in the present study. Additionally, studies using parent report measures of receptive vocabulary in this population suggest that many children with anarthria continue to acquire words through 7 years of age (Molinaro et al., 2020). Of course, a key strategy for advancing communication abilities in children with anarthria is the use of AAC systems. However, only four children in our sample had AAC systems. Furthermore, only one child used their AAC system during the caregiver–child interaction to support communication. We did not examine communication success between children and their caregivers. Additional research is needed to examine caregiver and child communication more holistically within these interactions to understand how AAC can be used to support communication within these interactions.

In contrast to findings from spontaneous language samples, we did not find significant differences in orthographic transcription intelligibility scores from naive listeners among 2-year speech-language profiles for children at 9–10 years of age. However, most children who were not talking at 2 years of age had insufficient speech production ability to generate speech samples for listeners to orthographically transcribe at 9–10 years of age. Thus, considerable data for these analyses were missing from the not-yet-talking group, which restricted our power and likely contributed to the nonsignificant omnibus tests. Specifically, only the three children with SMI (and none with anarthria) could complete the speech production task at 9–10 years of age. In contrast, language samples were obtained and analyzed from all children, but most children with anarthria had 0% intelligible utterances.

Our third and fourth research questions examined how 2-year-old speech-language profiles relate to speech-language therapy and AAC strategies at 9–10 years of age. It is important to note that based on the survey question wording, we cannot differentiate if children were primarily receiving intervention targeting speech or language or a combination of both. Likewise, regarding AAC strategies, our survey question did not provide examples of types of AAC strategies, so caregivers may have responded with a "no" when their child was receiving AAC strategies. We found a significant association between 2-year-old speech-language profiles and those who received speech-language therapy at 9–10 years of age. Specifically, children who were not talking at 2 years of age were more likely to be getting therapy at 9–10 years of age compared to those who were emerging talkers. There was not a difference in therapy status at 9–10 years of age between the not-yet-talking and established-talkers groups, likely due to the small sample of established talkers at 2 years of age (n = 4) and that half of the group was receiving speech-language therapy; the other half was not. While we did observe a significant difference between 2-year speech-language profiles and AAC status at 9–10 years of age, post hoc follow-up pairwise comparisons revealed no significant difference between groups. This is likely due to the fact that only four children (all classified as not talking at 2 years of age) in our sample had AAC systems at 9–10 years of age. In contrast, as we hypothesized, we did not find significant associations between 2-year-old speech-language profiles and which children would benefit from receiving speech-language therapy and/or having access to AAC strategies at 9–10 years of age. Given the high prevalence of SMIs among children with CP (e.g., Mei et al., 2020; Nordberg et al., 2013), we expected that most children would benefit from speech-language therapy (based on the presence of an SMI) as well as access to AAC systems (based on speech intelligibility below 80%) at 9–10 years of age regardless of their 2-year speech-language profile. These findings are consistent with previous work suggesting a potential misalignment of services that children with CP receive versus those they would benefit from, particularly for children with milder speech impairments (Hustad & Miles, 2010; Koopmans et al., 2022). However, it is important to note that there is some overlap in child participants between the current study and Koopmans et al. (2022) and Hustad and Miles (2010), although different time points were examined across these studies. This misalignment in services is particularly salient when considering individual child data for AAC access in Table 4. While most children in our sample would benefit from AAC systems at 9–10 years of age, based on speech intelligibility below 80%, only four had AAC systems. These results highlight the continued need to provide education about the benefits of AAC and the ways that AAC can be used in conjunction with speech so that stakeholders can make informed decisions about the use of AAC.

Overall, our results show that the communication outcomes at 9–10 years of age for children with CP who were not talking or even beginning to talk at 2 years of age differed from those who were emerging or established talkers at 2 years of age and that early speech, language, and communication profiles foreshadow later outcomes. These findings suggest that early communication interventions can be and should be differentiated based on communication abilities at 2 years of age to maximize later communication outcomes. In the present study, all but one child in the not-yet-talking group at 2 years of age required AAC systems throughout development because their ability to communicate via spoken language across partners and settings was very limited. Based on Hustad and Miles (2010) AAC framework, these children require comprehensive AAC systems as their primary mode of communication. At the same time, many are likely to be able to produce a limited number of words and use vocalizations to communicate with familiar communication partners. These modes must also be honored and included within the communication repertoire. For example, AAC might not be as effective as verbal communication for a child interacting with a family member during mealtimes. However, when communicating with unfamiliar or familiar communication partners with no shared context, AAC may be needed to reduce/repair communication breakdowns (e.g., Beukelman & Yorkston, 1980; DePaul & Kent, 2000; Sigafoos et al., 2004). Additionally, to ensure optimal outcomes, providing caregiver education on the advantages of incorporating AAC right away will be essential to leverage the early language learning years (e.g., Moorcraft et al., 2018, 2019). By increasing access to and teaching effective and efficient communication modalities, we can advance communication outcomes for this group of children as well as participation and quality of life outcomes.

Speech, Language, and Communication Outcomes in Children Who Were Emerging and Established Talkers at 2 Years of Age

Across all our research questions, we found no significant differences in outcomes at 9–10 years of age between children who were emerging and established talkers at 2 years of age. Regarding speech production abilities as measured by the VSS, none of the children in either group were classified as having no understandable speech (VSS IV) at 9–10 years of age. VSS ratings ranged between Levels I and III at 9–10 years of age for children classified as emerging talkers at age 2 years. For children who were established talkers at 2 years of age, there was minimal to no evidence of reduced functional speaking abilities at 9–10 years of age, as indicated by VSS ratings of Level I or II.

We observed similar patterns for the overall effectiveness of everyday communication using all modalities as measured by CFCS ratings. Specifically, for most children across both groups, there was minimal to no evidence of reduced functional communication at 9–10 years of age, as indicated by CFCS ratings of I (a person independently and effectively alternates between being a sender and receiver of information with most people in most environments) and II (a person independently alternates between being a sender and receiver with most people in most environments, but the conversation may be slower).

For impairment-based speech and language profile groups, no emerging or established talkers at 2 years of age were classified as ANAR at 9–10 years of age based on the SLPG. Across the two groups, at 9–10 years of age, some children showed no evidence of an SMI as indicated by the SLPG classification of NSMI, while, for others, there was evidence of SMI with and without co-occurring language impairment.

In this group of children at 2 years of age, Hustad et al. (2014) found significant differences between emerging and established talkers in speech and language outcomes obtained from a spontaneous language sample (i.e., caregiver–child interactions). Specifically, they found differences in the NDW, NTW, and % intelligible utterances but not for MLU-m. However, we did not find any significant difference in our outcomes derived from spontaneous language samples for this same group of children at 9–10 years of age. It is important to note, however, that there was variability within both groups observed across many of the SALT measures, as demonstrated by large standard deviations (e.g., NTW), as well as little variability in the means between the two groups for other measures (i.e., % intelligible utterances, MLU-m). These findings extend the work of Hustad et al. (2018), who examined this same group of children at 4 years of age and showed that some emerging talkers at 2 years of age had caught up with age-level expectations for speech and language comprehension.

While we see growth in the speech and language outcomes derived from spontaneous language samples from the data reported by Hustad et al. (2014) at 2 years and what we report here at 9–10 years of age, this growth is less than expected for typically developing children. For example, at 5 years of age, we expect an MLU-m of 4.09 (Rice et al., 2010). In the present study, children classified as emerging talkers at 2 years of age had an MLU-m of 2.85 at 9–10 years of age. This was descriptively lower than for those classified as established talkers at 2 years of age, with an MLU-M of 3.4. Given the current debate on the usefulness of MLUm as a metric of language development in older school-aged children (e.g., Frizelle et al., 2018; Potratz et al., 2022), we used age 5 years as a comparison timepoint. The average MLUm for both emerging and established talkers at 9–10 years of age is lower than what is expected for typically developing 5-year-olds. Likewise, connected speech intelligibility is expected to be close to 100% at 9 years of age (Hustad et al., 2021). However, both groups had 80% complete and intelligible utterances at 9–10 years of age. Thus, there is a clear need for ongoing intervention to support both speech and expressive language development.

Findings from the present study provide preliminary evidence that, as a group, children with CP who begin to talk at 2 years of age catch up with those who were established talkers at 9–10 years of age. This finding has promising implications for early communication interventions, specifically around AAC systems. Using Hustad and Miles's (2010) AAC framework, for children who are emerging talkers at 2 years of age, it will likely be beneficial to have both AAC systems and speech as primary communication modes. However, as speech develops, AAC may become more of a backup communication mode. It will be important to educate caregivers and professionals about the benefits of supplementing speech with AAC as speech develops for these children to ensure they have access to effective communication modes. Additionally, the presence of an SMI and its severity varies among children who were emerging or established talkers at 2 years; thus, whether AAC strategies are a primary or secondary communication mode will depend on the presence/absence and severity of the SMI. However, currently, we cannot reliably determine the presence/absence of an SMI at 2 years; therefore, at 2 years of age, communication interventions for both groups of children should target both speech and AAC strategies to meet children's communication needs if children are delayed relative to typical age-level expectations.

It may also be beneficial to consider other known early predictors of spoken language to help inform intervention planning in these earlier years. For example, canonical babbling predicts later spoken language in children with IDD (Yoder & Warren, 2004; Yoder et al., 1998). Preliminary work from our lab shows that children with CP produce fewer and less diverse canonical syllable types compared to children with resolved gross motor delays (Long & Hustad, 2024). Studies should continue to examine the extent to which the frequency and diversity of canonical vocal acts could be used to help guide intervention planning for children with CP. As mentioned earlier, in the current study, we did not distinguish between speech and/or language with regard to intervention goals. Children with CP who have no and/or mild SMIs may benefit from speech-language therapy but with a primary focus on language and communication to further maximize social participation outcomes.

Limitations and Future Directions

While our findings have important clinical implications, several limitations regarding our sample and methodology should be considered. First, our sample size is relatively small (n = 23), which may have impacted our ability to detect significant differences among 2-year-old speech-language profiles at 9–10 years of age. Relatedly, the 2-year-old speech-language profiles did not have equal representation across groups. Specifically, there were only four children who were established talkers at 2 years of age; the extent to which this is representative of the population is unknown. Given that participants of the current study came from a larger longitudinal study examining speech and language development, there may have been a bias toward families with speech-language concerns participating. Therefore, there is a need for prospective research that includes population-based samples to examine speech-language development in children with CP. Third, most children in the not-yet-talking at 2 years of age group could not complete the speech elicitation task at 9–10 years of age, which resulted in missing data for the SWI and MWI GLM analyses. The missing data may have contributed to the insignificant omnibus test for the SWI and MWI analyses. Fourth, our caregiver reported survey questions about access to speech-language therapy and AAC systems were only able to capture these supports at a global level. To further our understanding of how speech and language profiles of children with CP are associated with the types of communication supports they receive, more detailed research is required. Lastly, it is important to note that we primarily focused on speech and spoken language outcomes. Future work should examine longitudinal nonverbal communication outcomes across 2-year-old speech-language profiles to understand differences in communication ability between the groups. This will provide a broader understanding of communication ability, which can improve future communication interventions for children with CP.

To improve communication outcomes of children with CP, there is a critical need for additional research that will enable clinicians to identify children with speech and language impairments earlier than 2 years of age to increase access to communication interventions at the earliest age possible. To ensure future communication interventions are tailored to a child's needs and preferences, there is a need to examine how best to combine AAC strategies and speech to optimize communication outcomes while also honoring the communication modality preferences of each child. Next-generation research should also include longitudinal studies to document the type of communication interventions received over time to understand how interventions impact development.

Conclusions

We found that children with CP who were not yet talking at 2 years of age had speech, language, and communication outcomes at 9–10 years of age that were more restricted than those children who were emerging or established talkers at 2 years of age. Additionally, we found no difference in outcomes at 9–10 years of age between emerging and established talkers. These results should inform communication intervention planning for children with CP. Specifically, for children not yet talking at 2 years of age, interventions should strongly emphasize AAC to ensure that children have a means to communicate with those around them.

Author Contributions

Marianne Elmquist: Conceptualization, Formal analysis, Methodology, Writing – original draft. **Katherine C. Hustad:** Conceptualization, Funding acquisition, Methodology, Writing – original draft.

Data Availability Statement

Data supporting the analyses and results presented in this article may be made available from the authors on request. Data are not publicly available due to institutional review board protections.

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