

# Pausing and Sentence Stress in Children with Dysarthria due to Cerebral Palsy

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## Keywords

Dysarthria · Cerebral palsy · Pausing · Sentence stress · Children

## Abstract

**Introduction:** Children with dysarthria due to cerebral palsy (CP) can experience problems manipulating intensity, fundamental frequency, and duration to signal sentence stress in an utterance. Pauses have been identified as a potential additional cue for stress-marking, which could compensate for this deficit. **Objective:** This study aimed to determine whether children use pauses to signal stress placement, and whether this differs between typically developing children and those with CP. **Methods:** Six children with CP and 8 typically developing children produced utterances with stresses on target words in 2 different positions. Pauses before and after the stressed target words were analyzed in terms of number, location, and duration. **Results:** Both groups inserted pauses into their utterances. However, neither group used pause location or duration in a systematic manner to signal the position of the words stressed. **Conclusions:** The results suggest that pausing was not used strategically by either group to signal sentence stress. Further research is necessary to explore the value of pausing as a cue to stress-marking in general and as a potential compensatory strategy for speakers with dysarthria.

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## Introduction

The highlighting of words within utterances, also referred to as “sentence stress,” is crucial to effective spoken communication. In conversations, it serves an important linguistic-pragmatic function. By emphasizing new or important information in the speech stream, the speaker directs the conversation partner to the most relevant part of the utterance, thereby structuring the information in the discourse [e.g., 1, 2]. It is well-established that in West-Germanic languages including English sentence stress is marked by increases in duration and intensity, as well as an expanded fundamental frequency (F0) range on the highlighted word [e.g., 3–5]. In parallel with studies investigating segmental speech development in children, researchers have also focused on the emergence of prosodic patterns. Evidence suggests that children speaking West-Germanic languages can reliably control duration, intensity, and F0 to signal sentence stress from the age of about 4–5 years [e.g., 6–10]. Production consistency and stability continue to develop beyond this age [8, 11].

In addition to the above 3 acoustic parameters, there is evidence that pausing might also be used to mark sentence stress in an utterance. Dahan and Bernard [12], Gee and Grosjean [13], and Swerts and Geluykens [14] demonstrated that adult speakers use pauses in discourse to either introduce new information or to highlight spe-

cific information. They did this by inserting pauses and/or increasing pause duration before the highlighted word. Dahan and Bernard [12] also showed that listeners benefitted from these cues as the presence of pauses before the stressed word led to an increased perception of emphasis.

Children's pausing patterns are less well-researched even though children tend to pause more frequently than adults [15]. The few studies investigating the possible role of pausing for discourse-structuring purposes suggest an adult-like use of pausing in the marking of new information in a discourse [15–17]. Specifically, Esposito [16] found that 9-year-old Italian children, similar to adults, pause to convey new information, and that longer pauses are associated with marking new information and shorter pauses with already-given information. Redford [17] also observed that English-speaking 5-year-olds paused longer before conveying new information, and they concluded that the children were aware of the role of pausing as a means of discourse-marking. Romøren and Chen [15] systematically investigated the link between pausing and sentence stress in 5-year old Dutch children. The authors elicited a range of sentences with varying sentence stress structures. They further found that pauses before stressed words are significantly longer than pauses occurring before the unstressed counterpart of the same word. The Dutch children made use of pauses more consistently than adults, suggesting that they exploited pausing more systematically to stress words in utterances.

The notion that pausing could potentially function as another indicator of sentence stress, alongside manipulations of duration, intensity, and F0, is relevant from a clinical perspective. Both adults and children with dysarthria are known to experience problems with stress production due to poor control of the abovementioned parameters. This includes children with cerebral palsy (CP) [18], and adults with Parkinson's disease [19, 20], ataxia [21–23], or brain injuries [24–26]. Therapeutic interventions focusing on strategies for more effective stress production, by modifying duration, intensity, and F0, have yielded inconsistent results [27–29]. Frequently, speakers are limited in their ability to increase performance levels in, e.g., intensity or F0, or to control parameters sufficiently to achieve the precise coordination required for successful stress-marking. A strategy that relies on a decrease in speech activity, i.e., silence in the form of a pause, may therefore represent a viable compensatory strategy to mark sentence stress. However, there is currently insufficient information as to how children and adults with dysarthria use pauses for stress-marking. An investigation of pausing in

contrastive stress tasks in a group of 10 adults with dysarthria due to hereditary ataxia showed that half the speakers used pauses systematically to signal sentence stress by placing pauses mostly before, but also after, the stressed word [22]. Similar findings were reported in a single-case study on another speaker with ataxic dysarthria due to a head injury [28]. These studies potentially indicate that these speakers were using pausing to spontaneously compensate for their impaired ability to manipulate other acoustic correlates of sentence stress. Given the potential benefits of pause insertion for stress-marking in adult populations, and the fact that Romøren and Chen [15] reported that typically developing children use pauses systematically to mark stressed words, the role of pauses for sentence stress-marking in younger speakers should be explored further. This may be particularly useful to investigate in speakers who are affected by dysarthria such as children with dysarthria due to CP.

CP is an umbrella term for a group of nonprogressive disorders of movement and posture caused by damage to the developing brain [30]. It is the most common cause of developmental motor problems [31], with recent population-based investigations suggesting that between 30 and 90% of all children with CP may present with dysarthria [32–34]. Common speech characteristics associated with dysarthria due to CP are shallow, irregular breathing, reduced vocal quality, inappropriate loudness levels, reduced pitch variation, hypernasality, a slower speech rate, and imprecise articulation [35–39]. These speech features can affect sentence stress production; a recent study by Kuschmann and Lowit [18] investigating children's ability to manipulate acoustic parameters to signal stress showed that the children with CP and dysarthria were not as effective as TD children. They found that the children with CP used a more limited set of acoustic parameters than their matched peers to mark sentence stress. Specifically, the children with CP were able to manipulate the duration but not the intensity and F0 of stressed words. This led listeners to being less successful in identifying the highlighted word. However, no study to date has investigated the use of pauses during stress-marking in this speaker population. We therefore currently do not know whether children make use of pausing to mark sentence stress. However, information on this will be vital to understand the potential clinical benefits, associated with pausing, for children with CP and dysarthria.

#### *Aim of the Study*

We aimed to investigate whether children with CP and dysarthria as well as typically developing children use

**Table 1.** Participant details

Child	Gender	Age, years	Type of CP	GMFCS	CSIM, % intelligible single words	Dysarthria severity
CP1	male	7	dyskinetic	I	80	mild
CP2	male	7	spastic	IV	91	mild
CP3	male	16	spastic	III	52	moderate
CP4	male	18	ataxic	IV	69	moderate
CP6	female	8	dyskinetic	III	60	moderate
CP7	female	15	dyskinetic	III	84	mild
Mean					72.7	
TD1	male	7	–		88	–
TD2	male	8	–		83	–
TD3	male	16	–		99	–
TD4	male	20	–		100	–
TD5	male	14	–		98	–
TD6	female	7	–		94	–
TD7	female	16	–		92	–
TD8	male	6	–		94	–
Mean					93.5	

CP, cerebral palsy; TD, typically developing; GMFCS, Gross Motor Function Classification System (I, walks without limitations; II, walks with limitations; III, walks using a hand-held mobility device; IV, self-mobility with limitations); CSIM, Children's Speech Intelligibility Measure (mild,  $\geq 80\%$ ; moderate, 50–80%; severe,  $< 50\%$ ).

pauses to signal sentence stress. Specifically, we wanted to determine whether both groups systematically use pausing to mark sentence stress within an utterance, reflected by the number of pauses, their position (before or after the stressed word), and duration.

## Methods

This investigation used sentence stress production data collected as part of a larger study investigating prosodic abilities in children with dysarthria and CP. The results of the participants' stress patterns, focusing on duration, intensity, and F0, were previously reported in Kuschmann and Lowit [18].

### Participants

Eight children and young people with dysarthria and CP and 8 age-, gender- and dialect-matched typically developing peers (TD) participated in the original study. For the pausing analyses, the data of 2 participants (CP5 and CP8) were excluded as they were either unable to complete the sentence stress production task (CP8), or did not consistently produce the target materials in a carrier sentence (CP5). This did not allow comparisons with the utterances produced by the other participants. All TD participants' productions were eligible for inclusion. Despite the resulting difference in group size, we report here on the data of all TD children to have a more representative control sample (Table 1; CP group: 4 boys and 2 girls, age range 7–18 years [mean 11.8 years]; TD group: 6 boys and 2 girls, age range 7–20 years, [mean 11.8 years]).

For all participants, hearing and vision were normal or adjusted-to-normal, and their cognitive skills were appropriate to follow instructions. The TD children had no history of communication disorders and no known developmental disorders. Three children with CP had been diagnosed with dyskinetic CP, 2 with spastic-type CP, and 1 with ataxic CP. All had been diagnosed with dysarthria by speech and language therapists and received speech and language therapy in the past. Speech intelligibility was measured using the Children's Speech Intelligibility Measure (CSIM) [40], indicating a mild to moderate range of dysarthria severity (Table 1).

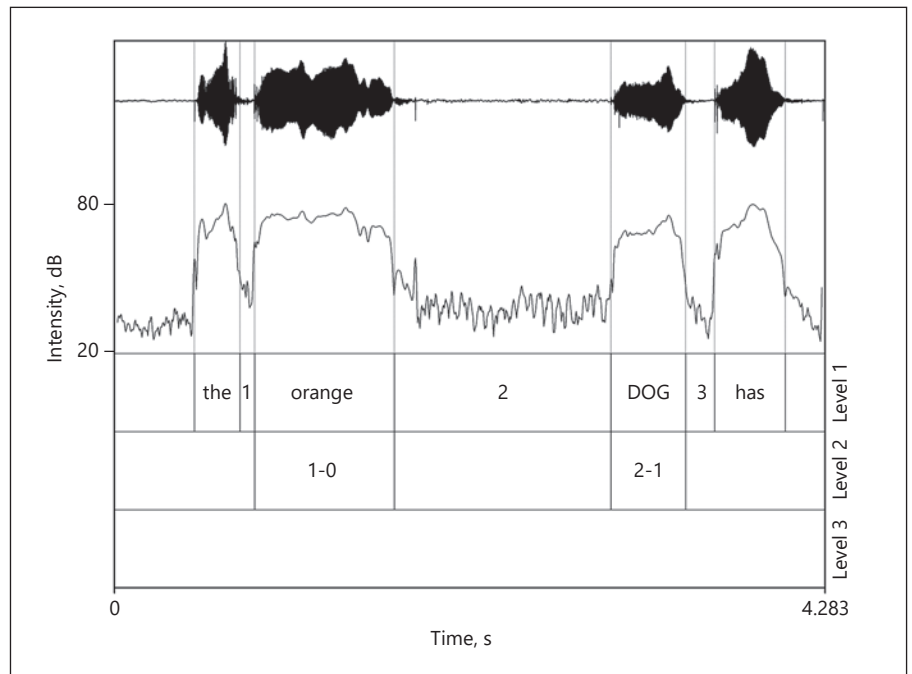
### Materials

To investigate the children's ability to mark sentence stress, a task containing short nominal phrases (NPs) was designed [18]. A set of 2 bisyllabic, prenominal adjectives (color: yellow or orange) and 5 monosyllabic nouns (animals: cow, dog, goat, goose, and horse) were combined to produce 10 NPs, e.g., "yellow dog." The use of short target structures aimed to reduce the impact of respiratory control issues in the children with dysarthria. Stress was elicited on the adjective, e.g., YELLOW dog, and the noun, e.g., yellow DOG, resulting in 20 phrases per participant and 280 phrases across both groups. This set formed the basis for the subsequent pausing analyses.

### Procedures

A picture-based question-answer paradigm, presented in Microsoft Office PowerPoint<sup>®</sup>, was employed to elicit the 2 different stress conditions. Participants were first shown pictures that prompted stress on the adjective (word 1), followed by pictures that required stress on the noun (word 2). When describing the

**Fig. 1.** The target structure “the orange dog,” produced by participant CP6, with the stress on the noun (indicated by capital letters), illustrates the different annotation levels: (1) orthographic annotation including pause position, (2) position of the stressed word, (3) comments. The intensity contour and its range are also shown. The oscillogram (sound wave) was added for illustrative purposes.



pictures, the participants were asked to embed the phrases in a carrier sentence, e.g., “The *yellow cow* jumped out.”

Each participant was tested individually in a quiet room at home, with the first author explaining and guiding the children through the test. Audio recordings were made using a portable Edirol R-09HR MP3 recorder with a 44.1-kHz sampling rate and 16-bit accuracy. Recording settings, instructions, and experimental design were the same for each participant to ensure consistency across recordings. The presentation started with an introduction to the task and practice stimuli, before proceeding to the actual experiment. Participants worked through the presentation at their own pace with pictures being shown one at a time.

#### Data Selection

The elicited phrases were prepared for pausing data analysis using Praat speech analysis software v5.3.39 [41]. Data selection followed the strict process outlined by Romøren and Chen [15] on typically developing speech, to ensure a controlled experimental environment with comparisons being made across the same phrasal structures. Following this procedure, participants’ responses were excluded if answers contained nontarget words, e.g., “duck” instead of “goose,” or additional words, if nouns were replaced by pronouns, e.g., the yellow “one,” as well as in instances of hesitations, self-repair, or stuttering. Additionally, due to the nature of the children’s speech difficulties in this study, productions were not included if phonetic deviations were present in the target structures. Based on these exclusion criteria, the final data set available for the analyses of pauses consisted of 221 phrases. Average response inclusion rate was 84% (range 45–100%) for the TD children and 72% (range 50–100%) for the children with CP.

#### Data Annotation and Analysis

The selected data were segmented into words based on waveform and formant changes in the spectrogram [42]. Segmentation

conventions were established to ensure consistency, e.g., onset positives were segmented directly before the burst. Data was annotated on 3 different tiers (Fig. 1):

1. orthographic annotation of the utterance including pause position (1 = a pause between determiner and adjective, 2 = a pause between adjective and noun, and 3 = a pause between noun and verb auxiliary);
2. annotation of the position of the stressed word (e.g., 1-0, with the first number denoting word position, i.e., word 1 or 2 of NP) and the second number denoting stress (0 = unstressed and 1 = stressed);
3. comments, if required.

Following Romøren and Chen [15], a pause was defined as a between-word interval of any duration with either no or insignificant amplitude, i.e., pauses were annotated using a strictly phonetic approach, combining Praat’s automatic silence detection function (silence threshold 35 dB and silence duration 20 ms) with a manual visual inspection. A Praat script was then employed to automatically extract pause duration from each labeled silence interval. Output data were inspected and cross-checked to detect any potential tracking and measuring errors of the software.

Based on the above annotation, the number and duration of pauses were determined and statistically analyzed in relation to their position (P1, after determiner; P2, after adjective; P3, after noun) and stress condition (C1, adjective stressed; C2, noun stressed). Statistical analyses included group comparisons for both measures, i.e., the number and duration of pauses in TD children and children with CP using the Mann-Whitney U test as well as within-group comparisons using the Wilcoxon signed-ranks test.

As per Table 1, there is a bimodal distribution of age in our data: younger participants (aged 6–8 years) and older participants (aged 14–20 years). Splitting the data into these 2 groups, however, would result in numbers too low for the purpose of meaningful statistical analysis and data interpretation, in particular for the

children with CP. The data were therefore collapsed into 1 group, with all results being cross-checked for age effects when interpreting the results.

## Results

### *Number and Position of Pauses*

Table 2 provides an overview of the individual results regarding the mean number of pauses per utterance across all 3 pause positions investigated; this was 1.35 for the TD children and 1.80 for the children with CP. The difference was not significant ( $U = 14.500$ ;  $p = 0.220$ ). As can be seen, half of the CP group fell within the range of the TD children, with a further 3 children showing values above this range.

The distribution of the observed pauses for each group and pause position is displayed in Table 3. Initial group comparisons showed no significant differences between groups regarding pause placement (P1:  $U = 68.000$ ,  $p = 0.188$ ; P2:  $U = 92.000$ ,  $p = 0.852$ ; P3:  $U = 68.000$ ,  $p = 0.193$ ), suggesting that the 2 groups paused similarly often in the 3 positions investigated. Subsequent within-group analysis, however, found that, across all productions, each group placed significantly fewer pauses at position 1, i.e., between the determiner and the adjective, than at positions 2 and 3 further on in the utterance (TD: P1 vs. P2:  $Z = -3.519$ ,  $p = 0.000$ , P1 vs. P3:  $Z = -3.297$ ,  $p = 0.001$ , P2 vs. P3:  $Z = -0.070$ ,  $p = 0.944$ ; CP: P1 vs. P2:  $Z = -2.944$ ,  $p = 0.003$ , P1 vs. P3:  $Z = -2.601$ ,  $p = 0.009$ , P2 vs. P3:  $Z = -1.071$ ,  $p = 0.284$ ). Further within-group analysis comparing the number of pauses in each position across stress conditions (C1 and C2) revealed no significant effects in either group (TD: P1:  $Z = -1.782$ ,  $p = 0.075$ ; P2:  $Z = -0.943$ ,  $p = 0.345$ ; P3:  $Z = -1.352$ ,  $p = 0.176$ ; CP: P1:  $Z = -0.135$ ,  $p = 0.893$ ; P2:  $Z = -1.826$ ,  $p = 0.068$ ; P3:  $Z = -1.461$ ,  $p = 0.144$ ).

Combined, these results suggest that the children did not use pause placement to mark the position of the stressed word in the utterance. Inspection of the individual data suggests that this was also the case for the 3 children with CP who produced a higher number of pauses than the TD group.

### *Duration of Pauses*

Table 4 displays individual results on pause duration across all 3 pause positions, showing that all children with CP (except CP7) had mean pause durations above the range of the TD children. Statistical test results for the group comparisons for each pause position confirmed

**Table 2.** Mean number of pauses per utterance across all 3 pause positions for each participant

Patient	Mean number of pauses (SD)
TD1	0.94 (0.90)
TD2	0.67 (0.94)
TD3	1.50 (0.50)
TD4	1.95 (0.38)
TD5	1.80 (0.83)
TD6	1.65 (0.91)
TD7	0.85 (0.79)
TD8	1.47 (0.88)
CP1	1.47 (0.81)
CP2	2.20 (0.98)
CP3	1.29 (0.75)
CP4	2.09 (0.51)
–	–
CP6	2.38 (0.74)
CP7	1.30 (0.78)
–	–

this observation (P1:  $U = 134.000$ ,  $p = 0.019$ ; P2:  $U = 1261.500$ ,  $p = 0.000$ ; P3:  $U = 1117.000$ ,  $p = 0.000$ ; Fig. 2).

Subsequent within-group analysis established that stress condition was not a factor that influenced pause duration in the different positions for either group (TD: P1:  $Z = -0.415$ ,  $p = 0.678$ ; P2:  $Z = -0.911$ ,  $p = 0.362$ ; P3:  $Z = -0.370$ ,  $p = 0.712$ ; CP: P1:  $Z = -0.153$ ,  $p = 0.878$ ; P2:  $Z = -0.249$ ,  $p = 0.804$ ; P3:  $Z = -1.143$ ,  $p = 0.253$ ). Separate within-group analysis to detect potential differences between pause positions showed that, for the TD group, P3 pauses were significantly longer than P2 pauses; however, the remaining comparisons were not significant (TD: P1 vs. P2:  $Z = -1.381$ ,  $p = 0.167$ , P1 vs. P3:  $Z = -1.045$ ,  $p = 0.296$ , P2 vs. P3:  $Z = -4.652$ ,  $p = 0.000$ ). A similar, albeit smaller effect was observed for the children with CP, with only a trend for P3 pauses to be longer than those in P2 (CP: P1 vs. P2:  $Z = -0.456$ ,  $p = 0.648$ , P1 vs. P3:  $Z = -1.186$ ,  $p = 0.236$ , P2 vs. P3:  $Z = -1.864$ ,  $p = 0.062$ ). These findings suggest that neither the TD children nor the children with CP manipulated pause duration to signal the position of the stressed word within the phrase.

## Discussion

This study investigated whether children with dysarthria due to CP as well as TD children used pauses to signal the position of stressed words in short utterances. Findings revealed that neither group used pause place-

**Table 3.** Percentage of pauses observed in the data for each group and position

	Determiner	Pause position 1	Adjective	Pause position 2	Noun	Pause position 3
TD						
C1	The	5%	YELLOW	22%	Cow	24%
C2	The	6%	Yellow	22%	COW	21%
Total		11%		44%		45%
CP						
C1	The	8%	YELLOW	21%	Cow	21%
C2	The	9%	Yellow	24%	COW	18%
Total		17%		43%		39%

CP, cerebral palsy; TD, typically developing; C1, first target in phrase stressed, i.e., colour; C2, second target in phrase stressed, i.e., animal. The stressed target words are in capitals.

**Table 4.** Duration of pauses across all 3 pause positions for each participant

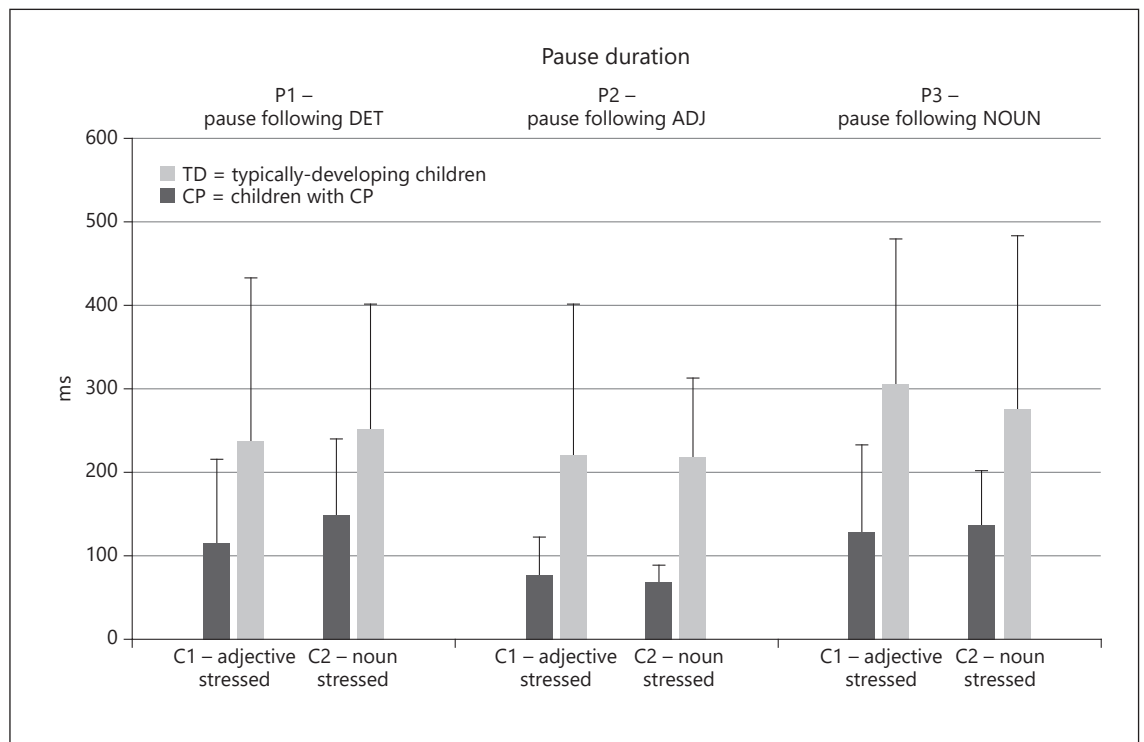
	Mean pause duration, ms (SD)
TD1	107.38 (51.39)
TD2	43.86 (28.08)
TD3	117.46 (62.98)
TD4	164.07 (87.23)
TD5	52.84 (11.93)
TD6	95.33 (43.85)
TD7	45.09 (5.21)
TD8	186.02 (105.06)
CP1	250.67 (141.06)
CP2	210.65 (99.01)
CP3	206.46 (120.30)
CP4	302.32 (68.09)
-	-
CP6	393.69 (224.50)
CP7	119.50 (48.40)
-	-

ment or duration to mark the stressed word within the utterance. Consequently, it can be concluded that the children in this study did not deploy pausing to mark the position of the stressed word within an utterance.

#### *Number of Pauses and Pause Placement*

The available research into pause placement for discourse-structuring purposes has shown that children insert pauses before new information [15, 16] comparable to adult speakers [12–14]. Similar pausing behaviors were observed in adults with motor speech disorders [22, 28], suggesting that the use of pauses can be a discourse marker for new information in disordered speech. However, in

our study, a general positional effect was evident, with more pauses towards the end of the phrase rather than before new information. This finding indicates that, in our group of children, pauses were not used as a main marker for new information. It is important to note though that both groups of participants paused frequently. This is in line with Romøren and Chen's [15] finding of a high frequency of pauses in TD children's speech and suggests that the frequent pausing in our sample was not a unique feature of dysarthric speech. However, despite the lack of a significant difference between the 2 groups in the number of pauses used, we observed that half of the children with CP fell within the range of the TD children, but the other half showed values above this range. This suggests a potential influence of dysarthria on pausing for these speakers. An inspection of the children's dysarthria severity level as well as age and type of CP did not reveal a specific pattern that could explain the greater use of pauses in these children. For instance, CP1's number of pauses fell within and CP2's above the range of the TD children, whilst both were diagnosed with mild dysarthria. At the same time, CP3, whose speech was moderately affected, had fewer pauses than both CP1 and CP2. The type of CP did not explain the observed performance either. Of the 3 children with CP, whose number of pauses was above the range of the TD children, one had ataxic CP, one had spastic CP, and one had dyskinetic CP. Age did not seem to be a relevant factor either, to account for the differences, with both younger (CP2 and CP6) and older children (CP4) producing more pauses. We therefore assume that factors beyond age, type of CP, and dysarthria severity, e.g., linguistic and prosodic constraints, may help to explain some of our observations on pause placement.



**Fig. 2.** Mean duration of pauses in milliseconds for each group (TD, typically developing children; CP, children with cerebral palsy) with regard to position (P1, P2, and P3, i.e., the pause following the determiner [DET], adjective [ADJ], and noun [NOUN], respectively) and stress condition (C1, adjective stressed; C2, noun stressed).

Research into the role of syntactic structure on pausing in adult speech found that pauses frequently occur at major syntactic boundaries [e.g., 43, 44]. For child speech, however, Redford [17] observed more pauses in syntactically unexpected locations than in adult speech. This observation aligns with our findings of some pauses being placed after the utterance-initial determiner or between the adjective and noun. Redford [17] argues that these unexpected pauses may indicate that children have yet to fully acquire knowledge about when to pause and how to coordinate speech breathing with linguistic content. This assumption might explain why we observed pauses across all 3 positions investigated.

This stated, we also found a position effect across both groups, with more pauses being placed towards the end of the NP (P2 and P3) than for P1. This finding could suggest that neither group paused randomly, adhering to prosodic constraints expected in typical adult speech [e.g., 45, 46]. For example, pausing directly after a determiner in utterance-initial position is undesirable from a prosodic point of view as function words are less likely to attract pitch accents than content words, unless they are stressed [e.g., 47–49]. A determiner, if followed by a pause

that signals an intonation phrase boundary, will therefore have to be assigned a pitch accent, which may alter the pragmatic meaning of the utterance and result in unusual or unexpected stress patterns. From this point of view, our results could suggest that both groups in our study successfully adhered to the rules of intonational well-formedness by placing fewer pauses in P1. This conclusion contradicts the assumption made by Redford [17] that children have yet to fully acquire knowledge on when to pause, but it must also be noted that our study had older participants. In summary, neither participant group appeared to use pauses strategically to mark sentence stress, but both showed signs of adherence to prosodic well-formedness rules by predominantly placing them towards the end of the utterance.

#### *Duration of Pauses*

Similar to pause placement, studies on pause duration in adult speech show that speakers increase pause duration before introducing new information in spoken discourse [12–14]. Research into child speech in this area is limited, but the available evidence suggests that children show adult-like pausing behavior by pausing longer be-

fore words that introduce new information [15–17]. Once again, this pattern could not be observed in our data, suggesting that our participants did not use pause duration to signal new information in their discourse.

We did observe, though, that children with CP paused for longer in each position than the TD children. Pause duration and articulation rate form the basis for the measure of speech rate, which is frequently reported to be reduced in children with CP [e.g., 36, 39, 50]. As already reported [18], this group of CP children produced longer speech segments during the sentence stress task than the TD children, indicative of a reduced articulation rate. However, there was no clear relationship between the children's word duration and pause length, and similar to our finding for number of pauses, dysarthria severity and type of CP did not appear to be determining factors for pause duration either. Specifically, CP2 who had a mild level of speech impairment produced longer pauses than CP3, who had the lowest intelligibility score of the group. Type of CP did not reveal any particular impact on pause duration either, as 2 participants with dyskinetic CP (CP6 and CP7) had the longest and the shortest pause times, respectively (Table 4). Age did not appear to be a determining factor either. Whilst CP6, one of the younger speakers, produced the longest pause times, CP2, another young participant, produced pauses that were comparable in length to CP3, who was part of the older age group. It thus appears that pause duration, similar to pause placement, was determined by factors other than those captured by the current evaluation tools. However, it is important to point out that participant numbers in each group may have been too small to detect potential patterns, and analyses of larger cohorts will be beneficial to establish to what extent our findings are reflective of the wider CP population.

Although we observed group differences in our data in terms of overall duration of pauses, analysis of the effect of stress condition on pause duration did not yield any significant results. As outlined above, regarding the TD children, this result does not support previous findings of a strong link between pause duration and the position of the stressed target word within an utterance, as reported by Romøren and Chen [15]. Our data showed a general positional effect for both groups that appeared to be unrelated to the stress condition. Specifically, both groups had significantly longer pauses following the noun (P3) compared to the adjective position (P2). This appears intuitive as pauses following the noun would be at the end of the NP, and hence in a position that could be considered a major prosodic and syntactic boundary. One could

further argue for the presence of a cognitive boundary after the noun, as this was the end of the target NP where the children had to pay attention to their output, as the remainder of the utterance consisted of the carrier phrase that was constant across all utterances.

Although our data do not support previous observations of a link between pause duration and stress position [15], the absence of a consistent link between pausing and sentence stress in our data does not necessarily imply that pausing is not available to the children as an additional parameter to mark stress. It is possible that pausing may not have been deployed by our groups for various reasons including differences in sentence material, age, and the language investigated. For instance, Romøren and Chen [15] investigated Dutch-speaking children, using a larger variety of sentence materials to elicit stress in different utterance positions. Also, the phrases produced by the children in our study were shorter and syntactically and prosodically less complex to accommodate the potential motoric restrictions in the children with CP. The differences in syntactic and prosodic complexity might have had an impact on the potential relevance of pausing as a cue to stress. In addition, Romøren and Chen's [15] participants were 5 years old, and thus younger than the children in our study who were at least 7 years of age. Romøren and Chen [15] argued that the children's more robust and consistent use of pausing to mark stress, compared to adults, might be partly due to the fact that their access to pitch accent cues for the purpose of marking stress is still developing. This might not be the case for the older children in our study, who may have already exhibited adult-like patterns to marking stress. Support for this assumption comes from their use of acoustic parameters to mark stress [18], which showed that the TD children used a combination of duration, intensity, and F0 to mark sentence stress, just as adults would; our perceptual data indicate that this strategy was successful in the majority of utterances. As a result, pausing may not have been required as another parameter to mark stress. However, whilst this might be plausible for the TD children, it is currently unclear why the children with CP did not exploit these cues to the same extent, as they experienced problems using intensity and F0 to signal stress, with only duration being used in a way that was comparable to the TD group [18].

Further research is clearly needed to better understand the potential role of pausing as a meaningful marker of sentence stress in TD children as well as in children with CP and dysarthria. As part of this, it should be explored in perception studies whether listeners can use pausing as



a cue to stress-marking, and thus whether this could be a helpful strategy for some children to communicate pragmatic intent.

### Limitations

Whilst our study has revealed important insights into pausing behaviors in children with dysarthria and CP and their TD peers, limitations exist. We reported the results of a small number of children with typical and atypical speech and, as a result, generalizations based on our findings are not possible. Small sample sizes are an inherent issue when working with children with dysarthria, often in combination with heterogeneous speaker characteristics, in terms of age, CP type, and dysarthria severity. Ideally, further research with larger sample sizes and comparable individual speech characteristics is required to get a fuller understanding of potential systematic patterns. Additionally, our data were originally designed to investigate the use of duration, intensity, and F0 in the production of sentence stress in children with CP and dysarthria. Whilst the data were effective for investigating pausing as an additional potential stress marker, they were not specifically designed with syntactic complexity in mind. This needs to be considered when putting current findings in context.

### Clinical Implications and Conclusions

This study on pausing patterns in children with dysarthria CP and their TD peers has shown that neither group signaled the position of stressed words in short utterances by pause placement or duration. Our findings therefore do not suggest that pausing was strategically deployed as an additional cue to marking sentence stress by our cohort. However, given the limitations of this study, a larger study using more targeted speech material might be able to throw further light on this issue. Additionally, structured experiments that require speakers to place pauses at specified locations, combined with listener eval-

uations, could help to demonstrate whether pausing could be deployed as an overt strategy to mark stress more successfully. This could aid the listener to locate highlighted information, in line with the finding of Dahan and Bernard [12] and might also help the speaker to modulate the primary stress markers more effectively.

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### Statement of Ethics

The research reported here complies with the guidelines for human studies. Ethics approval to conduct the study was obtained from the Strathclyde University's Ethics Committee. Written informed consent was gained either from the children or their parents, depending on their age.

### Disclosure Statement

The authors have no conflicts of interest to declare.

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### Author Contributions

A.K. was responsible for the design of the research project as well as data collection, annotation, analysis, and writing up the findings. A.L. made important contributions to the interpretation and discussion of the findings, as well as the write-up of the study. Both authors read and approved the final version.

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