Acoustic Characterization of Dysarthria in Children with Cerebral Palsy: Exploring Age-Related Effects

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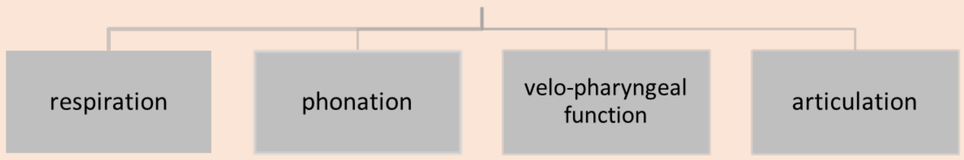
Introduction

- **Dysarthria** most frequent communication impairment in children with CP [1]
  - Neurologic speech disorder that reflects abnormalities in
    - Strength
    - Speed
    - Range
    - Accuracy of movement required for:



- Generally assumed that **at least one** – but often all - **speech subsystems** are affected
- **Speech characteristics** include shallow, irregular breathing, harsh and/or breathy voice, hypernasality, and imprecise articulation [2]

BUT: subjective perceptual evaluations of speech characteristics dominate in children with dysarthria

➢ Acoustic analyses to quantify speech characteristics in CP less prevalent, but interesting for **automated classification**, more **objective assessment**, and **monitoring of effectiveness speech therapy**

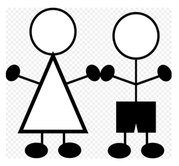
➢ Search for acoustic markers in CP speech is ongoing and gaining interest [3]

➢ Unclear to what extent acoustic quantification is influenced by the *developing* speech motor system

PURPOSE OF THE STUDY: To evaluate age-related effects in acoustic markers of dysarthria in children with CP

Cerebral Palsy (CP)
- Motor disorder caused by damage to the developing brain that affects movement, balance and posture
- Motor deficits often accompanied by difficulties with cognition and sensorimotor function
- Affects 2-3 children per 1000 live births

Methods: Participants



8 CP, 8 TD | 4 girls, 12 boys | 7 to 18 years

CP type (dysarthria severity):
3 spastic (1 mild, 1 moderate, 1 severe)
3 dyskinetic (2 mild, 1 moderate)
2 ataxic (1 moderate, 1 severe)

Methods: Materials

- Acoustic analyses conducted on:

50 single words (CSIM)	Monologue task (MONO)
20 short sentences (SENT)	Story retelling task (RETELL)

Methods: Measures

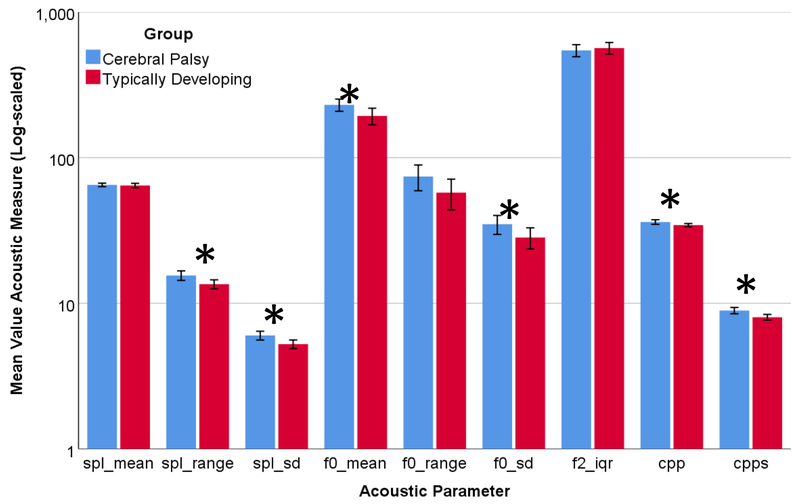
- Across all four speech tasks, suitable voiced fragments for acoustic analyses were quasi-automatically identified, labelled, extracted, and concatenated using Praat
- Acoustic measures were quasi-automatically obtained
- Measures reflect features of different speech subsystems
  - **Sound Pressure Level** (SPL: Mean, SD, 90th-10th percentile)
  - **Fundamental Frequency** (F0: Mean, SD, 90th-10th percentile)
  - **Second Formant Interquartile Range** (F2 IQR; 3rd quartile – 1st quartile)
  - **Cepstral Peak Prominence** (CPP) and **Smoothed Cepstral Peak Prominence** (CPPS)

Methods: Statistical Analyses

- Two-way ANOVAs performed to compare acoustic measures across
  Groups (CP, TD)
  Speech tasks (CSIM, SENT, RETELL, MONO)
- Subsequent Subgroup analyses for **Age**
  Younger: 7-8 years
  Older: 13-18 years

Results: Group comparisons across Tasks

Overview of group comparisons per acoustic measure, pooled over speech tasks (logarithmic scaled)



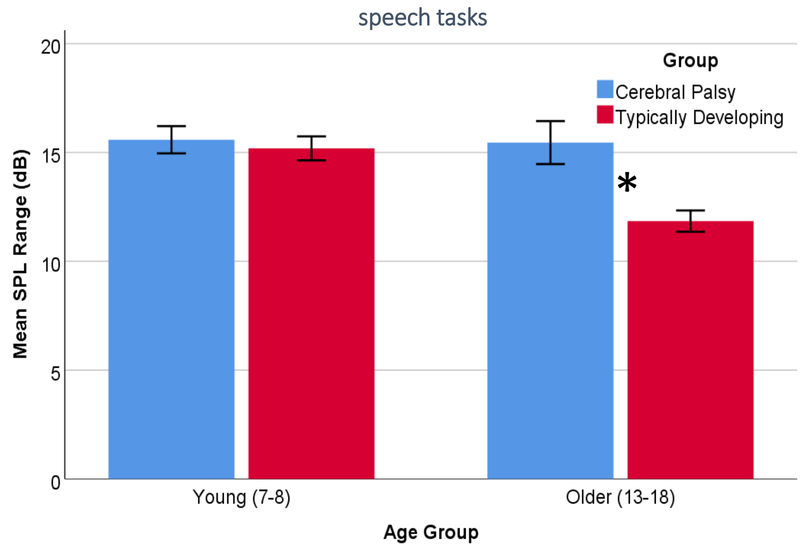
➢ A number of acoustic measures differentiated between CP and TD groups, but only when pooled across tasks

Results: Subgroup analyses for Age

- Focus on 3 measures associated with different speech subsystems: **SPL range, F0 SD, CPP**

① SPL range

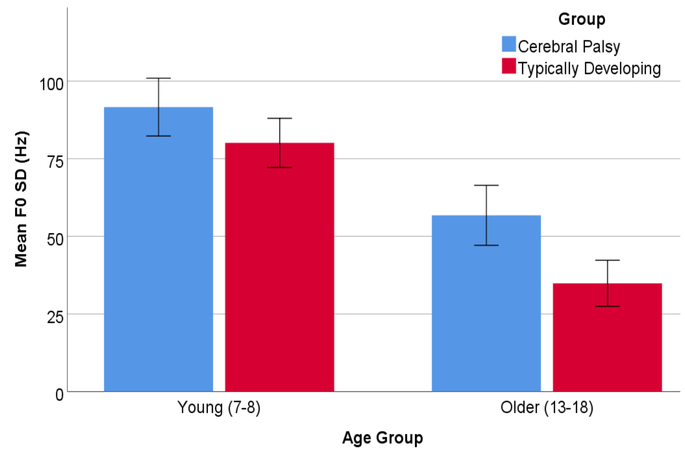
Group comparisons of SPL range with Age as factor, pooled over speech tasks



Notable results:
➢ SPL range larger in CP vs TD
➢ SPL range larger in Young vs Older
➢ Significant interaction effect: group differences for Older children but not Young children

② F0 SD

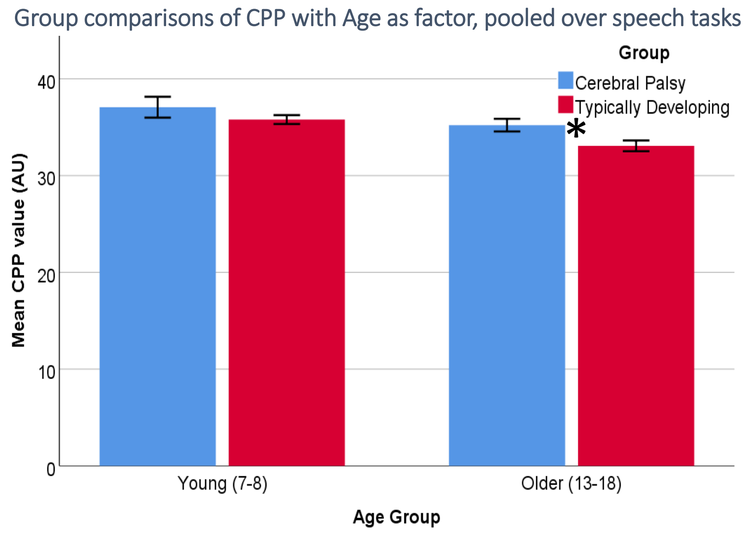
Group comparisons of F0 SD with Age as factor, pooled over speech tasks



Notable results:
➢ F0 SD larger in CP vs TD
➢ F0 SD larger in Young vs Older
➢ Non-significant interaction effect: no effect of age in differentiating children with CP and their TD peers

③ CPP

Group comparisons of CPP with Age as factor, pooled over speech tasks



Notable results:
➢ CPP larger in CP vs TD
➢ CPP larger in Young vs Older
➢ Non-significant interaction effect, however, significant group differences were found for the Older but not the Young children

Summary & Conclusion

A range of acoustic measures are suited to capture differences in speech features in children with CP and their TD peers, across different speech subsystems:

- Higher values for F0 and SPL measures in the speech of children with CP → reflects greater variation, most likely due to **reduced respiratory and phonatory** control
- CPP and CPPS also higher in this group, suggesting **voice** of the children with CP had a **hoarse quality** to it

Subgroup analyses:

- Age influences acoustic outcome measures, with younger children's speech consistently yielding higher values

→ Children's speech changes as system matures and indicates that, even though CP is a permanent condition, it is not a static one and **speech difficulties** and its manifestations are likely to **change over time**

→ <u>However</u>: some acoustic measures may be more suited than others to detect differences between groups in older children, i.e., **more sensitive predictors** of acoustic differences **once speech system has matured**

→ **Age is a factor to be considered when selecting acoustic markers to assess speech performance in children with CP**

References

[1] Parkes, J., Hill, N., Platt, M.J., Donnelly, C. 2010. Oromotor dysfunction and communication impairments in children with cerebral palsy: A register study. Dev Med Child Neurol. 52, 1113–1119.
[2] Nordberg, A., Miniscalco, C., Lohmander, A. 2014. Consonant production and overall speech characteristics in school-aged children with cerebral palsy and speech impairment. Int J Speech Lang Pathol. 16, 386-395.
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