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:
      - respiration
      - phonation
      - velopharyngeal function
      - articulation

- 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

**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)
  - 20 short sentences (SENT)
  - Monologue task (MONO)
  - Story retelling task (RETEL)

**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

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

**SPL range**

- 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

**Methods: Participants**

- 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

**Methods: Materials**

- 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

**Methods: Measures**

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

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
- However: 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