

## **An ultrasonographic and acoustic investigation of consonant cluster reduction in children with atypical phonological development**

**Background & Purpose** - Simple consonant clusters of the CCV type have a higher level of articulatory complexity than CV or VC syllables. As a result, CCV syllables are acquired later. Some children fail to acquire the CCV pattern at the expected age and reduce CCV to CV. However, previous acoustic studies have demonstrated that children with atypical phonological development use a strategy of compensatory lengthening of the vowel in the structures judged as CV (target CCV) in contrast with CV targets. The aim of the study was to characterize and compare the productions of CCV vs. CV syllabic patterns of children with typical and atypical phonological development. Articulatory Phonology predicts that simplifications of CCV to CV are associated with different degrees of overlap in the adjacent gestures and/or with the reduction of the magnitude of the gesture of C2. Therefore, we expected to find longer durations (based on acoustic measures) and different tongue shapes (based on ultrasound imaging) of the CV syllables produced for CCV targets in the children with atypical phonological development.

**Methods** – Ultrasound and audio data of ten monolingual speakers of Brazilian Portuguese (5-6 years), five with typical and five with atypical phonological development, were analyzed in this study. Speech material consisted of 20 Brazilian Portuguese words with CCV and CV syllables. The CCV clusters all contained a rhotic consonant in the C2 position. The participants repeated each word three times. The sound files and images of the contour of the tongue were analyzed. The audio files were evaluated by three experts using phonetic transcription. In the acoustic analysis, the relative duration measure of CCV and CV productions was used. The contour of the tongue was traced manually and the height of the tongue tip, blade and dorsum were measured. These values were transformed into ratios (tip by blade, tip by dorsum and blade by dorsum). The statistic tests were conducted with repeated-measures ANOVAs with Bonferroni post hoc tests ( $p < 0,05$ ).

**Results** - All productions of the atypical children were judged as cluster reductions to CV. The relative syllable duration differed between CV and CCV targets in both groups, with longer percentage durations for the CCV targets. There were no significant differences between the groups of children. The tongue tip by blade was different for the syllabic patterns for the typical children, with mean ratios of -2.61% for the CCV and -4.01% for the CV.

The tip by dorsum ratio differentiated both the syllabic patterns and groups of children. The typically developing children's productions showed mean ratios of 18.11% (CCV) and 16.54% (CV), whereas the productions of the children with atypical phonological development showed mean ratios of 34.56% (CCV) and 33.14% (CV). The blade by dorsum ratio differentiated between the groups of children. The typically developing children productions showed mean ratios of 19.37% and 19.41% (CCV and CV), which were smaller than those of the children with atypical phonological development with mean ratios of 31.64% and 30.53% (CCV and CV).

**Conclusions** - The acoustic and articulatory results confirmed that the children with atypical phonological development differentiated the production of CV and CCV targets, even though their CCV productions were perceived as cluster reductions. The articulatory results in the children with atypical phonological development suggest the presence of covert tongue tip elevation, indicating a partial production of the rhotic tap in the C2 position of the CCV targets.