

# Acquiring the acoustics and articulation of complex consonants in Estonian

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When children learn to speak, they need to acquire the fine motor control skills required to move the speech articulators, as well as adjust their articulations in response to their growing anatomy. As a result, consonants with multiple lingual articulations are typically acquired later in development, e.g., /dʒ/ and /ʃ/ [1], due to the acquisition of 'lingual differentiation', i.e. control over different parts of the tongue [2]. However, some accounts suggest that one set of lingually complex consonants, secondary palatalisation, is acquired among the earliest sounds produced [3], [4]. Anatomical reasons are cited for this: children's tongues are proportionally shorter than adults', and their larynx is higher, which brings the back of the tongue closer to the hard palate [5]. We investigate the balance between, on the one hand, the acquisition of fine motor control and lingual differentiation, and on the other hand, the constraints of child anatomy in speech production. We focus on the acquisition of phonemic palatalisation in child Estonian speech as a case study for lingually complex consonants with a secondary palatal articulation.

We address the following research questions: 1) Are there age-related differences in the acoustic realisation of secondary palatalisation? 2) Are there age-related differences in the extent of lingual differentiation? 3) Is there a relationship between tongue motor-control skills, lingual differentiation, and realisation of the acoustic targets?

Simultaneous acoustic and ultrasound data were collected in autumn 2025 and winter 2026 from a total of 73 participants. We recorded children from three age groups (3;2-4;6, 5;6-7;1, and 10-11 years old) in schools and pre-schools, as well as 20 adults (18-35 years old). The experiment included the production of 8 palatalised and non-palatalised minimal pairs, as well as motor control, storytelling, perception tasks, and a background questionnaire. Here, we analyse three measures. First, an assessment of tongue motor control skills: the number of repetitions in a shortened diadochokinetic (DDK) task where participants produced /pa/, /ta/, and /ka/ in a 5-second time window. Second, the acoustic quality of the vowels that precede palatalised and non-palatalised consonants. The magnitude of the change in the F2 values of the preceding vowel has been shown to be a reliable measure of the degree of palatalisation in Estonian [6]. 20 equidistant F2 measurement points of the vowels that preceded palatalised and non-palatalised consonants were extracted using a script that finds a unique formant ceiling with the least errors for each of the vowels. Third, we fitted splines to the ultrasound images and calculated the Modified Curvature Index (MCI) of the tongue contours using a script by [7] to assess the acquisition of lingual differentiation.

The analysis is ongoing. Our pilot results [8] indicate developmental differences in lingual differentiation, and we predict our ongoing analysis will also demonstrate developing motor-control skills. We predict that children are able to produce the acoustic targets for palatalisation due to an anatomical bias towards palatal sounds. However, the development of lingual differentiation and motor control skills mean that children have different articulatory realisations of the same acoustic targets. At the same time, the articulatory bias means that younger children take time to acquire acoustically non-palatalised consonants. Our results are discussed in the context of the trajectory of consonant acquisition across languages and the development of child speech motor control.

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