Development of coarticulation in German children: Acoustic and articulatory locus equations

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The present study investigates the development of coarticulation in German children between 3 and 7 years of age. To quantify coarticulation degree, we will not only apply the commonly used method of Locus Equations (LE) on the acoustic signal, but also on the articulation recorded with ultrasound, which so far has been rarely done in children (Noiray et al., 2013). This allows us to directly track dynamic movements instead of inferring (co)articulation from the acoustic signal.

Coarticulation can be viewed as connecting single speech sounds by varying degrees of articulatory overlap. While some aspects of coarticulation are claimed to be universal, resulting from anatomic properties (e.g., overlap of labial consonants and lingual vowels), others are not that predictable and may be language-specific (e.g., vowel-to-vowel coarticulation). The way children acquire the coarticulatory patterns of their native language has been discussed intensively (i.e., holistic versus segmental theory). The present study extends previous work by investigating coarticulation with a broader set of phonemes, multiple age groups, and in both acoustics and articulation.

Five cohorts of monolingual German children (3 to 7 years of age) as well as an adult control group are tested. Stimuli are elicited in a repetition task embedded in a child friendly setting. The prerecorded acoustic stimuli consist of disyllabic pseudo words following the pattern $C_1V_1C_2V_2$, preceded by the carrier word "eine" (/a͡ɪnə/). Within the stressed first syllable (C_1V_1), C_1 is /b/, /d/, /g/, or /z/ and V_1 one of the tense, long vowels /i/, /y/, /u/, /a/, /e/, and /o/. The second CV syllable consisting of the same consonant set as C_1 plus the neutral vowel /ə/ is added to the syllable of interest such that C_2 is never equal to C_1, resulting in three different contexts per C_1V_1. In total, there are 72 different pseudo words. Besides the CV coarticulation within the pseudo word, the carrier phrase enables the investigation of V-to-V anticipatory coarticulation from V_1 on the preceding schwa. At Ultrafest VII we will present the first results for CV coarticulation in the cohort of 5 year-olds and adults.

During the recordings, children are comfortably seated in an adjustable car seat. They are recorded with a portable ultrasound system (Sonosite Edge, sr: 48Hz) with a small probe fixed on a custom-made probe holder. The probe holder was designed to allow for natural vertical motion of the jaw but prevent motion in the lateral and horizontal translations. It is positioned straight below the participant's chin to record the tongue on the midsagittal plane. Ultrasound video data are collected with synchronized audio speech signal (microphone Sennheiser, sr: 48 KHz) on a computer. In addition to tongue motion, a video camera (Sony, sr: 50Hz) records the participant's face to track the labial articulation as well as head and probe motion enabling us to correct the data from a jaw-based to a head-based coordinate system.

As for the analysis, target words in the acoustic speech signal as well as relevant tongue data are extracted using custom-made Praat and Matlab programs. Acoustic LE measures of the CV coarticulation will be based on the F2 transitions between the very onset of V_1 and its midpoint, while the articulatory analysis will focus on the highest tongue point's motion between C_1 and V_1. As the ultrasound allows us to track motion earlier than is visible in the acoustic signal, we will not only use the onset of the vowel but move further into the consonant to find early cues of the vowel's influence on the tongue shape.