

Development of coarticulation in German children: Mutual Information as a measure of coarticulation and invariance

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The study aims to investigate the development of coarticulation in 3- to 7-year old German children. At Ultrafest, we present the results for 5-year-olds and adults. We try to characterize the maturation of speech motor system by looking into the way different aspects of consonant production vary on quantitative coarticulation/invariance scale as a function of age. Mutual Information (MI), a method that has been used to measure coarticulation degree by quantifying independence between two variables in adults (Iskarous et al., 2013) is adapted to the developmental field. For coarticulation, it measures the amount of information about segment B that is present during the production of segment A. MI between contiguous segments is large under coarticulation and small if the segments are relatively independent. For each consonant, we can determine the degree of independence for each of its articulators (e.g. various points on the tongue, lips, jaw). Thus, the MI method allows us to generalize the results obtained with other methods that rely heavily on tongue motion (e.g. LE) to more articulators.

Four cohorts of monolingual German children (3 to 7 years of age) as well as an adult control group are tested at LOLA Lab (Germany). Stimuli are elicited in a repetition task embedded in a child friendly setting. The prerecorded acoustic stimuli consist of disyllabic $C_1V_1C_2V_2$ pseudo words preceded by the carrier word "eine" ($/\underline{a}ɪnə/$). Within the stressed first syllable (C_1V_1), C_1 is /b/, /d/, /g/, or /z/ and V_1 one of the tense 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.

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.

Up to now, MI metrics has been only used to quantify articulatory data from EMA corpora. In this study, we will extend the MI metrics to a different form of articulatory data quantification, i.e. ultrasound. We will also extend the set of German consonants described with respect to their position on the coarticulation/invariance scale. Last but not least, the method allows us to quantify the changes in the position of certain consonants on coarticulation/invariance as a function of age. MI analysis is less dependent on data distribution which can be of crucial importance for children data considering the difficulties of child data collection.