Are developmental differences in vocalic lingual anticipation perceivable? Insights from German child and adult listeners.

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To understand spoken language development, it is crucial to elucidate the relationship between speech production and perception. The present study examines coarticulation, which regards the overlap of articulatory gestures between segments and is an important characteristic of fluent speech. In our previous studies [1, 2] we found developmental differences in coarticulatory patterns between children in kindergarten, primary school and adults. Here, we are specifically interested in whether and how these differences are transferred to the perceptual domain.

In previous production studies using articulatory data from the tongue we found that vocalic influences on the spatial and temporal organization of the lingual gesture for preceding segments (anticipatory coarticulation) depended both on age and consonantal contexts [1, 2]. Children initiated the lingual configuration for the gesture of the upcoming target vowel earlier and to a higher degree than adults within and across syllables. In addition, the degree of vocalic influence was mediated by the gestural compatibility between consonants and subsequent target vowels. Consecutive segments that recruited different organs for their production (e.g., lips and tongue in /bV/) permitted greater vocalic influence as compared to segments for which the same organ was recruited (e.g., tongue tip and tongue dorsum in /dV/). Still, children globally showed greater anticipatory coarticulation than adults.

To our knowledge no study so far has tested children's perception of anticipatory lingual coarticulation in child speech [but see e.g., 3 using synthetic or adult speech]. As regards adult listeners, it is still unclear how differences in coarticulation degree related to age and consonantal context affects their perceptual processing [4, 5, 6]. The present study addresses those limitations by examining adults' as well as children's perception of vocalic anticipatory coarticulation. First, we expected adults and children to identify upcoming vowel targets earlier in child's speech as compared to adult's speech because of the earlier gestural onsets and greater degree of anticipation in child speech, which may make vocalic information perceptually more salient to listeners. Second, perceptual responses should reflect the gestural compatibility between consecutive segments, resulting into different degrees of perceptual salience of coarticulatory information. Here, we expected vowel identification to benefit from consonantal contexts allowing greater coarticulation with vowels (e.g., /b/) in both adults and child speech than consonants allowing minimal vocalic influences (e.g. /d/). However, because children globally show greater vocalic coarticulation than adults, we predicted consonantal effects on vowel identification to be reduced with the child speech stimuli.

To test these hypotheses, we investigated the ability of 94 German adults and 26 7-year old children to identify a target vowel (V = /i:, y:, u:, a:/) ahead of its acoustic onset in short utterances of the form article + nonword (ainə + C**V** with C= /b, d/; schwa, noted @ from here). We designed a multiple forced choice gating paradigm [7] using the speech of 3-, and 7-year old German children and adults with 4 temporal gates corresponding to the temporal windows (@ offset; C midpoint; C offset; V midpoint) for which we had previously calculated coarticulation degrees [1, 2]. Tests were conducted with OpenSesame for children and additionally with SoSci for adults. Accuracy measurements were calculated for each gate by listeners' age, speakers' age and consonantal context. Generalized additive mixed modelling (GAM, Fig. 1) revealed that child listeners were in general less accurate in vowel identification than adult listeners. Adult listeners were more accurate with adult speech than when listening to the speech of 7-year-olds. This pattern was also partly present in child listeners albeit vastly reduced in temporal extent and magnitude. For most gates speaker's age effects were even absent. Last, both listener groups could identify the vowel better in /d/ than in /b/ contexts.

Our findings suggest that coarticulation in production provides information that are accessible and used in both adult's and children's perceptual processing. The overall difference in accuracy scores between child and adult listeners are in line with previous studies in which child listeners were less successful in using coarticulatory information than adults in adult speech [8, 9]. We extended this finding to child speech. It has been suggested that those differences arise due to immature auditory skills [9] or less consistent and slower perceptual processing in children than in adults [8]. Contrary to our expectation, the results indicate that child speech didn't facilitate vowel identification. The patterns of responses in adult listeners mirrored those found by Sereno et al. (1987). They proposed that imprecision and variability in child speech may prevent adult listeners to reliably use coarticulatory information in their processing making vocalic information in adult speech more accessible. In our study, children didn't show a remarkable difference between speaker groups which also suggests that their ability to extract vocalic information may be in general more narrowed than in adults. We also could not replicate the finding that consonants allowing for more coarticulation may facilitate vowel identification [6]. Since /b/ also allows for more variability in the vocalic transition it may be less informative for adults than in /d/ contexts. Again, in children this effect is reduced as they might only be able to parse a restricted amount of information.

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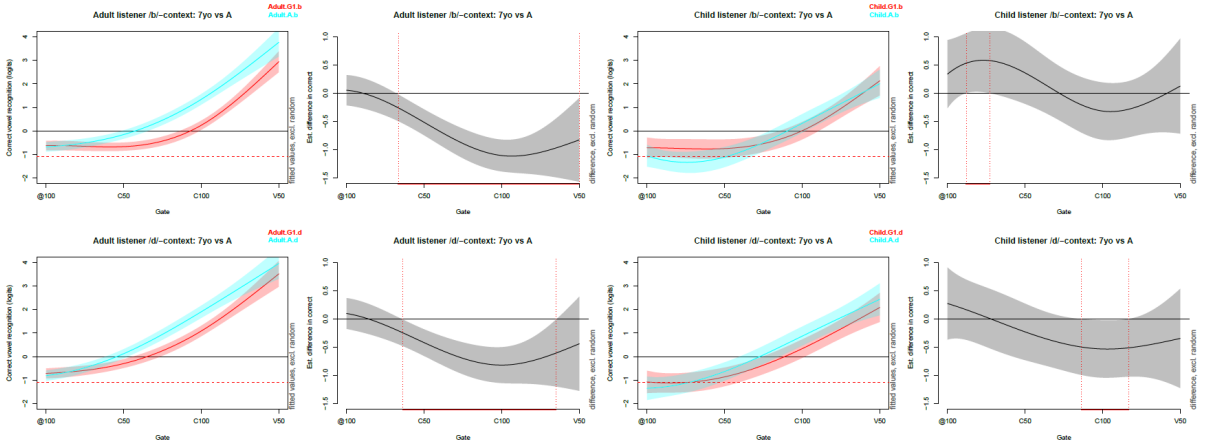

Fig. 1: First and third column: Logits for each gate and time point for 7-year-olds (red) and adults (blue) within listener group in /b/ and /d/ contexts. Red dashed line indicates chance level (p = 0.25, L= −1.099). Second and fourth column: Differences in logits between the speaker groups within listener group in /b/ (upper row) and /d/ (lower row) contexts. Red line on the x-axis indicates time points where differences are significant.