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Supplementary Materials for

Phonological acquisition depends on the timing of speech sounds: Deconvolution EEG modeling across the first five years

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Supplementary text

Previous research has indicated that higher-order linguistic processing can affect phonological processing in infants' already (49), which means that the increases in linguistic knowledge in older children may have impacted the trajectory feature acquisition described in this manuscript. To control for the increase of higher linguistic knowledge as children age, we have included a predictor for semantic and syntactic processing to our feature-based TRF models. For this, we have employed the surprisal metric based on information theory (73). Surprisal has been successfully used to quantify semantic and syntactic processing costs on a word-by-word basis and has been successfully used to capture semantic and syntactic processing from EEG recordings of naturalistic speech in recent years (e.g., 74,75). In line with recent studies, we have computed lexical-semantic information for each word using word form surprisal from GPT-2. Given the big disagreement about the appropriate computational modeling of syntactic structure in the literature, syntactic information was quantified as part-of-speech surprisal, calculated from a Universal Dependencies parse. In addition, we employed word frequency as a proxy for age of acquisition (76) Inclusion of word frequency, semantic and syntactic surprisal into the TRF models did only change the results for phonological feature acquisition quantitatively, but did not affect the main outcomes and conclusions qualitatively.

However, this finding does not exclude the possibility of an interaction between higher order linguistic processing and phonological feature processing. As a next step, we have therefore assessed how the feature-based prediction accuracy in the native language is moderated by either word frequency, word expectancy, or part-of-speech expectancy. We performed a median split on word frequency, GPT-2 surprisal, and part-of-speech surprisal respectively, of all content words. Given the generally high frequency of function words and the higher impact of word frequency on content words, which already arises in infancy (77), we have limited this analysis to content words. We performed a median split of frequency, GPT-2 surprisal, and part-of-speech surprisal and computed the prediction accuracy separately for high and low frequency, GPT-2 surprisal, and part-of-speech surprisal for every fold of the cross-validation procedure; we then averaged prediction values within high/low, across folds. We then conducted separate mixed-effects models for word frequency (high vs. low), GPT-2 surprisal and part-of-speech surprisal values (high vs. low). The model for word frequency showed no main effect, $t = -0.81$, $p = .421$, nor an interaction between word frequency and age, $t = 1.71$, $p = .092$. The surprisal models also showed no significant effects of word surprisal on the prediction accuracy for its features (GPT-2: main effect: $t = -0.2$, $p = .841$; surprisal x age: $t = 1.04$, $p = .304$; part-of-speech: main effect: $t = 0.22$, $p = .829$; surprisal x age: $t = -0,3$, $p = .764$). We therefore find no evidence that higher-order linguistic processing influenced phonological feature processing in this study.

Supplementary Figure S1

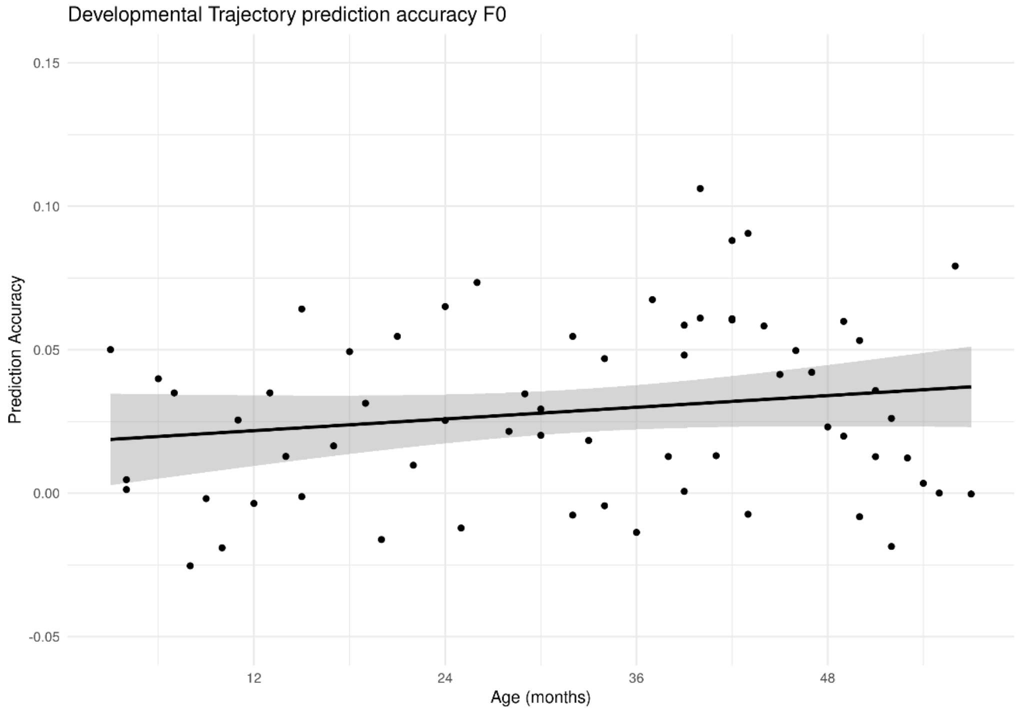

Figure S1: Development of prediction accuracy to F0 across age. Development of prediction accuracy to F0 across age. Dots indicate the observed prediction accuracy minus a baseline value obtained from a permutation of time-shifted F0 values. F0 processing significantly increases with age. F0 processing is significantly above baseline for the youngest age in our sample (i.e., 3 months), indicating that prosodic processing abilities are established early.

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