Using anticipatory nasal coarticulation for word recognition in German and French

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In speech production, the articulatory gesture of velum lowering for an upcoming nasal consonant typically starts already way in advance of the target sound. This anticipatory coarticulation is reflected in the acoustics and hence in principle available for listeners in perception. English [1] and French [2] listeners have been shown to use anticipatory coarticulation in spoken-word recognition. The present study compared the use of anticipatory nasal coarticulation for VN sequences in native French and German listeners. The two languages differ in the presence vs. absence of contrastive nasalization on vowels and speech production experiments have shown that the extent of contextual nasal coarticulation in VN sequences is comparable in German and French, but more variable in German [3]. Given the different phonological role of vowel nasality in French and German as well as the difference in cue consistency for contextual nasality, it stands to reason that French listeners may be more attuned to contextual nasality compared to German listeners.

Sixteen native French and 20 native German listeners participated in visual-world eye-tracking experiments [4] in their respective native language to assess their use of coarticulatory information in real-time. If coarticulation is used, eye fixations should vary systematically with variation in the onset of coarticulation in the acoustic signal. Stimuli were sampled from a production experiment that quantified nasal coarticulation [3] involving nasal-oral minimal word pairs in context sentences. Nasal tokens were selected separately for German and French such that nasalization duration was either from the longest or shortest quartile of each language. German mean extensive nasalization duration was 241ms, constrained 48ms. For French these values were 154 vs. 47ms, since lower variability did not allow for sampling as extreme values as for German. For each nasal token an oral minimal-pair counterpart from the same speaker was selected. Each target was presented in its original context sentence for 114 unique trials, each presented twice and mixed with about the same number of fillers. Visual referents were printed words of the minimal pairs with targets presented once left and once right.

Fig. 1 (top) illustrates the target fixations over time (5ms bins) in response to targets in the extensive vs. constrained nasalization conditions. Time zero indicates the beginning of the nasal consonant. Statistical analyses were then run to test whether listeners were sensitive to the extent of coarticulation in VN sequences, that is, whether and over which time window target fixations differed between the extensive and constrained nasalization conditions. The bottom panels of Fig. 1 show results of a bootstrapped smoothed divergence analysis as implemented in the eyetrackingR package [5]. Results show that for German, target fixations differed between 120 and 315ms after the onset of the nasal consonant suggesting an earlier use of extensive than constrained coarticulation. For French, target fixations did not significantly differ at any point.

In sum, first results suggest that, overall, German as well as French listeners use anticipatory nasal coarticulation in spoken-word recognition. However, only in German where, firstly, nasality is not contrastive on vowels and, secondly, the extent of nasal coarticulation is more variable than for French [3], are listeners sensitive to the amount of nasalization in a preceding vowel. This runs counter our hypothesis that the French, due to the specific function and distribution of nasality in their language may be more attuned to this cue.

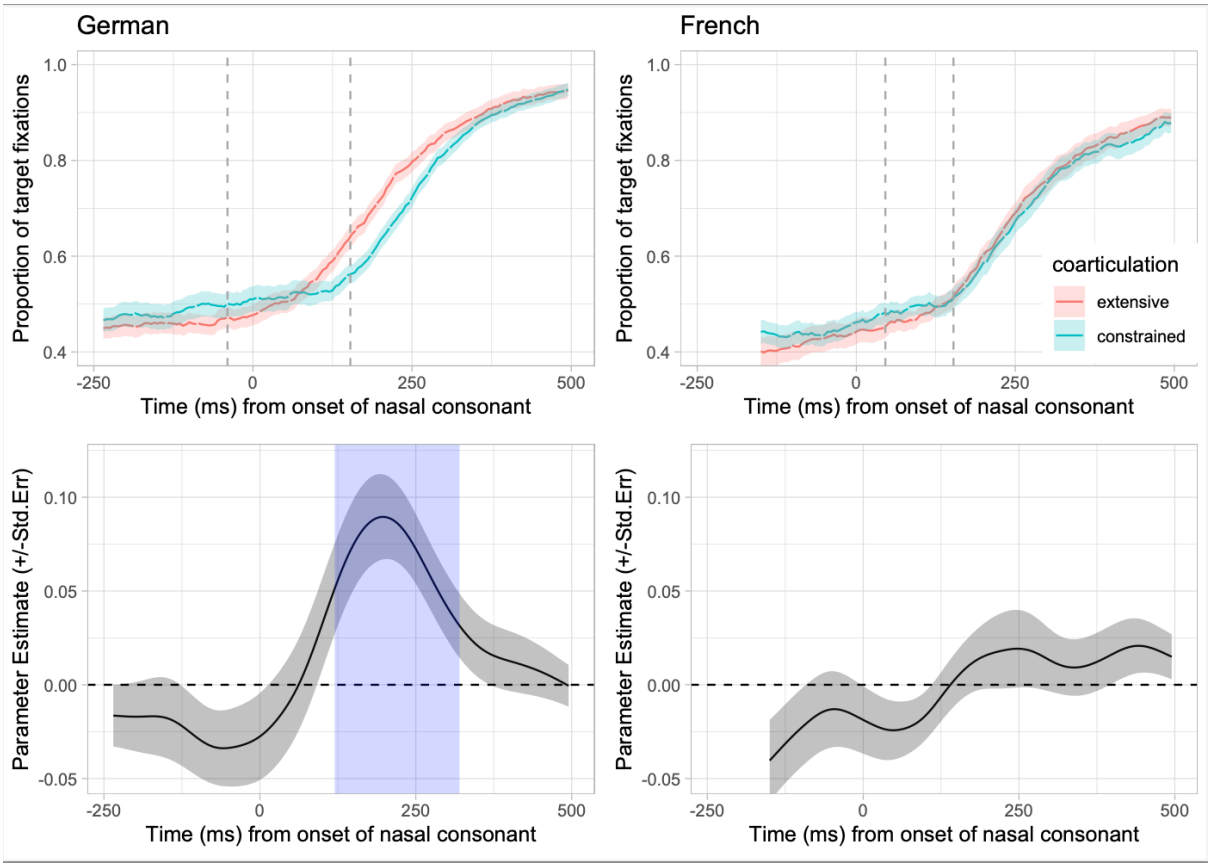

Fig. 1: *Top*: Time course of target fixations for German (left) and French (right) in the extensive (red) and constrained (green) nasalization conditions. Shaded areas refer to 1 SE. Zero refers to the onset of the nasal consonant. The dashed vertical lines represent the earliest timepoints at which the use of extensive vs. constrained coarticulatory information could be reflected in the fixation patterns accounting for the expected 200ms delay of audio-related fixations.
Bottom: Results of the difference curves between target fixations in the extensive vs. constrained nasalization conditions over time with standard errors (shaded areas) and highlighted time windows of significant differences as calculated in the bootstrapped smoothed divergence analysis. All plots are on the same scale, but lines start at the average onset of nasalization in the extensive conditions, which is later for French than German.

References

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