

# ANTICIPATORY LARYNGEAL MOVEMENTS

## An X-ray investigation

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### ABSTRACT

This investigation deals with the production of VCV sequences produced by French speakers, with particular focus on larynx position and trajectory. X-ray data are extracted from a database for four speakers, uttering sentences or VCV sequences at two speaking rates: normal-conversational and fast. Results obtained from a frame-by-frame analysis of midsagittal profiles reveal: (1) a high positive correlation between the larynx and the hyoid bone in their vertical displacements; (2) a confirmation of previous findings that the position of the larynx is lower for high vowels than for low vowels; (3) anticipatory laryngeal gestures in both /aCu/ and /uCa/ sequences; (4) that these anticipatory gestures are resistant to the behaviour of supraglottal structures, and also to speech rate conditions.

Research related to larynx vertical movements in the production of vowels and consonants have been reported in the literature (cf. e.g. Perkell, 1969 [7]; Bothorel, 1979 [3]). However, the search for anticipatory laryngeal gestures, combined with the use of speech rate as a perturbing factor, are indeed lacking in the literature. The present research is thus, hopefully, a contribution to knowledge on the control and timing of larynx position in obtaining vocalic and consonantal gestures, across rate variations. Anticipatory laryngeal patterns eventually unveiled should contribute to efforts in understanding and modelling glottal and supraglottal anticipatory gestures.

With regards to this interaction between the behaviour of the jaw, the lips and larynx height, it is hypothesised that the data reported here should: (1) highlight displacement correlations between these structures; (2) show comparable anticipatory strategies between the larynx, the lips and the jaw in producing /aCu/ sequences.

The corpus consisted of V<sub>1</sub>CV<sub>2</sub> sequences and sentences that embedded target words. The words were specifically chosen to study anticipatory behaviour in the production of V<sub>1</sub>CV<sub>2</sub> sequences, where V<sub>1</sub> is the low vowel /a/ and V<sub>2</sub> the high vowel /u/. Symmetrically, control V<sub>1</sub>CV<sub>2</sub> sequences were also investigated, where V<sub>1</sub> is the high vowel /u/ and V<sub>2</sub> the low vowel /a/. The medial consonant is either /p/ /t/ or /k/. Place of articulation is thus varied.

The same sequences were also produced by the speakers as nonsense words.

X-ray data are obtained for 4 speakers (two females and two males) who uttered the sequences and sentences once at two speaking rates, normal-conversational and fast.

With the help of a grid (and a software for the digitised data), measurement parameters for larynx and hyoid bone vertical positions during the production of the sequences were determined. Lip protrusion, lip-opening, tongue-tip, tongue-body and jaw displacements were also monitored and measured. Speech rate was varied as a perturbing factor, *i.e.* as a means of evaluating the robustness of the trajectories of the measured structures in the production of the different vocalic and consonantal phonetic categories.

*First of all*, results for all four subjects confirm a high positive correlation between the larynx and the hyoid bone in their vertical displacements. The position of the larynx (and that of the hyoid bone) is

systematically higher for the low vowel /a/ than for the high vowel /u/. These laryngeal settings and trajectories (and especially the vocalic ones) are all maintained in fast speech, thus suggesting their robustness in speech production. It should also be mentioned that in fast speech, the larynx and the hyoid bone have higher positions, compared with initial settings observed in normal speech. This result is true for all four subjects. It has been hypothesised elsewhere that increasing speech rate requires such an initial configuration, presumably necessary for the articulatory acceleration task. This may also be related to a probable co-variation between fast speaking rate and fundamental frequency. However, complementary acoustic data are needed in order to verify such an assumption.

*Secondly*, the entire data highlight displacement correlations between the larynx-hyoid bone couple, the lips, tongue-body and the jaw. The behaviour of all measured structures reveals a variable but certain degree of coupling: as the larynx goes downwards from vowel /a/ to /u/ across the consonant, lip-opening reduces, tongue body rises, while lip protrusion increases. One may conclude therefore that an interaction between the behaviour of these structures, regarding position and displacement, is proven.

*Thirdly*, the data reveal an anticipatory laryngeal movement for the /u/ in /atu/ and /aku/ sequences. These patterns are robust, as they are structurally similar in fast speech, apart from the fact that movements in this speaking condition are accelerated, with reduced amplitudes.

## CONCLUSIONS

From the experimental data analysed in this investigation, two main conclusions can be drawn.

Firstly, with regards to interaction between the behaviour of the jaw, the lips and the tongue, displacement and positional correlations between these structures and larynx height have been unveiled.

Secondly, such correlations cannot, however, be extended to anticipatory behaviour, since anticipatory laryngeal behaviour appears even when no anticipatory supraglottal gestures are observed.

Such results suggest that gestures that are coupled in given speech tasks, may no longer be correlated in anticipatory timing tasks, and therefore seem to pinpoint the specificity of anticipatory gestures in speech.

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