

## Rise shape dynamics is sufficient to distinguish question and continuation rises in French

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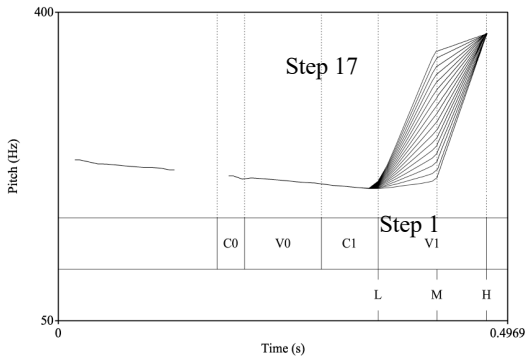
Two rising French contours, both labelled as H\*H%, are used respectively as a continuation rise or a yes/no question terminal in French [1, 2, 3]. The two contours also differ in terms of duration, with continuation rises showing longer pre-boundary lengthening [4, 5] while H% height has not been found to be consistently higher in questions [3]. More crucially, since Delattre's [6] initial observations, the two rises have been suggested to differ in shape, with continuation contours being more concave than questions', though this has not been confirmed by subsequent perception studies [7] or else the opposite effect has been found [8].

The AM model of intonation stipulates that the shape of the interpolation as well as the slope between two tonal targets is not relevant for descriptive purposes [9] (see [10] for a review). Dynamic properties of the F0 contour, such as peak shape [11, 12] and slope [11] [13] have on the other hand been claimed to be perceptually relevant for intonation category assignment. For instance, the Tonal Center of Gravity [14] hypothesis is based on the idea that perceived properties of intonation contours might be influenced by auditory integration of the dynamic properties of the contour, such as the area covered by a high or low F0 region within the pitch accented syllable.

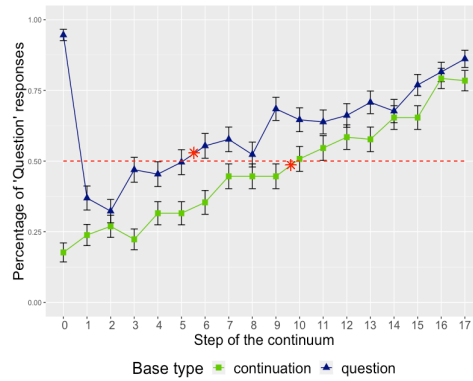
The hypothesis tested in this study is that a perceptual difference between the two rising contours of French could stem from the particular dynamic characteristics of the rise, notably from the shape of the interpolation between the L and the H tonal targets, once duration and tonal target scaling are kept equal. The same segmental content was hence used to create two intonational bases, produced by a female French speaker as either a declarative question or as a non-final, continuation contour ("La beauté des canaux?/", – *The beauty of the canals?/*). Segmental durations as well as tonal target scaling and alignment were rendered ambiguous between the two bases in stylized versions through PSOLA resynthesis in Praat [15]. Then, the form of the interpolation between the L (199 Hz) and the H (379 Hz) targets was modified by adding a midpoint whose scaling was altered in 17 steps of 10 Hz, from 209 Hz to 369 Hz, creating several rise shapes from the most convex to the most concave (see Fig.1).

Thirty native French speakers (6 males) participated in a two forced-choice test (continuation vs question response) with the help of the Perceval software [16], and with reaction times being recorded. We predicted that question scores would differ as a result of the Step (17 steps) manipulation as well as a function of the Base (question vs. continuation). Fig. 2 shows that at step 10, continuation stimuli started to be perceived as questions above 50% chance, while for questions this was true already after step 5. Mixed-effects regression models (with Participants treated as random factors, with random slopes) were applied to test the significance of the results. The model retained both Step and Base as significant fixed factors, while their interaction was not significant. Note that percentage of question responses increased with Step in both continuation-base ( $\beta = 0.18$  SE  $\beta = 0.02$ ,  $p < 0.0001$ ) and question-base ( $\beta = 0.16$  SE  $\beta = 0.02$ ,  $p < 0.0001$ ) stimuli, though continuation base stimuli globally received less question responses.

Our perception results reveal for the first time that contour shape alone can play a significant role in the identification of intonational form (once other cues are rendered ambiguous), though residual properties of the base might still be present. We hence propose a differential labeling of the two contours, with continuations being labeled as L\*H% and questions as H\*H%. Finally, as in the early observations by Grundstrom [8] and Di Cristo (1976), we propose that question rises need to have a large enough F0 span and higher final (perceived) target height, which could be attained by merely modifying the shape of the rise as predicted by the ToG approach.



**Figure 1:** Schema of the 17-step modification with segmental annotations (C for consonant, V for vowel), used to create the 2 continua.



**Figure 2:** Percentage and standard error of 'question' responses by Step and Base.

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