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AUTHOR Howie, John M.
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ABSTRACT

Recent studies of rising intonation contours in French, in particular the acoustical differences that serve to distinguish Yes/No questions from other rising intonations are reviewed. The preliminary results of a pilot study of rising intonations in French, in which average curves were obtained from spectrographic measurements of fundamental frequency, are also reported. In conclusion it is found that the preliminary set of average curves presented here lend support to Pierre Delattre's description of three of his ten basic intonations of French: Yes/No, major continuation, and implication. The method described for deriving these average curves from spectrographic measurements is seen as a sound one, promising worthwhile results in future studies. Finally, in a discussion of the results of Allan Grundstrom's experiment with synthetic speech, it is noted that they seem to confirm the assumption that fundamental frequency is an effective cue for the perception of intonational distinctions. Perception testing of synthetic intonations is emphasized as a fruitful technique for acoustic description, which will eventually provide an adequate acoustic description of the distinctive intonation contour for Yes/No questions in French. (HW)

Acoustical Measurements of Selected Intonation Contours of French*

John M. Howie
University of Missouri--Columbia

This paper will be a rather rambling review of some recent studies of rising intonation contours in French, in particular the acoustical differences that serve to distinguish Yes/no Questions from other rising intonations. (It should be noted at the outset that all interrogative sentences mentioned in this paper will be of the Yes/no type and, further, that all such questions will be of the type signalled uniquely by intonation, without the additional syntactic cues of subject-verb inversion, est-ce que, or the like.) This paper also will report the preliminary results of a pilot study of rising intonations in French, in which average curves were obtained from spectrographic measurements of fundamental frequency.

By way of background, I should like to begin by reviewing very concisely the late Pierre Delattre's descriptions of the relevant intonation contours, as found in two articles in the French Review: "Les Dix Intonations de

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base du français" (1966), and "La Nuance de sens par l'intonation" (1967). The contours for Yes/no Question, Major Continuation, and Implication all are described as rising to a relatively very high pitch on the tonic syllable, that is the last syllable of the sense group. (The sense group, or prosodic group, corresponds to the intonation contour from the structural point of view.)

To label these contours by their phonological features, Delattre adopted four significant levels of pitch, defined in terms of linguistic oppositions between the various intonation contours in French. The unaccented syllables at the beginning of a contour of either Continuation or Yes/no Question are supposed to remain close to the intermediate pitch level 2. The accented syllable at the end of a Minor Continuation rises from level 2 to level 3, and the accented syllable at the end of a Major Continuation or a Yes/no Question rises from level 2 to level 4. In an Implication contour, the unaccented syllables rise higher than level 2, so that the last unaccented syllable is almost at level 4. The accented syllable then reaches level 4, remains at a level pitch for an instant, and finally falls to a somewhat lower pitch. Delattre's schematic forms of these contours, seen in Figure 1, are thus intended to represent the pitch curves of the final syllable of Question and of Major Continuation, and the

last two or three syllables of Implication.

While all three contours can be labelled by the same phonological features, that is pitch levels 2-4, Delattre also claimed that they differed in the shape of the pitch curves. As just described, the curve for Implication has a convex shape, if viewed from above, called a "decreasing rise" and symbolized by the minus sign in the feature label. On the other hand, the curve for Question has a concave shape, with a steeper rise on the final syllable, called an "increasing rise" and symbolized by the plus sign in the feature label. The differences in shape between these two curves are great enough that Question and Implication may be considered distinctive contours. Delattre claimed that they are never confused in listening tests. The intermediate shape of the curve for Major Continuation, however, can be distinguished less easily from the other two, and, besides, it cannot be logically opposed to either of the others since Major Continuation can never be the final contour of a sentence.

Another recent study that deals with rising intonations in French and with the question of a distinct contour for Yes/no Questions is Allan Grundstrom's "An Experimental Study of Interrogative Intonation in French," appearing (1968) in Monograph No. 4 of the Speech Communications Research Laboratory of Santa Barbara. This study is

interesting because its results do not support Delattre's descriptions and its conclusions call into question the claim that there is a distinctive fundamental frequency curve for interrogative intonation in French.

Grundstrom made fundamental frequency measurements from spectrograms of 148 recorded utterances by four male French speakers in spontaneous conversations. The resulting F_0 curves were displayed separately for each utterance (on a linear frequency scale). Grundstrom then made a classification of the shapes of the curves seen during the vowel in the final syllable of every prosodic group. By this step, he eliminated from further consideration the actual shapes of the curves, in favor of a very general description in six broad categories of shapes and relative levels, such as "rising", "rising-falling," "high-level," etc. Grundstrom observes, "Although these categories are to some extent arbitrary, they represent, without loss of significant detail, a reasonably accurate description of all the fundamental frequency contours in the data. There was no evidence that rising intonations differ from one another on the basis of the rate of change of the slope of the rise as reported by Delattre. This classification does, however, include both rising and rising-falling categories which may be similar to Delattre's <u>increasing rise</u> and his <u>decreasing rise</u>."

Grundstrom's final step was to correlate his contour categories with the linguistic function of the prosodic groups, categorized as question, quasi-question, or non-question. After eliminating Yes/no Questions that used syntactic devices like est-ce que or a tag to signal the Question function, he found that practically all of his Questions had his "rising" contour. But only about half of all the "rising" contours were Questions! Grundstrom concluded that "if questions are, in fact, signalled by intonation alone, some further specification of rising fundamental frequency contours seems necessary," or possibly that other prosodic parameters (such as intensity and duration) may contribute to the perception of a distinctive interrogative intonation. In an effort to clarify the problem of acoustic cues for the perception of questions, he later turned to perception testing with synthetic speech, in which the prosodic parameters could be individually controlled. I will discuss some of the results of this experiment in a moment.

I should now like to present the results of a "pilot study" of my own, in which average F_0 curves were obtained from spectrographic measurements of the last two syllables of the three rising contours identified by Delattre. In this "pilot study," the method itself is of as much interest as the preliminary results. Because making measurements

from spectrograms is a laborious and time-consuming process, one objective of this method was to be as efficient and economical as possible. Hence only the last two syllables of the prosodic group, where the distinctions in the F_o curves are expected to be found for these three contours, are included in the measurements. Another objective was to produce a generalized shape for each contour that would nevertheless capture details in shape that might contribute to a distinction between contours. To achieve this generalization, all the individual curves of each intonation were first grouped together and an average curve was made separately for each intonation.

To facilitate the production of average curves, the assumption was made that the prosodic parameter of duration does not play a distinctive role in the perception of intonation. Once this assumption had been made, the durational aspect of the segments to be measured in all the utterances was normalized by the same means used for the measurement of Mandarin Chinese tones, that I reported to this group four years ago. The duration of the last two syllables was thus normalized by locating the points at which the fundamental was to be measured on the spectrograms in terms of per cent of duration, from the onset of voicing in the penult to the termination of voicing in the final. The measurements were made at intervals of five per cent of the duration during steeply moving stretches, and of ten per cent during less

steeply moving and level stretches. The frequency values, measured usually from the tenth harmonic and expressed to the nearest 5 Hz, were plotted logarithmically against duration, using tracing paper. The individual curves for each intonation were then superimposed and an average curve was drawn by eye through the "family" of curves.

The preliminary results obtained by this method may be seen in Figure 2. I used the utterances recorded by Pierre Léon for the textbooks Exercices Systématiques de Prononciation Française, by Monique Léon. There were seven utterances of Question, twelve utterances for Major Continuation, and three utterances for Implication. The shapes of my average curves bear a strong resemblance to Delattre's descriptions of these rising contours, represented by the schematic forms in Figure 1. The resemblance might be even stronger if the average curves were shifted up or down on the pitch scale so that their highest points were all at approximately the same level. (The four levels of pitch are, of course, relative to a given utterance, as well as relative to a given speaker.) The shapes of the average curves for Question and Implication are clearly distinct, with the curve of Implication almost reaching its highest point in the next-to-last syllable, as Delattre suggested. I believe that further work deriving average curves by this method will yield even more conclusive support to Delattre's description of these contours.

Having succeeded in producing a set of average curves that adequately approximates Delattre's curves for Question, Major Continuation, and Implication, I was very much interested in comparing them with Grundstrom's synthetic F_o curves as plotted on the same scale. Grundstrom describes this experiment on the perception of rising contours in a paper, "Des Formes acoustiques de l'intonation interrogative en français," read at the International Symposium on Intonology in Prague, in 1970. I shall mention in this brief review only the most relevant part of Grundstrom's experimental procedure. The object was to synthesize rising pitch curves on the final syllable of a short sentence, such that they would have the shapes of the three contours described by Delattre as rising to level 4. The three contours are "Increasing rise" for Question, "Constant rise" for Major Continuation, and "Decreasing rise" for Implication. These synthetic contours were expected to be perceived as either <u>questions</u> or <u>non-questions</u> by French listeners, testing the assumption that Questions and Implications can always be distinguished, while Major Continuations cannot be recognized consistently in this sentence-final position.

The prosodic parameters of the sentence, "Ils sont au même niveau." (originally spoken with a falling pitch on the final syllable), were manipulated with a speech

synthesizer at the Speech Communications Research Laboratory at Santa Barbara, California. The three curves of fundamental frequency shown in Figure 3 are the curves having the greatest pitch range and the steepest slopes. Grundstrom presented all the synthesized variations of this sentence to a group of twenty-eight listeners for identification in five categories: (1) definite question, (2) probable question, (3) neutral sentence, (4) probable non-question, and (5) definite non-question.

The results of Grundstrom's listening test at least confirmed that fundamental frequency is an effective cue for the perception of distinctions in intonation! None of these three synthetic intonation contours, shown in Figure 3, was judged either a definite non-question or a probable non-question, even though the original falling pitch on the final syllable was definitely a non-question intonation. In other words, by changing the pitch curve on the final syllable from falling to rising, Grundstrom obtained responses from his listeners indicating the perception of a question, rather than a simple declaration.

The "decreasing rise" and the "constant rise" were both judged--on the average--to be probable questions, and the "increasing rise" was judged to be a neutral sentence--which is certainly a non-committal response, but which could be interpreted as meaning a possible question. Thus

Grundstrom's three synthetic contours, intended to give rise to the perception of both Question and Implication intonations, were in fact all perceived to some degree as Question. The shapes of the three contours, then, are not at all distinctive, and fail to serve as cues for the perception of the distinction between Question and Non-question intonations.

In his paper, Grundstrom does not speculate on the possible reasons for this unexpected result of his listening test. But, by plotting the three curves that I have described on a graph with the same scales as the one used for my average curves, so that the shapes of the two sets of curves may be compared directly, some interesting observations may be made. First, it seems clear that the aspect of the curves that signals Question is not only the extent of the pitch range in the rise but primarily the angle of the slope--which must be relatively steep, as it is in my average curve for Question in Figure 2. This requirement is met in the first segment of Grundstrom's "decreasing rise," where the slope is much steeper than anywhere in the other two curves. I believe that it is this initial steep slope of the "decreasing rise" that led to the listeners' responses, giving it the highest interrogative value of all the curves.

A second observation concerns the perception of the other two synthesized curves. Grundstrom evidently intended the pitch of his "constant rise" curve to rise uniformly over time, as a straight line, and the pitch of his "increasing rise" curve to rise with a uniform increase, as a symmetrical concave shape. But, because he drew these curves on a graph with a linear frequency scale instead of a logarithmic one (corresponding to our perception of pitch), the shapes of the synthesized curves must have been distorted somewhat. When plotted on a graph with a logarithmic frequency scale, as in Figure 3, the "constant rise" curve actually decreases near the end, and the "increasing rise" curve actually straightens out near the end. Both these curves, then, are presumably less steep than intended, and would thus be perceived as less interrogative than expected (if I am correct in my assumption that steepness of slope is the primary interrogative cue).

A third and final observation concerns further possible reasons why Grundstrom's "decreasing rise" curve, which was intended to simulate Delattre's Implication curve, was not perceived as a non-question. As I have already noted, the initial slope of the rise is probably too steep for this curve to be perceived as anything but a question. In addition, this synthetic contour does not have the fall in pitch at the end, which is an important feature of

Delattre's description of Implication. But more important, I believe, is the overall pitch pattern of the two syllables niveau, where there is too much difference in pitch between the two syllables. According to Delattre, the Implication curve will almost attain its summit in the penult. I suggest that a synthesized contour with a rise to more than 150 Hz during the penult syllable ni-, continuing to rise slightly at the beginning of the final syllable -veau, and then falling at the end to near 150 Hz, would approximate much more closely the Implication intonation and would probably be judged as a non-question in a listening test that also included contours similar to Grundstrom's "constant rise" and "increasing rise".

Grundstrom's experiment with synthetic speech is a fascinating study that demonstrates the efficacy of testing the perceptual effect of instrumentally manipulated prosodic parameters of speech. His work is one of the first steps in exploring a large and important field of linguistics: that is the acoustical description of intonation and other prosodic features of French. Although Grundstrom's experiment failed to provide a definitive specification of the rising fundamental frequency contours in French intonations, the problems encountered in his study will surely help those who follow him in this exciting and demanding area of research, and who will no doubt discover the acoustic cues

for distinctive interrogative intonation in French.

To conclude, the preliminary set of average curves that I have presented here lend support to Pierre Delattre's descriptions of three of his ten basic intonations of French: Yes/no question, Major continuation, and Implication. Moreover, the method I have described for deriving these average curves from spectrographic measurements appears to be a sound one, which promises worthwhile results in future studies. Finally, in discussing some of the results of Allan Grundstrom's experiment with synthetic speech, I have noted that they seem to confirm our assumption that fundamental frequency is an effective cue for the perception of intonational distinctions. And I have emphasized that the technique of perception testing of synthetic intonations is a fruitful one for the phonetic description of languages, which eventually will provide an adequate acoustic description of the distinctive intonation contour for Yes/no Question in French.

John M. Howie
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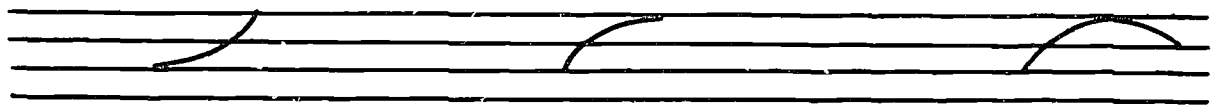

Figure 1. Delattre's schematic forms of curves rising to level 4. "Les Dix Intonations de base du français," French Review, XL (1966).

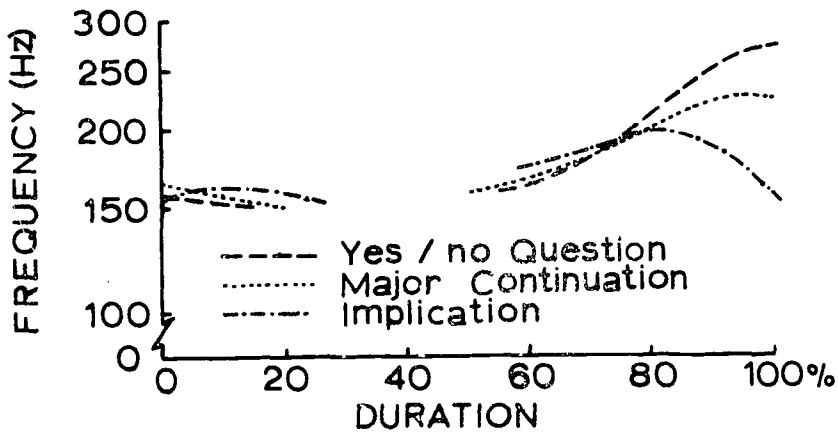

Figure 2. Average curves of three rising intonations spoken by P. Léon in the recorded Exercices Systématiques de Prononciation Française, Hachette/Larousse (1964).

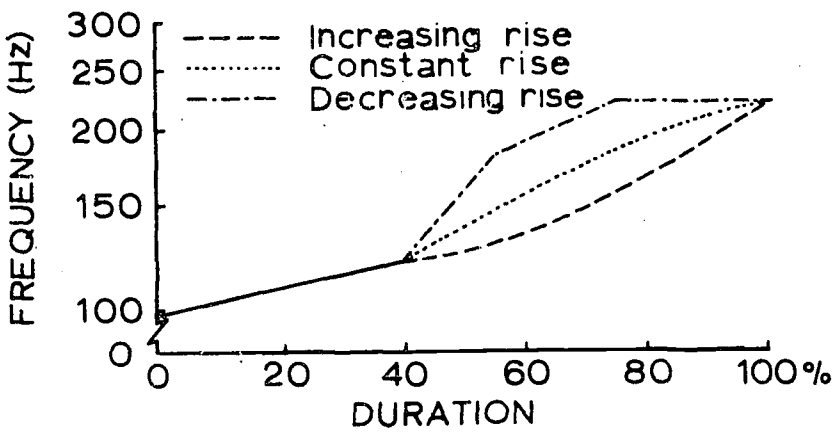

Figure 3. Logarithmic plots of Grundstrom's synthetic contours for the word niveau: curves 6, 7, and 8 on the final syllable. "Des Formes acoustiques de l'intonation interrogative en français," International Symposium on Intonology, Prague, 1970.