THE PITCH OF GLIDE-LIKE F_0 CURVES IN VOTIC FOLK SONGS

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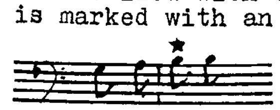
ABSTRACT

It has been shown recently that in Votic folk songs two successive tone glides, one rising and the other falling, create a clear unambiguous pitch sensation. An experiment was conducted where musically trained subjects had to match such F_0 curves with their voice. The stimuli consisted of four-note excerpts from the natural song performed by a low female voice, where the third note corresponded to a glide-like F_0 variation. The results confirm that the perception of such F_0 curves belongs to the category of fusion, which is characterized by the pitch sensation near the arithmetic mean of the terminal frequencies and a small dispersion of the subjects' responses. However, it seems more appropriate to define the pitch as F_0 at the point of two thirds of the overall duration of the note.

INTRODUCTION

In speech, permanent F_0 changes are very common while long time intervals with a stable pitch are perceived as something unusual. Music, on the contrary, is considered to be a sequence of notes, i.e. of discrete segments with a relatively stable pitch each. Actual relationship between pitch and frequency in musical performance can, however, be quite complex. When a particular note is perceived as having a stable pitch it does not necessarily mean that during this note F_0 should behave as stably as the pitch. Among such frequency changes which contribute more to the overall impression of sound than to the pitch sensation, the best known is vibrato. Vibrato can be defined as a simultaneous frequency, amplitude and phase modulation. Evidence can be found in literature that in European concert singing F_0 can be modulated within the limits of up to 2.5 semitones, the modulation rate being 5-8 Hz /1/.

Recently glide-like F_0 variations in notes with a stable pitch have been described in Votic one-voiced folk songs /2/. (The Votes are a Baltic-Finnic ethnic minority group living near Leningrad.) As was shown in /2/, glide-like F_0 variations in these songs tend to occur due to the coincidence of the metric accent, word stress and melody culmination. They have a shape somewhat similar to a circumflex where the right side is approximately twice as long as the left one. The difference between the initial and the final frequencies is considerable and in the case of the (left-side) rising glide can reach up to 4 semitones (see Fig. 1). As a matter of fact, the decision about the perceived pitch stability in such cases can be made without special experimental research. In ethnomusicology, a written transcription of performed song into conventional notation is an obligatory procedure and ethnomusicologists are very sensitive even to minor pitch changes which are beyond the limits of conventional notation. There is a whole arsenal of special symbols designed to mark down such changes. We have compared the conventional of the songs under investigation with the results of an F_0 extraction procedure and have not found any special symbols at the notes with a glide-like F_0 variation which means that these notes are perceived as having a stable pitch. In this paper we consider glide-like F_0 variations mainly in one song called "Admonishment of the bride". This song belongs to the older layer of the Baltic-Finnic musical folklore, the origin of which is dated back at least as far as the 11th century. The song is characterized by a strongly recitative manner of singing and is performed by a low female voice in the frequency region of 180-250 Hz. During the song one and the same melody pattern is repeated 12 times with possible modifications. Glide-like F_0 variations occur most frequently where an odd repetition is passing over to an even one. The transition looks like this (the first note of the even repetition, which is always characterized with a glide-like F_0 pattern, is marked with an asterisk):



Such a transition does not occur at the end of even repetitions as they terminate a minor structural unit in the song. The total number of repetitions being twelve the present melodic segment occurs six times. The F_0 patterns of the notes marked with an asterisk are presented in Fig. 1. Fig. 2 displays the F_0 curves of the note next to that with an asterisk (i.e. the final note in the example presented above, or the 2nd note in the basic melody pattern). The difference between Figs. 1 and 2 is considerable and it seems necessary to find an answer to at least two questions in this connection. First, what is the F_0 value corresponding to the pitch of the note with an asterisk, and second, whether the pitch of the note with an asterisk is the same as the pitch of the next note. A psychoacoustical experiment was conducted in order to answer these questions.

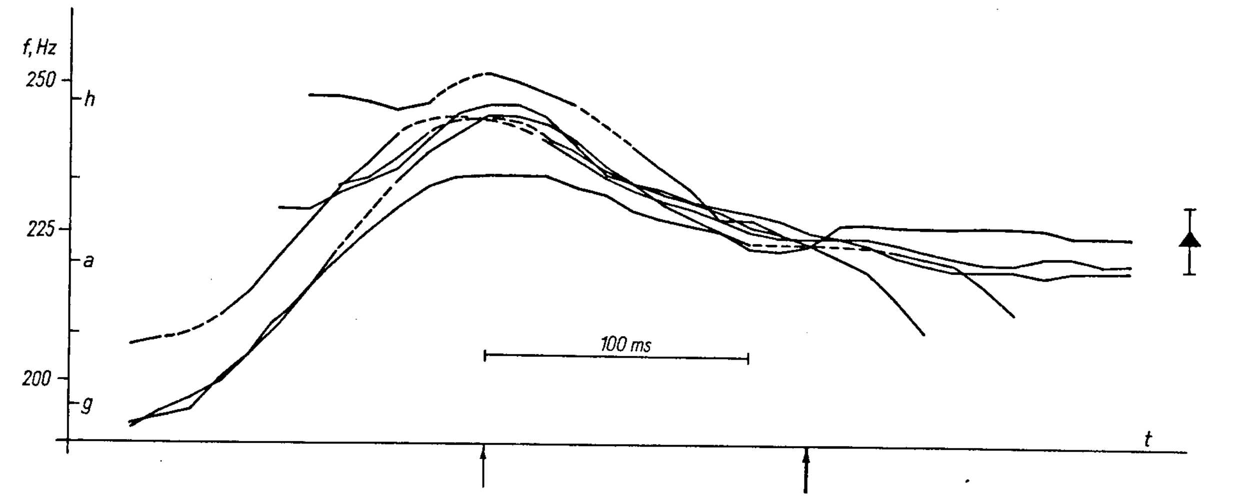


Fig. 1. F_0 patterns in a Votic wedding song which are perceived as having a stable unambiguous pitch. Six F_0 patterns are normalized with respect to the frequency maximum (marked with the left arrow) along the time axis (abscissa). Ordinate: the frequency scale (Hz) and its division according to the equal temperation. The right arrow on the abscissa roughly corresponds to the point at two thirds of the overall note duration. Mean F_0 values from a pitch-matching test, with standard deviation, are presented at the rightmost side.

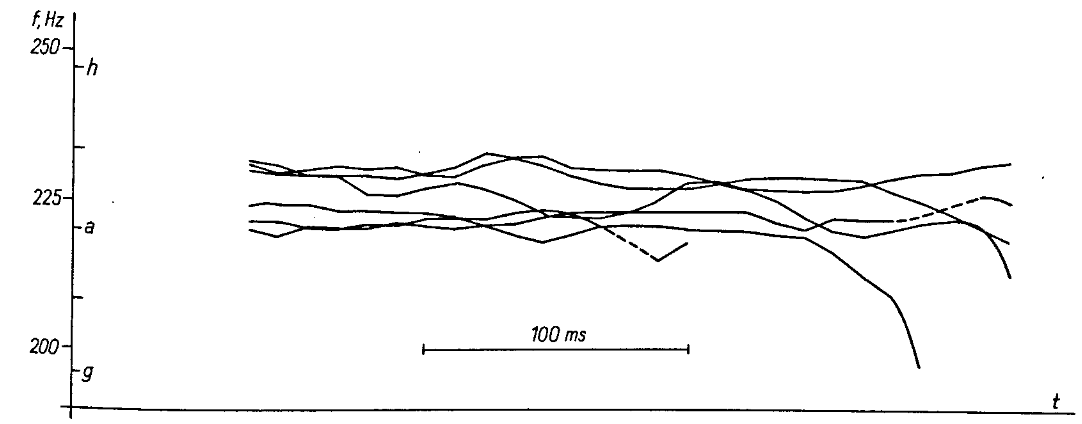


Fig. 2. F_0 patterns in a Votic wedding song which are perceived as having the same pitch as those in Fig. 1. Abscissa: time, ordinate: frequency scale (Hz) with its division according to the equal temperation.

PROCEDURE

The song "Admonishment of the bride" was stored on a magnetic disk of the EC1010 computer from a tape-recorder via a low-pass filter with a cutoff frequency of 5 kHz and a 12-bit A/D-converter with a sampling frequency of 10 kHz. Six odd-to-even transition samples were separated from the song and played back to subjects via a 12-bit D/A-converter, a lowpass filter with a cutoff frequency of 5 kHz and TDS-1 earphones. The subjects were free to regulate the SPL to a comfortable level and listen to every sample (almost identical to each other musically) as many times as they chose. The subjects were instructed to match the pitch of the third note in the melodic pattern with their voice. (This pattern was presented to them in a written form, too.)

Three subjects, two male and one female, participated in the experiment, all with a musical education at least on college level but with no reported absolute hearing. They were told to use octave transpositions of pitch if necessary in order to sing in a more comfortable frequency range. As all 3 subjects responded to 6 melodic patterns, the total number of answers was 18. The answers were then stored on a magnetic disk using the hardware mentioned above and run through a pitch detection program. The resulting F_o response curves of all three subjects were smooth enough with a frequency change of no more than 5 per cent. The frequency which occurred most often was chosen as the response in every case.

RESULTS AND DISCUSSION

Both male subjects were able to match the pitch of the stimuli with no octave transpositions, i.e. they used the same frequency range as the singer originally did. The female subject performed the task one octave higher. So, the frequency values of her responses were replaced by twice smaller ones during the following computation.

We assumed that in the original song the singer uses a kind of internal tone scale and frequency deviations in the case of one and the same note may occur only incidentally. The mean F_o value of all of the 18 responses are presented on the right side of Fig. 1, with standard deviation. As one can see, the range of standard deviation is practically identical to the range of the F_o variation in Fig. 2. So we can conclude that the pitches of two successive h's (3rd and 4th note in the note example above) are equal despite the remarkable differences in the corresponding F_o patterns.

Nábělek, Nábělek and Hirsh /3/ have studied the pitch of sound bursts where two terminal frequencies are connected by a linear frequency change. They have found that three modes of perception can be distinguished with such glides, namely fusion, separation and indecision. Fusion is characterized by a pitch sensation near the arithmetic mean of the terminal frequencies and a small dispersion of responses. In the case of separation the pitch of the glide is matched at one or both terminal frequencies. Indecision means that the subjects' responses are widely distributed among the frequency axis between the terminal frequencies. Glide-like F_o patterns in Votic songs seem to belong to the category of fusion, as the dispersion of the subjects' responses is small and the perceived pitch corresponds neither to the initial nor to the final frequency but is rather matched at the middle of the glide. Nábělek et al. have concluded that in the case of tone bursts with a linear change of frequency during 100 per cent of the burst duration, fusion occurs when the difference between terminal frequencies Δf is not too great and the duration of the glide t_b not too long. As one can see in Fig. 1, in Votic songs $\Delta f \simeq 50$ Hz and $t_b \simeq 100$ ms in the case of a rising glide (the left part of the circumflex) and $\Delta f \simeq 30$ Hz and $t_b \simeq 200$ ms in the case of a falling glide (the right part of the circumflex). When we compare the values of Δf and t_b with those of Nábělek et al. considering the left and the right sides of the F_o pattern separately, we find that single tone bursts with such parameters clearly fall to the category of fusion. So we can conclude that the results are in good agreement with their investigation.

However, the conclusions by Nábělek et al. are rather general in nature as they enable us only roughly to determine the F_o value which corresponds to the perceived pitch. In their following work /4/ the authors wrote even more cautiously that "in fusion ... the sound burst was matched by a single frequency located somewhere between the initial and final frequencies". In the experiment of Lublinskaya /5/ subjects had to mimic with their voice the F_o variation in synthetic vowels /a/ with a glide-like frequency change. The author proposes that the most important task is to determine the initial and final frequencies of a glide whereas the pitch as corresponding to their arithmetic mean can be considered their derivative. The comparison of the original F_o and the response curves in her study confirm that it is the terminal frequencies that are stressed in subjects' responses.

Rossi /6/ has shown that the pitch of the synthetic vowel /a/ with both an ascending and a descending glide-like F_o change ($\Delta f = 23$ Hz, $t_b = 200$ ms) is percеived at the point of two thirds of the overall duration of the vowel. This point approximately corresponds to that marked with an arrow at the right side of Fig. 1. As one can see, at this point all six F_o curves are passing quite a narrow frequency region of 224-226 Hz which very closely corresponds to the mean of the subjects' responses in the described pitch-matching experiment. So our experimental results well agree with those of Rossi, too.

CONCLUSIONS

The pitch of tone glides has been explained on the basis of hypothetic mechanisms operating both in frequency and time domain. When pitch is measured in the frequency domain, it is the determination of the initial and final frequencies that seems to be of the greatest importance. In the time domain, the pitch should correspond to the F_o value at the point of two thirds of the overall duration of the stimulus. The results of the present experiment can be explained both on the basis of the frequency and the time domain hypotheses, but as the latter allows us to determine the F_o value more precisely, this explanation should be preferred.

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