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STUDY OF THE ACOUSTICAL PHENOMENA CHARACTERISTIC
OF THE TRANSITION BETWEEN CHEST VOICE AND FALSETTO
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Abstract

The two main registers of the human voice, usually referred to as chest voice and falsetto, correspond to two different emission mechanisms of the vocal cords; thick cords with long closed phase or thin cords with no closed phase. During the transition from one type of emission to the other, a loss of control of the pitch and of the vocal color can be observed. The vocal color of falsetto is generally different from chest voice, in particular, significant differences in the distribution of energy between the first harmonics may be observed. We have carried out the study of this break with different subjects, singers or non-singers of both sexes. Whether the subject is a singer or not, according to his vocal technique and according to the cultural context, this break can be so masked as to become imperceptible, or on the contrary, it can be used as a musical effect (yodel).

Introduction

A simple vocal test is to sweep the whole vocal extent with a glissando. When we ask a singer (or a non-singer) to execute such a glissando through the whole range of his voice, from the lower limit to the very upper limit (not only the trained part of the voice), we find at least one or two breaks or failures in the continuous sound.

Figs. 1a and b shows two breaks for a male voice as well as for a female voice. This paper concerns only the lower one of the two breaks shown in Fig. 1.

One of us (Roubeau, 1982) previously used a different techniques such as radiography and electroglottography to study this phenomenon; we present here results of an acoustical investigation.

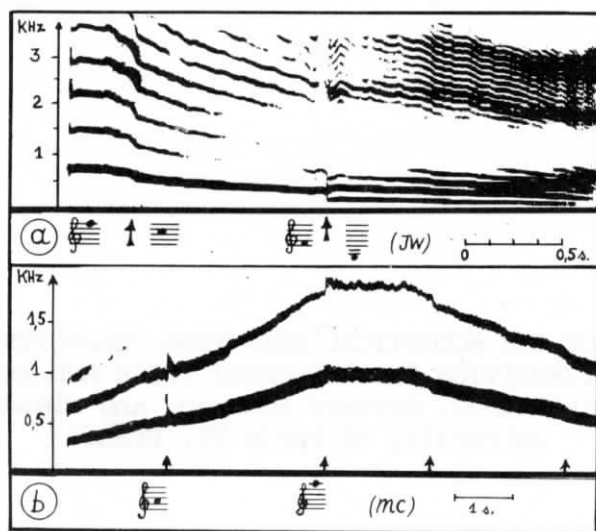


Fig. 1. Glissando over the whole range of the voice. (a) male voice: a bass showing two breaks near 600 and 300 Hz. (b) female voice: a soprano first singing an ascending glissando, then a descending glissando. The sonogram shows two breaks near 880 and 440 Hz. The breaks, also two (marked with arrows) delimit three registers.

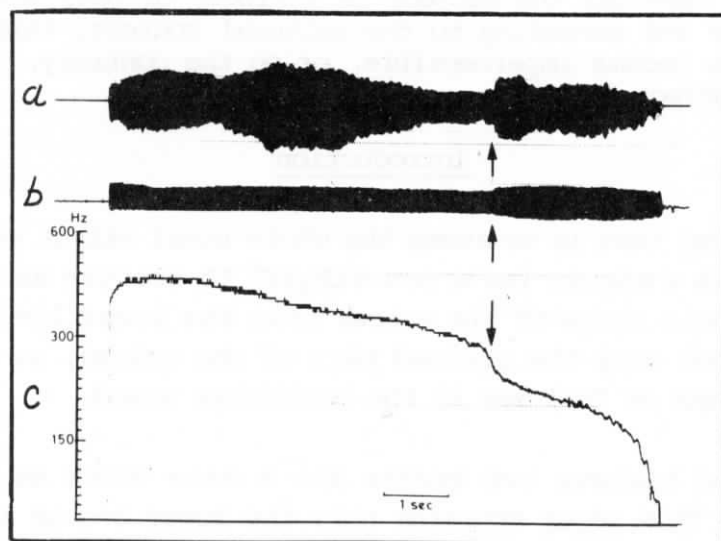


Fig. 2. Study of a descending glissando from a male voice. (a) Sound wave. (b) Electroglottographic curve. (c) Fundamental frequency. One can see a simultaneous alteration of the three curves when the change between the two registers occurs (arrows).

Fig. 2 shows clearly that the break (here not exactly a break but a sudden change of the slope) is related to a change in the glottographic curve. We agree with Garnault (1895), Hirano, et al. (1970), and Hollien (1974) that there are two main registers for men as well as for women.

There remains the difficult problem of choosing terms to designate the registers: first and second, low and high, modal and loft... etc. Arbitrarily we use "PLAIN" voice for all the sounds produced below the break, and "FALSETTO" voice for sounds above this break.

Acoustical characteristics of a break found in a glissando

Let us now look at the acoustical characteristics of such a change between Plain voice and Falsetto voice during a glissando. They can be different depending on whether the singer is trained or not.

Fig. 3 shows two ascending glissandos on the same vowel /a/ from untrained singers, a male and a female, with a jump in the frequency and an important change in the spectra.

Fig. 4 is an ascending and descending glissando from a student singer. At the transition between the registers there is no break but a kink, and a drop in the brightness.

Among the professional singers, those whose voice normally use the two registers, for instance counter-tenor, practice to rub out the transition. Nevertheless, in an example given by a singer from "Les Arts florissants" singing an ascending and a descending scale, we hear clearly the transition as a break and we can see it on the sonagram (Fig. 5). Another example from R. Jacobs is more subtle. When the pitch is descending, we hear clearly a break but we can notice in Fig. 6 that probably consciously the singer changes the colour of his voice one note before crossing the transition. Ascending, the transition is perceivable as a slight change in the legato between the two notes E and F#(MI₃ and

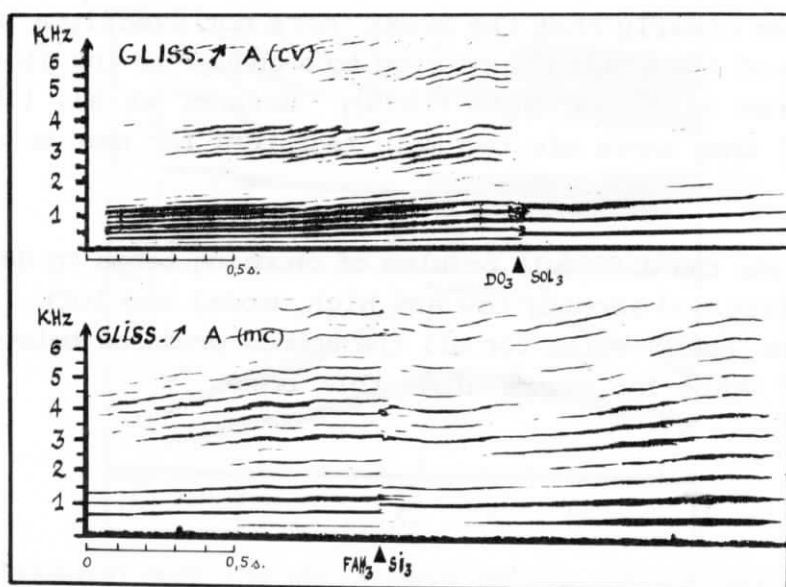


Fig. 3. Sonograms of ascending glissandos produced by two non-trained singers, a male (cv) and a female (mc). The break is clearly visible (arrows): it appears as a frequency jump and a change in the spectrum.

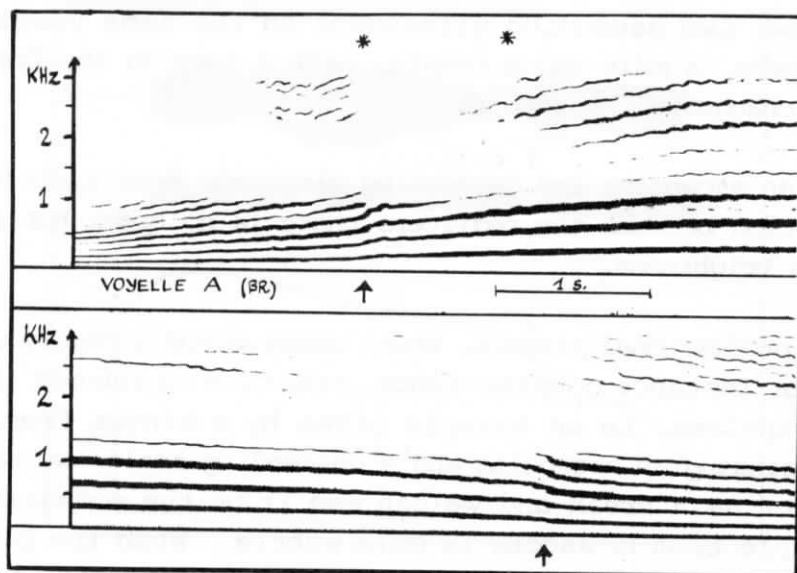


Fig. 4. Sonogram of an ascending and a descending glissando from a student singer: at the passages (arrows) there is no break but a kink and then spectral change perceived as a drop in the brightness.

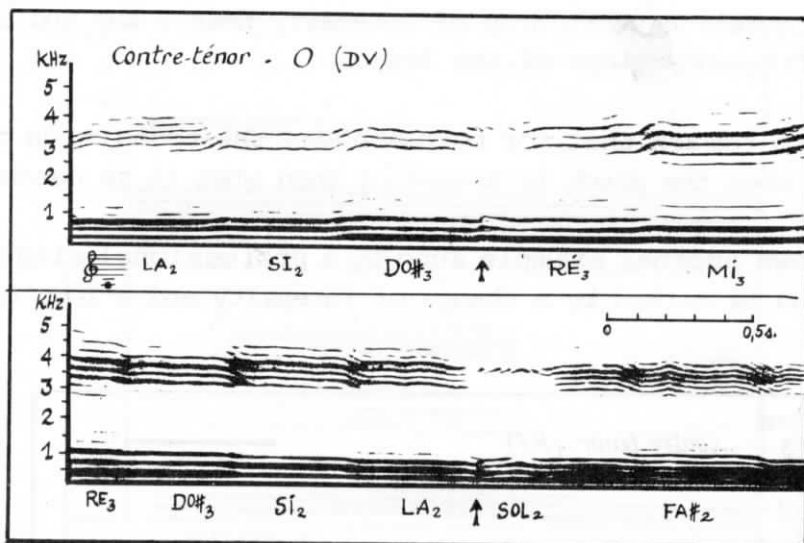


Fig. 5. Sonogram of an ascending and a descending scale from a professional counter-tenor: the spectrum is similar below and above the passage (arrows), but we notice a short drop in the intensity of the harmonics at the passage.

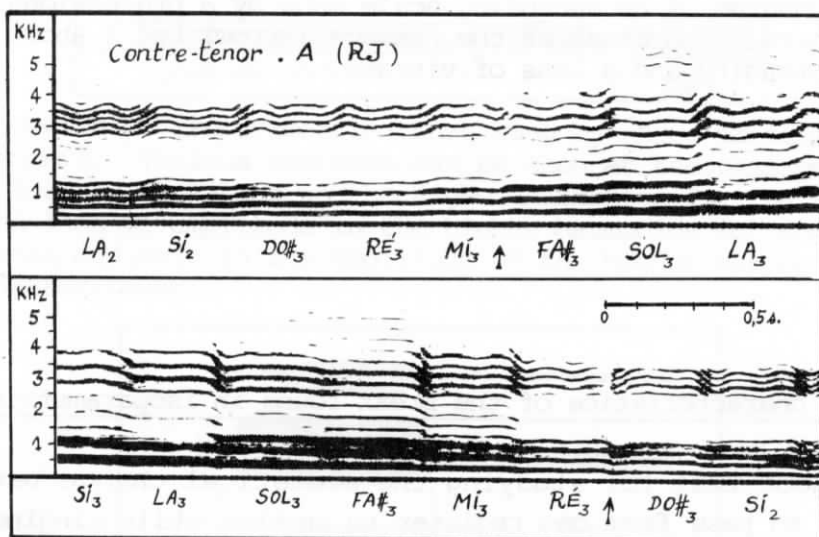


Fig. 6. Sonogram of an ascending and a descending scale by a professional counter-tenor: René Jacobs. At the passage in the descending scale there is an extremely short loss of coherence in the voice: notice that the singer consciously changes the color of his voice one note before the passage. The upper part of the falsetto voice has a different spectrum than the lower part but the change is continuous. The passages are marked by arrows.

FA₃ in the figure): a short drop of intensity near 3 kHz and a modification of the frequency slope of the legato.

Let us also remark that for both singers the transition occurs on a higher note, when the pitch is ascending than when it is descending.

Fig. 7 shows another example sung by a professional singer in which the transition is marked by a change of intensity and a loss of vibrato.

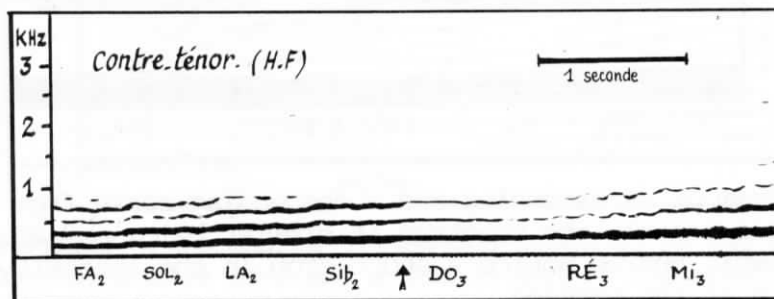


Fig. 7. Sonagram of an ascending scale sung by a professional singer: there is no break at the passage (arrow) but a short drop of intensity and a loss of vibrato.

Acoustical characteristics of the break found in isoparametric tones

Another good test for studying the acoustical change between two registers is to pass from one register to another while singing the same pitch with the same intensity.

We asked three professional singers: a Tenor, a Baritone and a Countertenor, to make this test (Fig. 8).

With the tenor, there is no break but a loss of harmonics in the falsetto voice. With the baritone there is a break and also a loss of

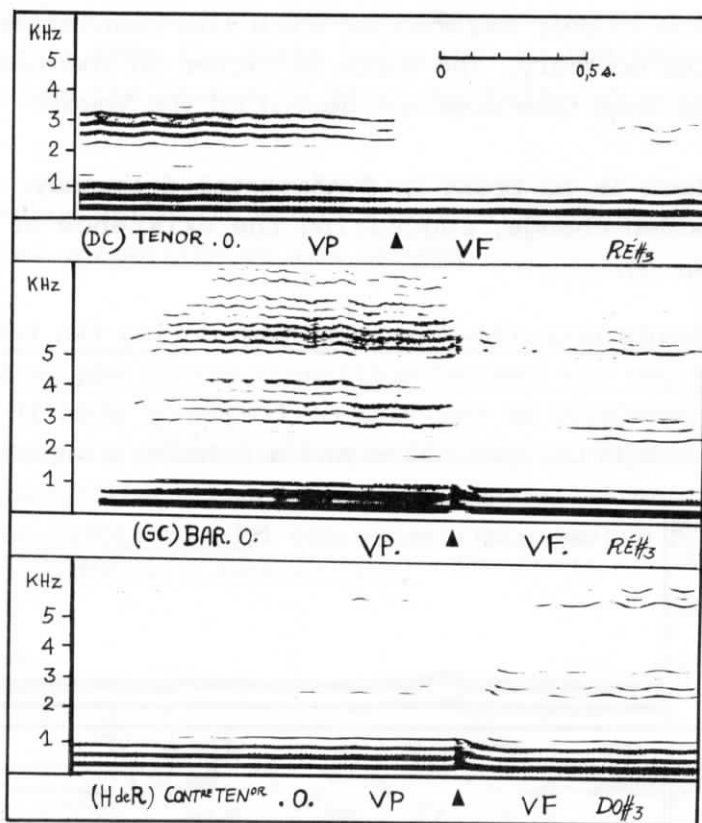


Fig. 8. Sonagram of isoparametric tones sung by three professional singers. Various features can be seen at the passage (arrows): a loss of amplitude in the higher harmonics for the tenor; break and loss of amplitude in the higher harmonics for the baritone; break and gain in the amplitude of the higher harmonics for the counter-tenor.

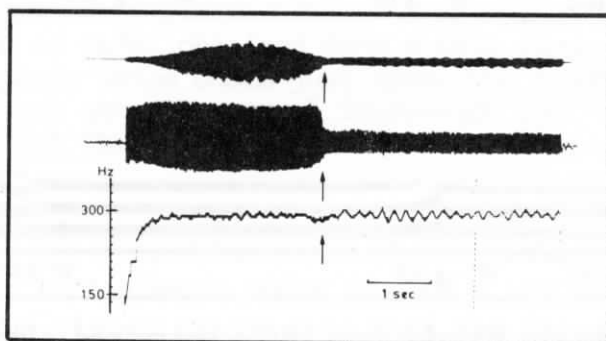


Fig. 9. Sound wave, electroglottographic curve and melodic curve of the isoparametric sound of the tenor (see Fig. 8). There is no break in fundamental frequency but the glottographic curve shows a sudden change, probably related to different laryngeal adjustments.

amplitude of the higher harmonics. With the countertenor there is a break, but on the contrary, the voice is richer in the falsetto register. We have verified that this does not depend on the vowel.

Even when there is no break in fundamental frequency, the glottogram does show a sudden change, suggesting the existence of two different mechanisms (Fig. 9).

Some comments upon the frequency jump during the transition

Let us look carefully at the jump of frequency when it does occur. In Fig. 10, three subjects, two males and a female, sing the same note on

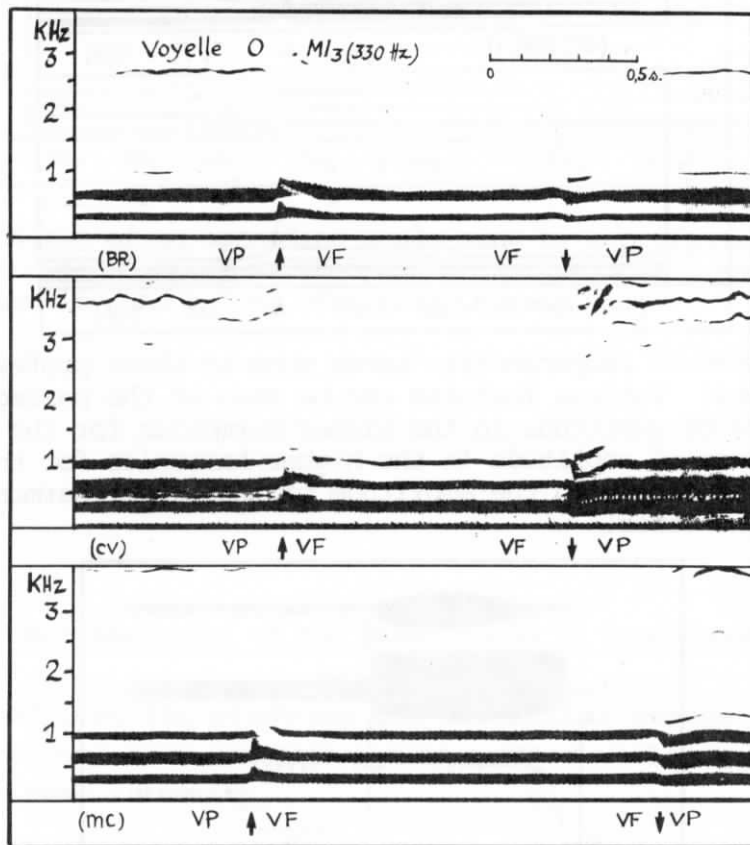


Fig. 10. Isoparametric sounds from three untrained singers (2 males and a female) singing the same note on the same vowel: the jump in fundamental frequency at the transition (arrow) occurs upward when the change is from the plain voice (VP) to the falsetto voice (VF) and downward when the change is from the falsetto voice to the plain voice.

the same vowel: the frequency jump during the transition occurs UPWARD when the change is from the plain voice (VP) to the falsetto voice (VF), and DOWNWARD when the change is from the falsetto voice to the plain voice.

This phenomenon seems to be quite general and supposedly related to the physiological properties of the larynx.

Musical use of the transition between two registers

Contrary to the classical technique of singing, there are examples of the musical use of the break such as the yodel. Sonagrams of African yodel as well as Tyrolian yodel are similar to the one shown in Fig. 11, which was obtained from a folk singer.

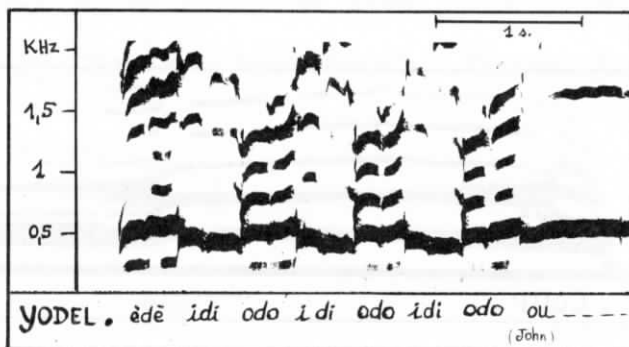


Fig. 11. Sonagram of yodel obtained from a folk singer: the second harmonic of the plain voice comes just above the fundamental of the falsetto voice: one gets the visual impression that the plain voice is higher than the falsetto voice.

We remark that the second harmonic of the plain voice is just above the fundamental of the falsetto voice in such a way that, at first sight, you could have the visual impression that the falsetto is at a lower pitch than the plain voice. The weakness of the fundamental in a plain voice compared to the dominance of the fundamental in a falsetto voice is emphasized by the change of vowel, which probably helps the voice to jump across the transition.

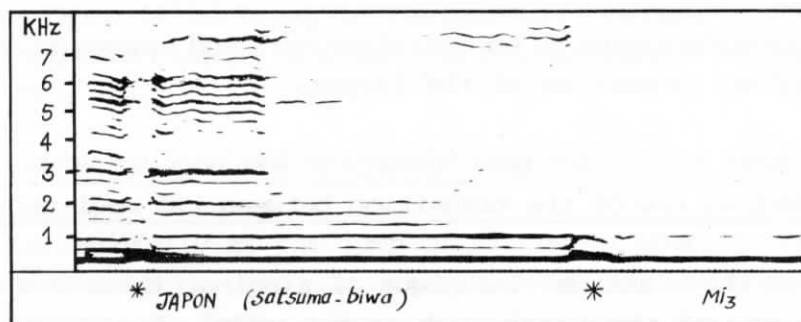


Fig. 12. Sonagram from a Japanese singer using as a musical effect the change of register on the same note: one can see a sudden change of color simultaneously with a short controlled upward jump of pitch.

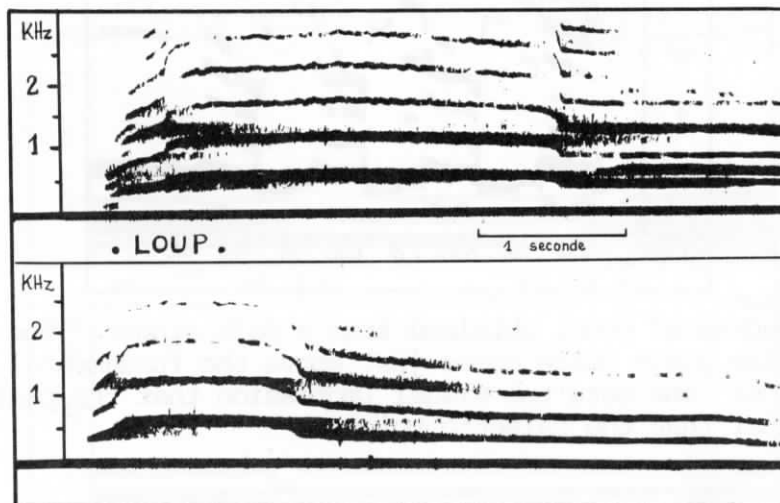


Fig. 13. Sonagram of wolves' cries including examples of breaks.

A Japanese singer was found to use a sudden change in voice colour as a musical effect simultaneously with a jump in fundamental frequency (Fig. 12).

Conclusion

The passage between the two main registers is a quite general feature which can be assumed to be related to a mechanical change in the vocal folds. The register break does not seem to be limited to the human voice: similar breaks can be found in the cry of wolves, for instance (Fig. 13).

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