# The timbre of the voice as perceived by the singer him-/herself

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## ABSTRACT

### Background

The unfamiliarity when listening to the recordings of our own voice is probably caused by the different route the sound takes to the hearing system. When we listen to someone else's voice, only an air conduction component is present, but when we hear our own voice, it also includes a bone conduction component (Békésy, 1949). There have been attempts to specify the transfer function of our "inner hearing". In the experiments of Shuster and Durrant (2003), the participants generally preferred low-pass filtered speech, but the investigators were unable to determine the transfer function. Won et al. (2006) used a ceramic piezo-electric transducer for registering the bone component of the sound and concluded that a speaker's/singer's voice is heard as a substantially low-pass filtered signal. Pörschmann (2000) measured the transfer function for the direct diffracting sound component from the mouth of the speaker to his/her ear canal and estimated the parameters for bone conduction transfer function indirectly by using the masking phenomenon. He found that bone conduction dominates the perception of a person's own voice for frequencies between 0.7 kHz and 1.2 kHz. In all aforementioned experiments the possible influence of stapedius reflex (SR) to the hearing was not taken into account. The investigation of SR-s detailed frequency characteristics (by measuring cochlear microphonic potential) has mainly been done on cats as it needs an invasive operation (Pang et al., 1986).

### Aims

The aim of the present research is to estimate the goodness of seven possible transfer functions which are based on different hypotheses as to how the vocalist perceives his/her voice timbre during singing.

### Method

Each participant from the group of 15 classically trained singers was asked to sing small vocal tasks at various pitch levels and on two vowel successions (/a-o-a-o/ and /i-e-i-e/) with full supported voice. The performances were recorded at the studio with low reverberation time. Seven timbral modifications of these recordings were prepared by digital filtering, each of which corresponded to a certain hypothesis about the shape of corresponding transfer function. The modified recordings of the participant's voice were played repeatedly back to him/her in random order and the participant was asked to estimate how similar the timbre was to his/her voice as perceived during singing.

### Results

The participants most often preferred the modifications where the construction of the transfer function, the shape of which resembled that of trapezoid, was based on the data from Pörschmann (2000) combined with the frequency response data known about stapedius reflex. The modifications least often preferred by participants were: those which were based only on Pörschmann's transfer function; those on which only low-pass filtering was applied; or those on which the filtering was not used.

The preferences of participants did not depend on the vowel succession or on the used pitch region.

### Conclusions

The shape of the transfer function which characterizes how we perceive our own voice resembles the trapezoid or band-pass filter. The timbre of self-perceived own voice depends on the frequency transfer characteristics of the air and bone conduction components, but also on the change in the hearing system itself due to the triggering of the stapedius reflex.

### Keywords

voice, timbre, hearing, singing, stapedius, reflex

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