Aesthetic Perception of the Singing Voice in Relation to the Acoustic Conditions

The subject of study is the analysis of the timbre of solo singing voices in audio recordings depending on the acoustic conditions of the performance spaces. Halls in which live music is performed without additional sound system differ from each other, both in terms of functionality and in terms of physical and acoustic characteristics. Different spatial conditions affect the listener as well as the music performer. At the same time, they are both adapting to some extent. Listener with perception, and the singer, at times, with the mode of phonation.

The recordings subject to this study feature solo performances of three Slovenian professional opera singers, with different voices - tenor, baritone and bass. For the needs of this study, they recorded a series of basic vowels of the Slovene language on the tone in the passage zone (it. zona di passaggio), twice in two spaces, with different acoustic characteristics: namely in the halls of KD Franc Bernik Domžale and Slovene National Theatre Opera and Ballet Ljubljana.

The principal objective of the study is to answer the question of how professional opera singers respond to different acoustic conditions of the performance spaces and to find out whether a timbre analysis of male singers from recordings gives adequate results for forming conclusions concerning the aesthetic and vocal technique parameters of their performances in different acoustic conditions. Based on the theoretical knowledge of acoustic properties of the singing voice and using the empirical analysis of the timbre it aims to verify the hypothesis that the singer adjusts the acoustics of the vocal tract depending on the acoustic conditions of the performance space. Thus it aims to show one of the approaches to explaining the principles of phonation and perception of vocal timbre in space.

Given the theoretical starting points, the methodology for the treatment of selected sound patterns was determined, in particular the determination of the appropriate frequency range for analysis, in terms of their technical quality and acoustic characteristics of the singing voice and its appearance in the space. A method for analyzing the acoustic properties of halls and timbre analysis of audio recordings was also determined.

The acoustical-geometric properties of the performance spaces were verified by use of sound ray drawings of the first reflection, or even the second or third reflection in the case of returning of the emitted sound back to the area of the singer. For halls, the reverberation times were estimated by calculation and measured as the indicators of the frequency characteristics of the performance spaces. Some parameters for evaluating the acoustic properties of the halls in question were determined: cubic volume per listener, space proportions, the difference in the path of the direct sound and the first reflection, the average absorption coefficient, the diffuse-field distance, and the bass ratio.
After repeated listening, sound samples and cut portions of individual singers’ audio recordings to use in the spectrographic analysis were chosen. Commented and compared are the most characteristic or, the most prominent patterns by the author’s choice. Computer readouts of power spectra and vibrato characteristics were used to analyze the harmonic series of timbre and the vibrato parameters of the performers.

The results of the singers’ sound readouts were broken down, causally – from the point of view of the vocal technique and the acoustics of the vocal tract, and consequently – the influence of the mode of phonation on the sung sound (harmonic partials, the position of the formants, etc.). The fundamental frequency, harmonic series and its relative strength, formants that support certain harmonics and the possible presence and position of cluster in the area of the singing formant, essentially influence the color of the singing voice and together with the vibrato largely determine its character.

The results thus obtained, in connection with the sound impression, served as the basis for determining the type of voice and different ways of vocal tract – resonator tube tuning for a particular singer, as well as for evaluating the singing sound and the vibrato in the context of the acoustic characteristics of the performance spaces. From the interpretations of the diagrams and results in the comparative tables, as well as through the listening of selected audio samples, we can discern the similarities and differences in the approach to the tuning of the vocal tract of individual singers.

The analyses of the power spectra and the vibrato parameters in most cases coincide with the perceptual estimates of individual audio recordings, i.e. with the aesthetic perception of the singing sound and as such a welcome aid in determining the causes and consequences of the formation and perception of the singing sound. In this way, through the listening of audio recordings and the proper interpretation of the results of measurements, we can determine the region, timbre and character, and conclude on the type of voice and, in part, its capacity and absolute strength in given space.

By knowing the vocal technique and the acoustic characteristics of the singing instrument and the performance space, we can thus use the visual representation of the singing voice to strengthen the auditory image of the timbre and character of the individual singing voice, which further enables us also to indirectly determine the method of the singer’s phonation, in particular the role of individual articulators in the tuning of the vocal tract, and partly the character of the tone onset and the body support (it. appoggio).

An experienced observer is able to evaluate the level of interpretation of a certain musical substance at the very moment of listening, and to extract the individual aesthetic characteristics of its performance (intonation, rhythm, expression, intensity, timbre, character; vibrato, tremolo, legato, portamento etc.). With the empirical exemplification, these characteristics become even more evident.

When it comes to professional opera singers, they tend to adapt well to different spaces, but they also adjust their phonation in accordance with various acoustic properties of the hall, especially in the case of singing of the vowel “a”. This is achieved by consistent use of the body support and tuning of the vocal tract, both with the help of varying lowered larynx positions, and by adjusting other articulators, depending on the pitch and the produced vowel. The singers are changing geometry of the vocal tract
and thus adjust its acoustic properties practically for each separate tone. In this way, they try to merge the timbre of the separate positions of the vocal range (fr. voix mixte) and thus acoustically approach the “western ideal of beautiful singing.”

Comparisons of singers’ singing in various acoustic conditions therefore in part confirm the hypothesis that the singer adjusts the acoustics of the vocal tract not only in terms of their own dispositions and the characteristics of the performed music, but also depending on the acoustic conditions of the performance space.

Bearing in mind the possible deviations due to different spatial and other conditions and the technique of recording, the power spectra graphs are sufficiently illustrative. Therefore, the answer to the question whether vocal timbre can be reliably analyzed by the sound recordings in different performance spaces, is certainly affirmative. Based on this kind of analysis, this can be concluded not only about the aesthetic level of interpretation and the aesthetics of the singing voice, but also about some elements of the vocal technique of the singers in given acoustic conditions.

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