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14. INTERDISCIPLINARY APPROACH TO ASSESSING THE ACOUSTIC QUALITY OF VIOLINS

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Abstract: *The paper presents the interdisciplinary approach to assessing the acoustic quality of violins through a survey addressed to specialists in the field of music - instrumentalists, teachers, artists. Violins with modified geometric parameters in intermediate stages from a technological point of view were investigated, respectively unfinished violins (in white). The aim of the study was to classify the musical instruments heard according to five acoustic criteria considered relevant for violinists. Criteria such as: bright tone, clarity of sounds, warm/silky sound, amplitude of sounds and equal sound on all 4 strings were also established through a survey of artistic impressions among specialists, in a stage prior to the study presented in this article.*
Key words: *acoustic quality, violin, questionnaire, interdisciplinarity*

1. Introduction

The violin body composed of the top plate, the back plate, the ribs and the counter-ribs has the acoustic role of amplifying the musical sounds emitted during the friction of the bow on the strings. This subassembly is constructed so that the top and back plates operate as a membrane, capable to transmit vibrations and to amplify them. For strength reasons, the violin body also contains constructive elements that secure the two plates (by means of the counter-ribs and corners) and also elements which support and fix the violin neck. The plates have a spatial shape both in longitudinal and transverse direction [1, 2]. Their thickness varies from the centre (the area between the f-holes) towards the edges (Fig. 1). The violin neck has the role of ensuring the required string length. It also an aesthetical role, being provided in the keys area with a carved shape - generally a scroll, usually made of ebony wood. The tailpiece and the keys have a functional role ensuring the fastening of the strings. The bridge and the saddle ensure the optimal distance between the strings, the tongue and the violin body. Part of the vibration energy is transmitted through the bridge to the top plate and the fluid inside the violin body.

Between the top plate and the back plate, a soundpost is positioned, that has both an acoustic role – that of transmitting vibrations - as well as a resistance role – to ensure the stability of the top and back plates, next to the longitudinally bar, fixed asymmetrically to the left of the instrument). The string begins to vibrate

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both transversally - in the direction of the force applied by the bow, and longitudinally - along the string. The transversal vibrations are transmitted through the bridge to the top plate of the violin and further to the entire air volume inside the violin body [3–6]. The violin body behaves like a Helmholtz type resonator, forming compression and dilation waves between the top plate, the back plate and the ribs, giving rise to intense sound. The intensity of the sound, the acoustic pressure and the timbre of the violin are closely related to the body's ability to vibrate and amplify the sounds. That is why increasing the volume of air inside the resonator box, by changing the thickness of the plates as we propose through the innovative models from the project, lead to improve the acoustics of violins. The violin is a very complex musical instrument, consisting of over 60 components. The manufacturing technology comprises more than 80 operations, which rely both on modern processing techniques, and on manual craftmenship gained over many years of experience, especially in the case of Maestro violins (Cotta, 1983).

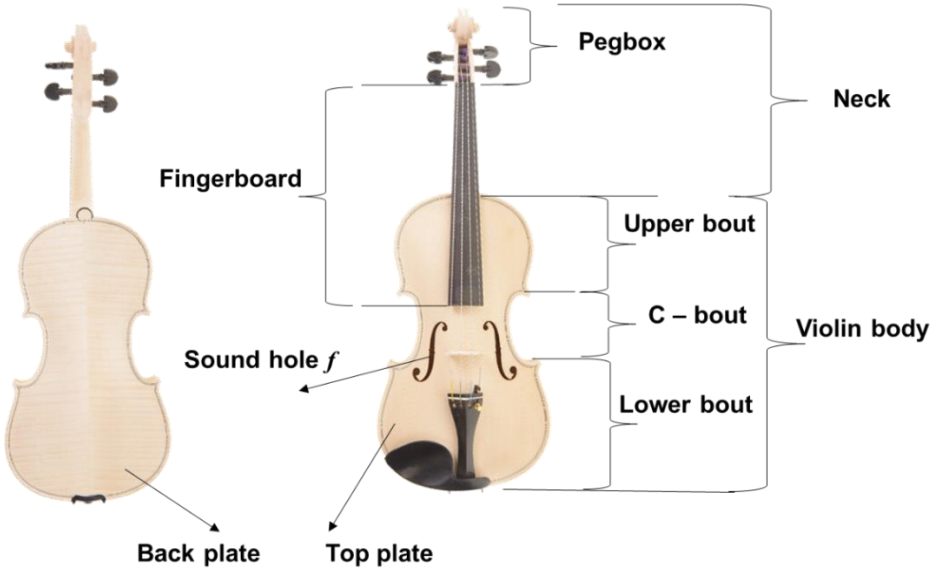


Fig. 1. The main parts from violin structure

The objective of this study was to evaluate the acoustic quality of 14 violins with modified geometric parameters, the evaluation being performed based on listening to a musical fragment by the musicians/instrumentalists participating in the survey.

2. Description of the structures studied and the method

2.1. Studied violins

For this study, seven violins were manufactured, having seven different categories of thicknesses: thus, the nominal thickness (noted by 00) was set to be the thickness used for the current construction of violins at the factory of musical instruments S.C. Gliga Instrumente Muzicale S.A. The coding of violins is based on the following principle: the first letter represents the anatomical quality class of wood (A), the following code represents the type of thickness (0 - nominal thickness used in the current production of violins; P - increased thickness; M - reduced nominal thickness); the figures represent the tenths with which the nominal

thickness has changed (2; 4; 6 - represents the quantity 0.2; 0.4; 0.6 mm which was reduced or added to the nominal thickness). In Fig. 2 are presented the cross-sections through the studied violins using computer tomography (denoted CT) from the Laboratory of Radiology and Medical Imaging, Faculty of Veterinary Medicine of Cluj-Napoca. The unvarnished violins have the codes: A00C1, AM2C1, AM4C1, AM6C1, AP2C1, AP4C1, AP6C1 (Fig. 3).

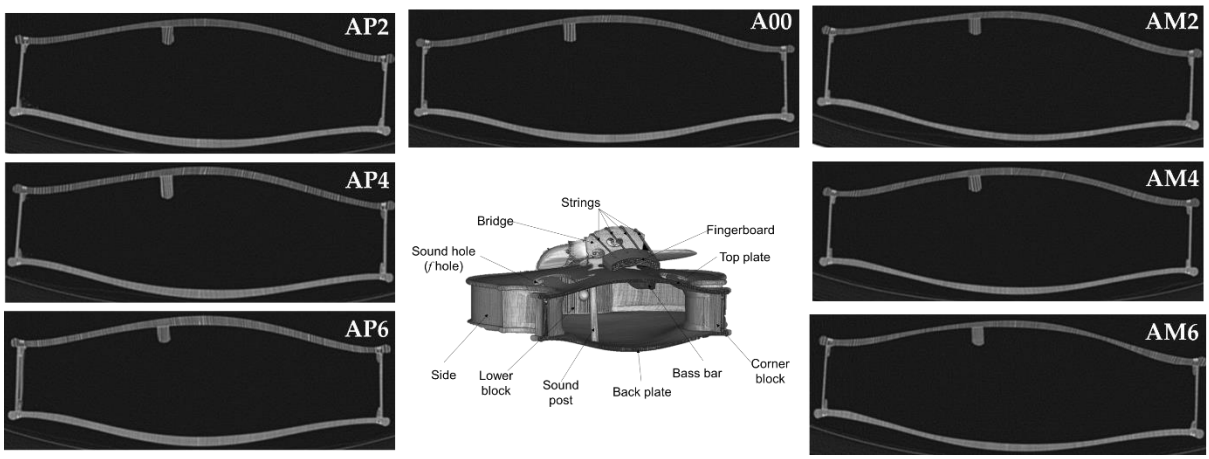


Fig. 2. Violins cross sections by means of computed tomography analysis



Fig. 3. The analyzed violins (courtesy of S.C. Gliga Instrumente Muzicale S.A.)

2.2. The methods

2.2.1. Acoustic recording

In the first stage, the white violins were recorded, and after their varnishing, after about 6 weeks, the finished violins were recorded. The acoustic recording of the violins was made in the concert hall of the Brasov Philharmonic, and the musical performance for all violins studied was provided by Nauncef Alina Maria, first violinist at the Brașov Philharmonic and teacher at the Faculty of Music, Transilvania University of Brașov. The performed musical fragment consisted of four parts and was performed on all 14 violins:

- the first part consisted in the excitation of the open strings with the bow (Sol (196 Hz), Re (293.7 Hz), La (440 Hz), Mi (659.3 Hz)).
- the second part consisted in the excitation of the open strings in Pizzicato style (pinching the strings)
- in the third part, an excerpt from Max Bruch - Concerto no.1 in G minor op. 26, PI (first cadence of the solo violin) was played

Representative of the Romantic musical period, Max Bruch was a violin teacher, conductor and renowned German composer, who composed no less than 200 works and dedicated 3 concerts to the violin, which are part of the universal

repertoire of all violinists. Violin Concerto no. 1 in G minor, op.26, composed in 1866, is one of the most famous and performed concerts of Romanticism, approached by famous pupils, students and soloists. The choice of this fragment was due to the fact that, in addition to the seductive and sinuous melody, the first cadence includes a wide range, starting with the lowest tone of the violin, gradually passing from the G string to the D string, where it stops on the octave of the first beginning sound, to continue on the A string and then ending the musical discourse on the fermata on D from the third position, on E string. So, the composer chooses from the very beginning that the melody of the violin cadence goes through all the 4 timbres specific to each of the 4 strings of the violin. In this sense, by recording this first cadence, one can reach much clearer conclusions regarding the equality of the sounds of the strings, the sonorities, the dynamics and the timbre of each violin that is recorded (Fig. 4).



Fig. 4. The musical fragment Concerto no.1 in G minor op. 26: First Candence of the Concerto for violin and orchestra no.1 in G minor, op.26 (Recording III)

In part four, an excerpt from *Jules Massenet* - Meditation for violin and orchestra from the Opera Thaïs was played French composer, representative of late Romanticism, who was very successful both during his life, and after his death, only after 1970 he was rediscovered and his musical creation was recognized and performed. He dedicated himself entirely to the genre of opera, where passionate style, lyricism, drama, are very important characteristics. The opera Thaïs, composed in 1894 is one of the representative works of the composer, the work that also includes the famous "Meditation" for violin and orchestra, which is a very important work in the violin repertoire. When choosing the short fragment from the Meditation of Thaïs, the lyrical character, which implies a warm, penetrating and sweet sound, which enhances any violin, be it new, master or heritage, weighed a lot. No wonder that this delicate and beautiful song is found in the repertoire of all violinists, but also of almost all musical instruments, for which transcripts and arrangements have been made. The beginning fragment of the recording includes the first 8 bars of the violin, bars that are interpreted, according to the indications of expression of the composer, only on the two strings A and E. This short fragment of Meditation was chosen precisely in order to be able to follow the differences between the violin sounds recorded on these 2 strings from the middle and high register of the violin.



Fig. 5. Measures 1-10 - Meditation from the Thaïs Opera by J. Massenet

Both recordings are composed in the Romantic style. The two works were composed at a distance of 32 years. Although the 2 works belong to the same stylistic period, differences can be observed between the German school (whose representative was M. Bruch) and the French school (Jules Massenet): the diversification of rhythmic formulas (at Massenet); changing registers by using large intervals (at Massenet); in Bruch the phrase has a conclusive character, unlike Massenet where the phrase is open having continuity to the next sentence (the width and continuity of the musical phrases are much more obvious in Massenet).
The location of the sound generation and recording equipment was done according to Fig. 6, marking the position of the violinist and the microphone stand, in order to maintain the same positions throughout the tests. The professional recording equipment (24 bits, 48000hz) and the special AKG microphone for sounds emitted by the strings were provided by the company A.P. Studio Brasov. The musical fragment composed of the 4 parts lasts about 1 minute, so that the 14 violins can be evaluated, in optimal psychoacoustic conditions.

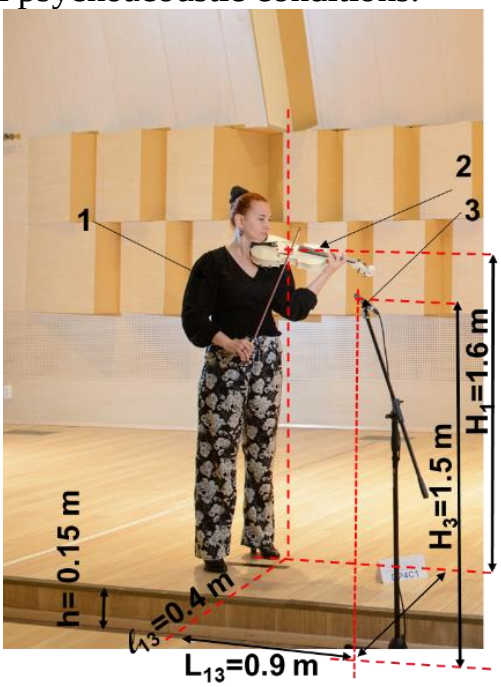


Fig. 6. The relative position of the performer (1) and the violin (2) in relation to the recording equipment (3)

2.2.2. The acoustic quality evaluation survey

The survey was developed in order to evaluate the acoustic qualities of the violins. The questionnaire was completed by experts in the field (composers, performers etc.), after the audition of the musical sequence [5 – 8]. The questionnaire used consisted in awarding grades from 1 to 5 (where 1 - represents the lowest acoustic / worst quality level, and 5 the highest acoustic / excellent quality level), for the following criteria of artistic impressions: sound clarity; warm sound; bright tone; amplitude of sounds; equal sound on strings, criteria that were in turn established on the basis of a survey of opinions to which the respondents were violinists.

From an artistic point of view, the **bright and strong tone** refers to the

quality of the sound produced by the instrument, a sound that is very penetrating and open, being able to cover a large performance hall with the harmonics produced. The **sound clarity** is determined by the vibration of the strings that produce very clearly identifiable, isolated sounds, without mixing with the vibrations of other sounds. The **warm, silky sound** is that velvety sound that caresses the hearing and that determines a relaxation and pleasure to the listener. A violin can have both warm, silky and bright sounds, depending on how the musical text is interpreted. But there are also instruments that have soft and warm sounds, but which have the disadvantage of not entering large concert halls. The **amplitude of sounds** refers to the way in which the sounds of the violin are able or not able to go very far, being capable to cover larger or smaller rooms. It all depends on the amplitude of the wave and the distance between the points with the highest vibration and it is measured in units of measurement called decibels (dB).

Equal sound on all 4 strings - to determine that a violin is sound-wise equal on all 4 strings, each string is played, one by one, with the same pressure and bow speed, while listening very well if all strings respond the same, with the same color, the same timbre and the same intensity [9]. It is also observed if each of the 4 strings responds just as easily, with the same minimum of effort. The online questionnaire was developed using the Google Forms. For each music sample recorded with each violin, selection boxes in the form of a grid with 5 rows (criteria) and 5 columns (grades) were generated. Additionally, questions on artistic experience, artistic field, gender and age category were added. The survey was completed by the voluntary action of the respondents, whose distribution by gender, age and experience is presented in Table 1.

In the first stage, for each parameter and each violin, the average of the marks given by the respondents was calculated, obtaining a ranking from the point of view of the audience experience, gender and age, for each violin and acoustic criterion assessed. Then, in order to achieve the ranking regarding the acoustic quality of the violins, the averages obtained by each violin in relation to each acoustic criterion were comparatively analyzed. Finally, the global ranking on the acoustic quality of the violins was calculated by summing the averages of the marks given to all the criteria for each violin.

Tab. 1. General information on the participants in the study

Male	10						
Female	21						
Age category	<17	18-24	25-34	35-44	45-54	54-65	>65
No. participants	0	9	7	7	3	3	2
Experience	<5	6-10	11-15	16-20	21-25	>26	
No. participants	0	3	4	9	5	10	

3. Results and Discussions

The five acoustic characteristics of sounds presented in section 2.2.2 were evaluated after the data from the surveys was processed. In Figure 7 can be seen the evaluation of the violins studied according to the analyzed parameter. In terms of sound clarity, the highest values were obtained by violins AM4C1, AP2C1,

AP6C1, values over 3.9 points. The lowest rated were the violins, AM2C1 and AM6C1 (3.23 - 3.29).

• The evaluation of the warm sound of the violins led to the following result: the violins rated with warm sound are: A00C1, AP4C1, AP2C1, AP6C1, (over 3.5 points), and the weakest values are registered in the range 3.3 - 3.4 (AM6C1, AM2C1 and AM4C1).

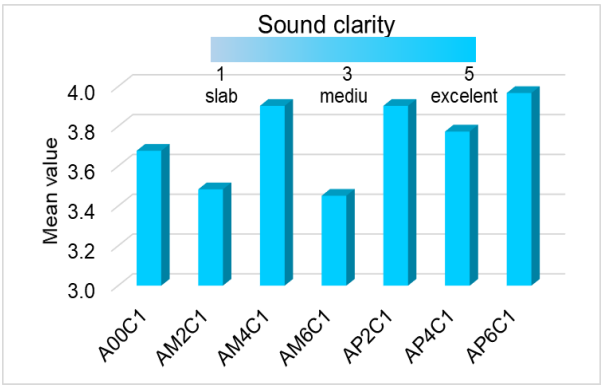
• The bright tone was appreciated with high values for the violins AM4C1, AP4C1, AP2C1, AP6C1, while the violins A00C1, AM2C1 were evaluated with the lowest scores (3.25 - 3.29).

• In terms of sound amplitude, the highest values were obtained by violins AP6C1, AP4C1, AP2C1, and the lowest, by violins A00C1, AM2C1 and AM6C1.

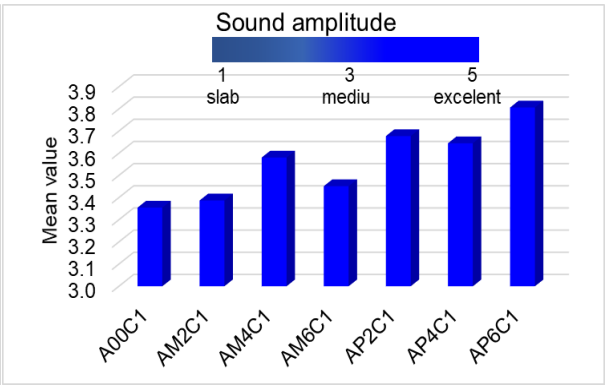
• The equal sound on the strings was appreciated with high scores for the violin AP6C1, then with lower values, the violins AP4C1, AP2C1, AM4C1, A00C1, while the violins AM2C1 and AM6C1 obtained the lowest scores.

From the point of view of the total ranking, the analyzed violins - unfinished maestro are ranked above the average acoustic quality, respectively with scores between 67 and 76% of the maximum score that expresses excellence. Thus, the best ranked are the violins AP6C1, AP2C1, AP4C1, AM4C1 with scores over 70%, and the lowest rated are AM6C1, AM2C1 and A00C1.

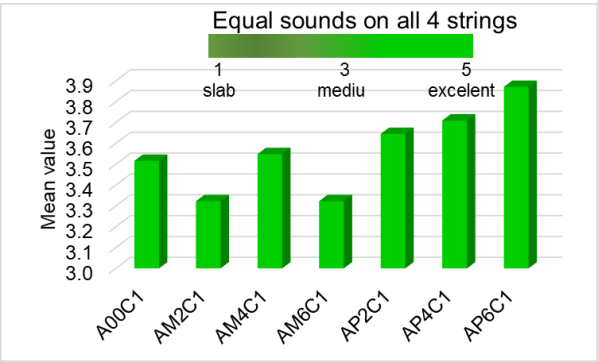
In the end, an overall "score" of the combined acoustic quality of the violins is highlighted in Figure 7f, where you can see the ranking of all the violins in the study.



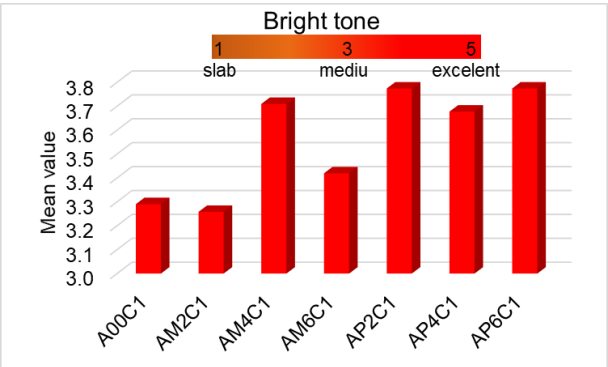
a)



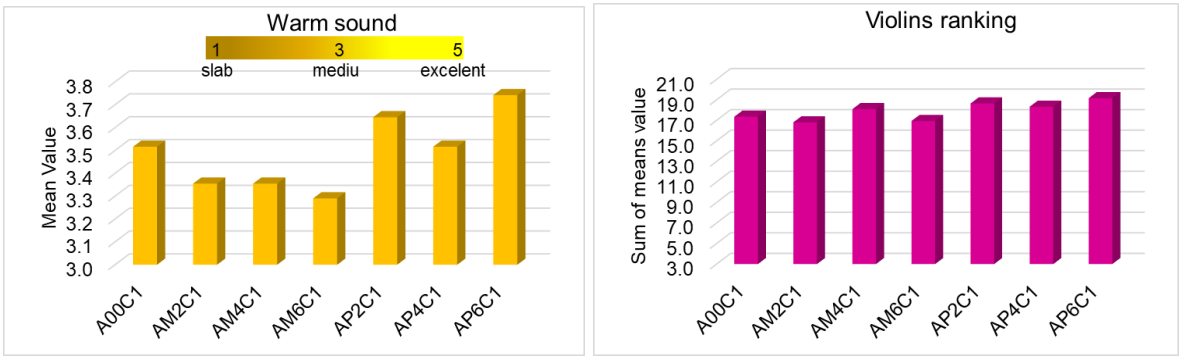
b)



c)



d)



e) f)

Fig. 7. The acoustic characteristics for each violin, on a scale from 1 to 5

4. Conclusions

The paper presents the psychoacoustic researches performed on 7 violins in white (without varnishing), having the modified thickness compared to the reference thickness. The aim of the research was to identify the acoustic quality of geometrically modified violins based on the acoustic evaluation by artists through musical audition of the same melodic passage performed on all studied violins by the same performer. In addition to the results presented - strictly from the perspective of classifying violins according to the analysed criteria, the survey method also highlighted aspects related to the degree of exigency of the auditor according to experience, gender, age.

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