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PSYCHO-ACOUSTIC ASSESSMENT OF VIOLINS WITH DIFFERENT ANATOMICAL FEATURES OF WOOD

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Abstract: In this paper, the manufacturing technologies of violins, followed by a study on the psycho-acoustic evaluation of violins with different anatomic structure of wood are presented. The evaluation was performed by music experts (performers, teachers, students) based on music auditions of excerpts recorded on the violins studied. The musical performance was performed by the same violinist, under the same conditions. Respondents rated five acoustic criteria. The statistic results showed that age, experience, gender influence the acoustic perception and also that the geometric characteristics of the violins produce different acoustic impressions.
Key words: acoustic assessment, violin, wood.

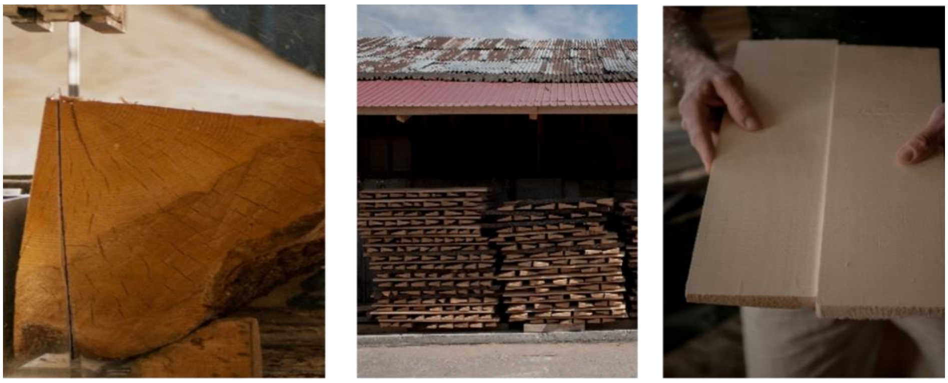
1. INTRODUCTION

In the production of violins, the selection of wood material is a fundamental requirement for ensuring the acoustic quality of the musical instrument. Following the mechanical processing of the constructive elements of the violin, the quality of the resonant wood is enhanced by their geometry and dimensional accuracy [1–3]. At the end of the production process, the instrumental artists are the ones who establish the acoustic quality of the instrument depending on the experience, personality, age, the way of artistic expression. Thus, numerous studies have shown that the choice of musical instrument is based on many criteria, such as: acoustic, constructive, ergonomic, brand, etc., [4–8]. In other studies, the acoustic perception was compared with the visual one in order to validate or invalidate the idea that the old violins have a superior acoustic quality to the new ones. Applying a blind test, in which the respondents did not see the violin, it turned out that their preference, from an acoustic point of view, was directed more towards the new violins than the old ones, [3]. In other research, the effect of acoustic changes (especially changes in the frequency response of the violin) on the perceptual qualities described in words by the respondent was studied, [4].

The paper presents the results regarding the acoustic impressions of the instrumental artists participating in an opinion poll, based on the musical audition of the violins studied. In addition to evaluating their acoustic quality according to the quality class, the acoustic preference according to gender and experience in the artistic field of the participants was studied.

2. THE MANUFACTURING TECHNOLOGY OF VIOLINS

Although it is considered that the violin has reached its architectural perfection with the famous productions of the Cremona violin school, constructive improvements are still possible, which will improve the sound performance of the instrument. 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 craftsmanship gained over many years of experience, especially in the case of Maestro violins. The dynamic response of plates greatly depends not only on wood species, but also on its shape and the mass of the plates. In a previous study, the violin plates from different wood species were dynamically tested [9]. In some new technological operations, manufacturers are always trying to establish a way in which wood yield is improved, starting with wood sorting and establishing the functional role of each piece of wood resulting from primary cutting and ending with wood finishing processes. A brief presentation of the technological sequence of operations specific to violin making is illustrated in figure 1. First, the wood is split radially (figure 1, a). The pieces obtained are called the blanks and are stored for natural drying for at least 3 years (figure 1, b). Kiln-drying must be avoided as much as possible because even mild kiln-drying conditions cause internal stresses and phenomena at the microcellular level that destroy the acoustic qualities of the resonance wood, [10]. However, in temperate climate zones natural air drying of the wooden cell walls cannot eliminate bound water rapidly at ambient temperatures. Long term drying is necessary taking about 10 years, for high quality of musical instruments. Therefore, kiln-drying should be employed in the final stage of drying blanks, in order to reduce the wood moisture content of the raw material for violins to a final moisture content of (6-8)%, [11]. Two symmetric blanks side by side are glued along the maximum height in order to achieve a symmetric anatomic structure of violin plates (figure 1, c). After conditioning by air drying, the plates are cut to the shape of the violin plate (figure 1, d). The thickness profile is carved in the violin plates (figure 1, e). The top plate is provided with two "f-holes" (figure 1, f) which ensure the flow of air from and in the cavity of the violin box. A resonance bar (made of resonance spruce wood) is glued on the inner side of the top plate for stiffening it (figure 1, g). In parallel, the ribs (figure 1, h) and linings are manufactured from resonance spruce wood. The ribs are consolidated by means of block-type elements made of spruce wood (figure 1, i). Their role is to enlarge the gluing surface between the violin plates and the linings, and in the corners (peaks). Then the ribs and linings are glued to the top and back plate (figure 1, j). In this way the violin body is created. A thin groove is then cut along the outer contour of each plate, for the so-called “purfling” (figure 1, k). This is usually made of three veneer layers. The last part of the violin to be processed is the neck. The violin neck consists of a single maple wood product, having the functional role of ensuring the string length. It is provided with four peg holes, and, for aesthetic reasons, a spiral shape called the "scroll" is carved at its end (figure 1, l). The fingerboard (tongue) is made of ebony wood, and has the role of ensuring different string lengths as a result of pressing the strings during the musical performance. It has a fixed part, glued to the neck (figure 1, m), and a free part, above the violin body. Ebony wood is chosen for the fingerboard not only for aesthetic reasons, but also because it is a wear-resistant species with high density and hardness, which ensures the necessary rigidity. At the end of the neck, a small piece called the “top nut”, also made of ebony wood, is glued to the neck (figure 1, n). Its role is to ensure the height of the strings relative to the neck and the violin body. After cutting to appropriate dimensions and sanding of the lower part of the neck called the “handle” (figure 1, o), the neck is ready to be fixed to the violin body. This is achieved by gluing it to the upper block, which is placed inside the body. At this point the so-called violin “in white” is achieved. Hereinafter, the violin is coated (figure 1, p), and then some more components are added. The soundpost (figure 1, r) is a cylindrical element made of resonance spruce, supported between the two plates. Its position can be modified depending on the desired musical tone. By applying the sound post, the tensioning of the top plate and the back plate is ensured. This contributes to the modification of the musical tone of the violin. At the lower part of the violin body, an ebony saddle is fixed, as a wear-resistant element, and the end pin, also made of ebony is inserted into the f hole (figure 1, s). Before the strings are added, the four pegs must be inserted into the peg box and the tailpiece must be attached. The four pegs (usually made of ebony wood) are inserted into holes of the peg box and then they are drilled in order to obtain the winding & tensioning holes for the strings (figure 1, t). The tailpiece, also made of ebony wood, is fixed to the end pin by means of an elastic element (figure 1, u). The bridge (figure 1, v), made of resonance spruce wood, is a simple element resting on the top plate, being held in position by the string pressure. Its role is to transmit the vibrations to the top plate. Finally, the finished product (the violin) is acoustically tested by musician as can be seen in figure 1, (w) and (x).



(a) Radial cutting **(b) Air drying** **(c) Pairing**


(d) Contour cutting


(e) Carving the thickness profile


(f) Recessing the „*f-holes*"


(g) Attaching the resonance bar


(h) Cutting and bending the rib components


(i) Consolidating the ribs by means of block elements


(j) Gluing and pressing to form the violin body


(k) Milling the groove for the purfling


(l) Carving the neck scroll


(m) Attaching the fingerboard


(n) Attaching the top nut


(s) Inserting the end pin


(t) Inserting and drilling the pegs


(u) Attaching the tailpiece


(o) Processing the neck handle


(p) Coating


(r) Attaching the sound post

(v) Attaching the bridge (w) Final product (x) Testing the violin

Fig. 1. Technological operations for the manufacturing of a violin

3. MATERIALS AND METHOD

3.1 Materials

For this study, four types of violins with the same geometric characteristics, but belonging to the four classes of anatomical quality of wood, were analysed. The anatomical quality class was established by studies on spruce and maple wood samples, the method and the results being presented in [12–14]. The anatomical structure of wood for classes A, B, C, D has different physical properties, measured quantitatively and qualitatively in previous studies [8]. Thus, for maestro violins, the wood grade is A, for professional violins, the B grade is used, for student violins, the C grade wood and for scholar violins, the D grade wood is applied.

3.2 Method

The method of investigation regarding the acoustic impressions consisted in probing the opinion of the responding artists based on the recordings made on the tested violins. The recorded musical fragment was performed by the same violinist and consisted of four parts: the excitation of the free strings with the bow, the excitation of the strings in Pizzicato style, an excerpt from Max Bruch - Concerto no.1 in G minor op. 26, PI (first cadence of the solo violin) and an excerpt from Jules Massenet - Meditation for violin and orchestra from the Thaïs Opera, [7-8]. The recording took place in the performance hall of the Brasov Philharmonic, Romania, under the same technical conditions. The evaluation of the acoustic quality of the tested violins was based on the completion of an opinion poll in which marks were given from 1 to 5, for five acoustic criteria relevant to artists: bright and strong tone; sound clarity; warm sound; amplitude of sounds and equal sound on all 4 strings, [11]. (https://docs.google.com/forms/d/e/1FAIpQLScyUUyuEYotsXgVSZM6LZOTix14tV0AAij29coOeRBXwQIRHQ/viewform?usp=sf_link). The participation of the 22 respondents was voluntary and the respondents agreed to the processing of statistical data. The general information regarding the participation in the study is presented in table 1. 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, [7 – 8].

Table 1. General information on the participants in the study

Male	9						
Female	13						
Age category	<17	18-24	25-34	35-44	45-54	55-65	>65
Female	1	5	3	3	1	0	0
Male	0	6	2	0	1	0	0
Experience	<5	6-10	11-15	16-20	21-25	>26	
Female	0	2	3	3	1	4	
Male	0	3	3	1	0	2	

4. RESULTS AND DISCUSSION

The preference scores were assigned to each instrument according to the acoustic quality criteria, while the average of the scores was calculated for each criterion. The classification of the violins for the five analysed criteria is presented in figure 2. Thus, it is observed that from the point of view of the clarity of the sounds, the first places are classified by the violins A (Maestro) and B (Professional) having the resonant wood with the best anatomical quality in their construction, according to the classification established by luthier. Class D violins, with the largest width of annual spruce rings in all four categories, and straight fibre for the maple backplate, have the lowest score for warm sound. At the opposite pole is the violin B, with the highest score. The brightest tone was assigned to the maestro violin, with an average score of about 3.6 out of 5. With the highest sound amplitude scores, class D and B violins are appreciated. Interestingly, class C and D violins, in the perception of the respondents, record the best equality of sounds on the four strings, with an average score of 3. 45. As an overall summary regarding the general acoustic impression of violins, we can appreciate the ranking obtained by summing the average values on each criterion, as shown in the comparison in figure 3. Thus, it is found that the first place is placed violin class B, followed by class A, then class D and last place class C. The results show that the acoustic preferences of artists, without knowing the physical appearance of the musical instrument, differ from the luthier's classification in terms of anatomical quality of wood.

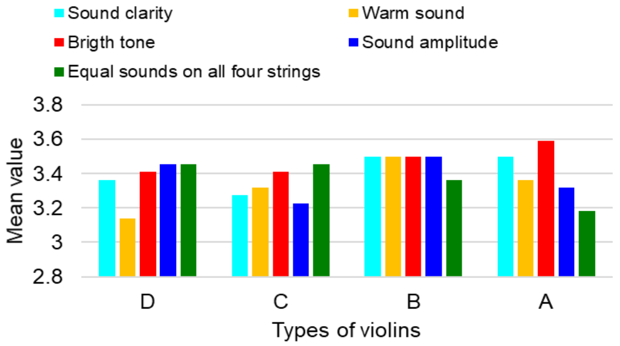


Fig. 2. The acoustic characteristics for each type of violin

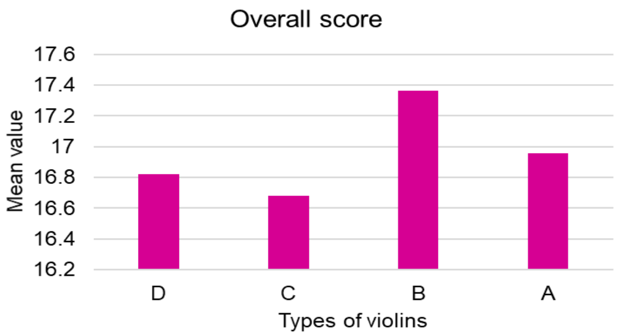


Fig. 3. Overall score of the combined acoustic quality of the violins

An important factor in the acoustic evaluation of violins proved to be the gender of the respondents. There are quantitative differences in the perception of sounds emitted by violins, as can be seen in figure 4. Thus, the largest differences in acoustic criteria are noted in terms of the clarity, the warmth and the amplitude of sounds (figure 4, a, b, d). The smallest perceptual differences between gender belong to the appreciation of the bright sound and the equality of sounds on the four strings (figure 4, c and e). A ranking of the four categories of violins according to gender is shown in figure 5. Thus, it is observed that from the perspective of women, the best violin is that of class B, followed by A, D and C, and from the perspective of men's auditory perception, the best violin is that of class C, followed by a close score by those of classes A and D.

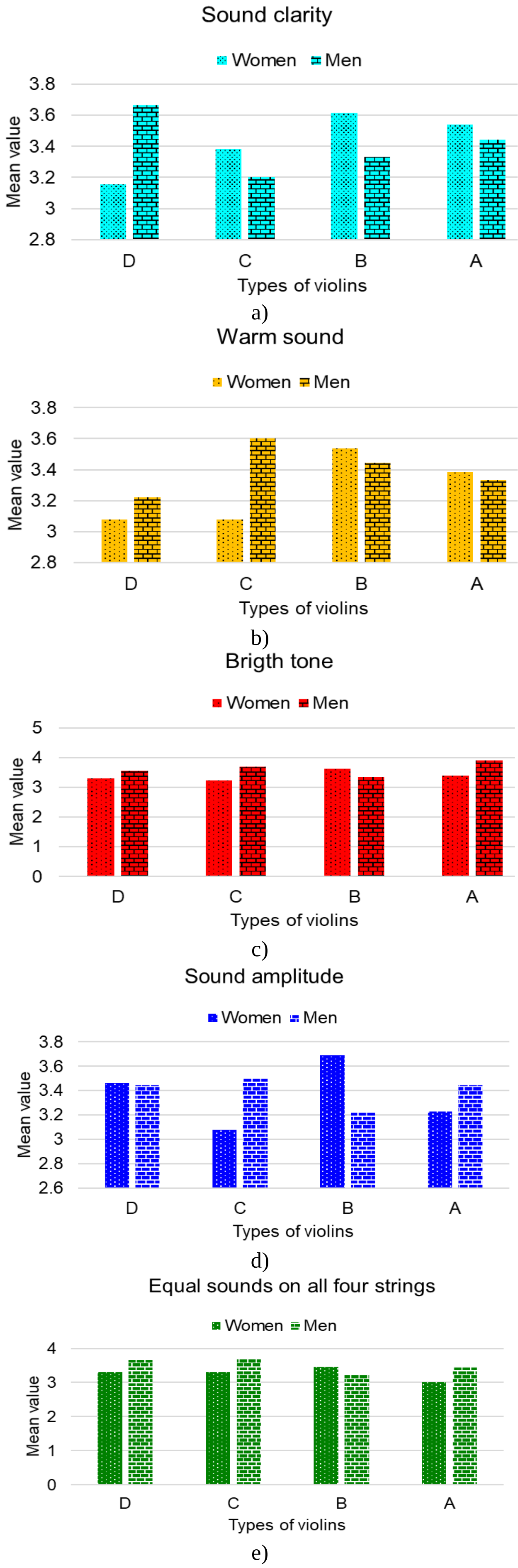


Fig. 4. Respondents' preferences according to gender

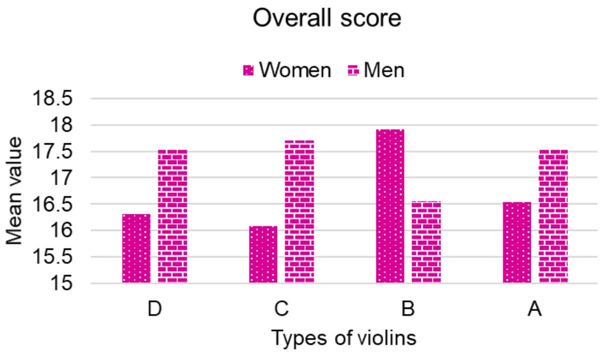


Fig. 5. General perception of the acoustic quality of violins according to gender.

5. CONCLUSIONS

In the first part, the paper presents, the manufacturing technology of violins and in the second part the psychoacoustic research performed on violins belonging to the four classes of anatomical quality of resonant wood. The psychoacoustic evaluation, based on five criteria of sound quality, highlighted the fact that the violins that satisfy the most acoustic demands of the respondents, regardless of gender, belong to class B (Professional). From the perspective of the participant's gender, preferences differ, so the class B violin is preferred by women, while the class C violin is preferred by men.

6. ACKNOWLEDGMENTS

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