Tonewood Selection: Physical Properties and Perception as Viewed by Violin Makers

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Abstract

The objective of this paper is to improve our understanding of the resonance wood and more precisely the interactions between their physical-mechanical properties, their natural variability, and the modalities of material's choice by violin makers. To identify craftsmen' practices and opinions, a "socio-technical" survey was created and completed by a psychosensory evaluation conducted with makers to evaluate directly 9 top plates and 9 back plates. These tonewood samples of various "qualities" and provenance were also characterised for their physical/vibrational properties and their visual/structural characteristics.

1. Introduction

Norway spruce (Picea abies) and Sycamore maple (Acer pseudoplatanus) are respectively used for the making of top and back plates of violin family and are known under the term of "Resonance Woods" [Bucur, 1992]. The mechanical and acoustical properties of these species are quite well characterized: high quality resonance spruce has low density, high specific modulus of elasticity, low damping and high anisotropy [Ono & Norimoto, 1983; Obataya et al. 2000]. As a pre-selected material, Resonance spruce shows unclassical relations between visual/structural features (Ring width, Latewood percentage) and the mechanical/acoustical properties. Empirical knowledge of makers is precious and can help to appreciate the concept of "resonance wood" but the perception of the raw material by luthiers, their practice and opinion has seldom been explored. According to the only psychosensory study on the subject [Buksnowitz, 2007] wood selection made by violin makers would rather rely on visual criteria than on mechanical or acoustical properties that seem difficult to be assessed on raw supply planks. It could also reveal the use of indirect indicators, and/or take into account personal or cultural preferences in wood choice [Brémaud, 2012]. The current challenge is now to take into account both the point of view of the practitioners (craftsmen and/or foresters) and of interdisciplinary scientific research. Therefore, the objective of this study is to improve the understanding of the interactions between physic-mechanical properties of resonance wood, their natural variability, and the actual expertise of violin makers in the selection, qualification and processing of their raw material.

2. Material and method

2.1 Survey

To identify craftsmen' opinions, practices, empirical knowledge and their main questions, a "socio-technical" survey on both qualitative and quantitative grounds has been created. It was first developed as face-to-face interviews using a modular and detailed questionnaire and then set to go online in a French and English version. Suppliers were also questioned and analysis was achieved using Sphinx software. Results are analysed on the basis of 9 questionnaires.

2.2 Mechanical and optical characterisation

To complete our survey a mechanical and psychosensory study was conducted with makers to evaluate 9 top plates and 9 back plates from different provenances and sold under different quality grades.
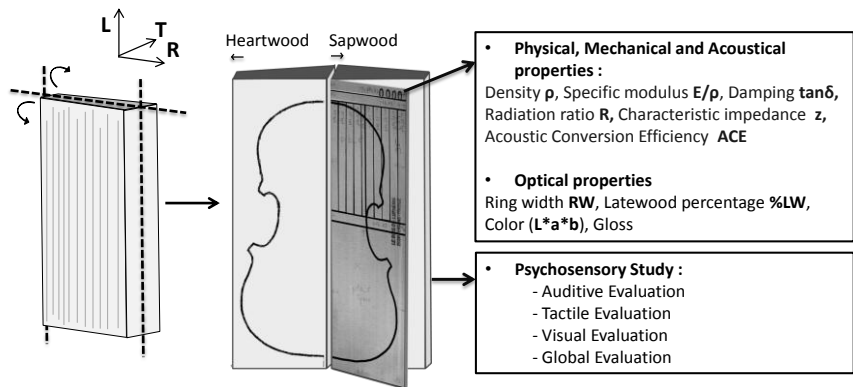

Figure 1 : General sampling plan

During the separation of the quarter cut blank plate into two halves of the future top (soundboard) or back plate, a thin board (2.5mm) was extracted from the centre in order to be representative of the plate. Radial and longitudinal specimens were cut from this board (figure 1) in order to assess the properties of the wood and their variations in these two directions. For a board, one to three radial specimens (120 × 2.5 × 12mm, R × T × L) and seven to ten longitudinal (12 × 2.5 × 150mm, R × T × L) specimens were obtained. They were stabilised at 65 % relative humidity and 20 °C for at least 3 weeks, to reach the equilibrium moisture content at circa 12%. These specimens were characterized for their physical/vibrational properties and "performance indexes" (Density ρ, Specific modulus of Elasticity E/ρ, Damping $\tan\delta$, Radiation ratio R , Characteristic impedance z, Acoustic Conversion Efficiency ACE) and their visual/structural characteristics (Ring width, Latewood percentage, Colour, Gloss) as described in [Carlier et al, 2014].

2.3 Psychosensory Evaluation

With the remaining blanks plates, wedge-shaped, two psychosensory studies (for spruce and maple) were designed in four steps in order to evaluate respectively the contributions of the auditory, tactile and visual perceptions of wood. Evaluation is done product by product which are randomly distributed during the four parts: auditive, tactile, visual and global evaluation (Figure 2).

Except for the global evaluation, which aims to reproduce closely the maker judgement as they do in their workshop, each protocol follows a same out-

Auditive Evaluation	Tactile Evaluation	Visual Evaluation	Global Evaluation
Opinion on the importance of audition	Opinion on the importance of touch	Opinion on the importance of vision	*Product by Product* - Free description - Global Evaluation - Acceptance test
Product by Product	*Product by Product*	*Product by Product*	
- Description of several attributes - Global Evaluation - Acceptance test	- Description of several attributes - Global Evaluation - Acceptance test	- Description of several attributes - Global Evaluation - Acceptance test	*On all the product* - Ranking

Figure 2 : Planification of the four steps of the Psychosensory evaluation of Resonance wood

line. First, some attributes are evaluated to establish a sensory profile of the blank according to each sense. This part permits to characterize the product and learn how the attributes define a board as excellent or unusable. The blanks plates are then globaly evaluated. Finally, an acceptance test is performed to determine the emotional attachment to the product. Results are at this time not complete to be statistically significant and are based on seven participants

3. Results

From the survey, it appears that empirical choice of violin makers are based on perceptual criteria that can be visual, tactile, physic-mechanical and auditory. The main criteria to qualify the spruce wood are: good quality of cutting orientation, density, percentage of latewood, growth ring uniformity and width. Makers report a lot of interest on several field of research including those on resonance wood. They considered the wood to be one of the most determining factors in sound quality of the instrument. They believed the acoustical properties of wood changed over time and depending on the instrument being played or not.

Thanks to the psychosensory study, the relative weight of the perception senses to choose the material were determined as well as the associated descriptors used by makers to evaluate the wood. The criteria favourably perceived by different senses to define a good top/back plate were isolated. The evaluation average for each top plate according to the different senses was calculated (figure 3) for the tests conducted at the time of writing (non-definitive results). It shows that differentiations between Spruce blanks are

not equal according to the type of evaluation; plates' discriminations are more difficult to assess by auditive rating than visual, tactile or global rating.
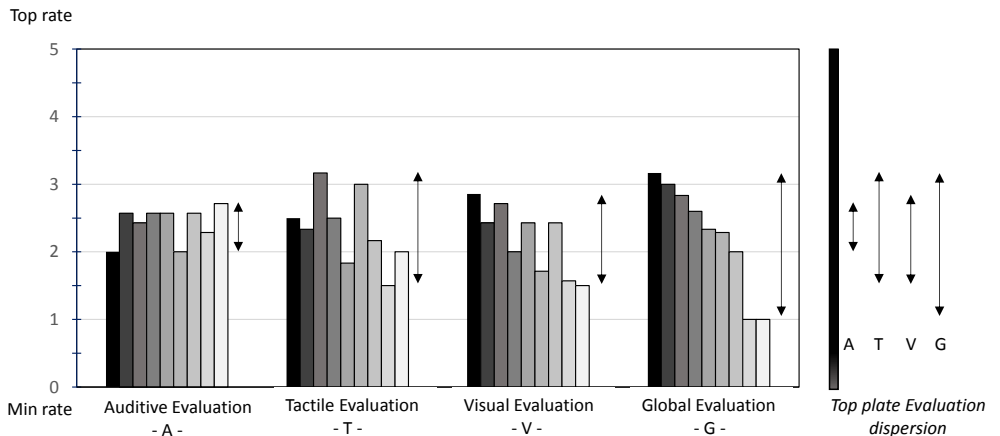

Figure 3 : Average rate of the Evaluation of the 9 top plates according to the different modalities of the psychosensory test.

Moreover the variability of makers' judgments according to the attributes in terms of profile or dispersion lead us to think that this result will evolve until the end of this experiment.

Finally, the evaluations of the makers were analysed in regards to the physical characterisations of the specimens in order to characterize the perception threshold. It permits to reveal how senses reflected the different properties of wood. For this particular case (non-definitive results), the tactile evaluation seems well related to density. Visual evaluation shows correlations with the modulus and specific modulus of elasticity and is well related to the damping and to the "characteristic impedance".

Acknowledgement

References

[1]   BUCUR, V. *Les bois de lutherie*. Journal de physique IV (1992) 2: 59–65,

[2]   ONO,T. ; NORIMOTO,M. *Study on Young's Modulus and Internal Friction of Wood in Relation to the Evaluation of Wood for Musical Instruments*. Japanese Journal of Applied Physics, (1983) 22(4) : 611–614

[3]   OBATAYA,E. ; ONO,T. ; NORIMOTO,M. *Vibrational properties of wood along the grain*. Journal of Materials Science, (2000) 35(12): 2993–3001

[4]   BUKSNOWITZ,C. ; TEISCHINGER,A. ; MÜLLER, U. AND AL. *Resonance wood (Picea abies (L.) Karst.)—evaluation and prediction of violin makers' quality-grading*. Journal of the Acoustical Society of America, (2007) 121(4):2384–2395

[5]   BRÉMAUD, I. *Acoustical properties of wood in string instruments sound-boards and tuned idiophones: Biological and cultural diversity*. Journal of the Acoustical Society of America. (2012) 131(1): 807-818

[6]   Carlier,C. ; Brémaud, I. ; Gril, J. *Violin making "tonewood": comparing makers' empirical expertise with wood structural/visual and acoustical properties.* ISMA (2014), 325–330