COST FP1302 WoodMusICK:
SECOND ANNUAL CONFERENCE
EFFECTS OF PLAYING ON EARLY AND MODERN MUSICAL INSTRUMENTS

SEPTEMBER 9-10, 2015

THE ROYAL COLLEGE OF MUSIC, LONDON

CONFERENCE GUIDE AND ABSTRACTS
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Aside from a few exceptions, musical instruments are very efficient tools, designed and built with the aim of combining the best musical result with ergonomic and economic considerations. However, as with many tools, their durability is closely connected to high structural tension, the reaction of materials to wear, chemical and humidity changes, and many other technical issues. The situation is further complicated by cultural expectations to experience the sound of musical instruments both passively and actively, regardless of their age.

It is sometimes the case that some instruments, for example those of the violin family, are used almost continuously for three hundred years or more. Their cultural appeal goes far beyond consideration of their sound, eventually leading to the idea that use is vital for their long term conservation. On the other hand there exist instruments, particularly from the keyboard or woodwind family, which have been restored to playing condition after long periods of rest due to increased interest in performing early music on original instruments over the course of the twentieth century. Conversely, other instruments are considered too fragile to be used and are therefore preserved for their cultural and aesthetic value, sometimes being used as models for the creation of functional copies. In all these cases, issues arise with regard to the effects of use and the choices of makers, the taste of performers, as well as with changing conservation policies and techniques: how is sound affected by continuous use, what effects does it have on the short and long term conservation of the materials, how does this affect decisions concerning modern replicas, how can preventive techniques help to minimise risks connected to use and improve musical performance?

Issues related to the use of instruments are also a primary concern for contemporary makers – both historical and present day, who are continuously experimenting with new materials and practical techniques in order to improve the performance and resilience of newly constructed instruments. While there are several elements that guide the choice of materials and working techniques, the reaction of the instrument to performance under a variety of conditions is certainly one of the leading ones. How do traditional and innovative materials react to playing? How much are cultural choices led by issues related to performance? How does the choice of different materials affect the performer and the audience?

This conference aims to broadly address the implications of playing on original and contemporary instruments and on replicas, with particular attention to:

- Historical and contemporary approaches to the choice of materials in musical instrument construction and the implications of such choices for performance.
- Monitoring and predicting the short and long term reactions of instruments to being played/not played.
- Acoustical and perception analysis of early musical instruments in action, also in comparison with replicas.
USEFUL INFORMATION

Delegate pack

Your delegate pack contains the following:

- Name badge
- Conference booklet
- Notebook
- Tube map
- Pen and pencil
- RCM leaflets

Lunch and refreshments

Refreshments (tea/coffee) and lunch will be available in the Britten Theatre foyer during breaks in the scheduled programme, see the conference timetable for details.

Internet facilities

Internet access is available with the following log-in details:

SSID - Events

Password – wonderworld2015

Assistants

Several RCM students are kindly assisting with the event. Identifiable by “student assistant” badges, they are available to answer questions and provide general assistance.

Emergencies

In the event of an emergency, please notify a student assistant or member of the RCM staff. In case of a fire, an alarm will sound and all delegates and members of staff will be asked to leave the building through designated emergency exits.

Please see the map on the following page to identify the shortest way to the emergency exit.

Instructions for presenters

Due to the busy conference schedule, it is vital that sessions keep to time. Speakers should ensure that their equipment needs are met before the start of the session. If you have not sent your presentation ahead of the conference, please report to the technology assistant at the conference table at the beginning of the coffee break before your session.

Restrooms

The nearest restrooms are located adjacent to the mezzanine level of the Britten theatre Foyer. Accessible toilets are located on the lower level next to the bar.
MAP OF RCM/VENUES
COST FP1302 WoodMusICK: Second Annual Conference
THE EFFECTS OF PLAYING ON EARLY AND MODERN MUSICAL INSTRUMENTS

CONFERENCE AGENDA

Wednesday 9th September 2015

08:15 Registration Begins (RCM main entrance, Prince Consort Road)

09:00 Welcome address, Kevin Porter (Deputy Director, Royal College of Music, London)

09:15 Perspectives from a Changing Culture: One Hundred Years of Debate on the Role of Musical Instruments
   Gabriele Rossi Rognoni (Royal College of Music, London)

Session 1a, Britten Theatre, Chairs: Giovanni Paolo Di Stefano

09:35 The Effects and Consequences of Playing on Historical Keyboard and Stringed Instruments
   Oliver Sandig, Barbara Meyer (Royal Academy of Music, London)

10:00 Playing on Old Stringed Keyboard Instruments in the Museum Vleeshuis
   Karel Moens (Museum Vleeshuis, Antwerp)

10:25 Preventing the Played Instrument’s Suicide
   Vera de Bruyn-Ouboter (Ringve Music Museum, Trondheim)

10:50 Coffee break, Britten Theatre Foyer

Session 1b, Britten Theatre, Chair: Anastasia Pornou

11:10 Recommendations for Accessing Musical Instruments in Public Collections: 1985-2015
   Renato Meucci (Conservatorio di Musica G. Cantelli, Novara)

11:35 Guitars in Different States
   Heidi Von Ruden (Staatliches Institut für Musikforschung, Berlin)
Poster sessions, Britten Theatre, Chair: Claudia Fritz

12:00 Towards a Standard for 3D-computed Tomography: the MUSICES Project
Frank P. Bär\(^{(1)}\), Theobald Fuchs\(^{(2)}\), Sebastian Kirsch\(^{(1)}\), Christian Kretzer\(^{(2)}\), Markus Raquet\(^{(1)}\), Gabriele Scholz\(^{(2)}\), Rebecca Wagner\(^{(2)}\), Meike Wolters-Rosbach\(^{(1)}\)
\(^{(1)}\) Germanisches Nationalmuseum, Nürnberg; \(^{(2)}\) Entwicklungszentrum Röntgentechnologie, Fürth

12:05 Play and Loose! A Study of the Oil Varnish’s Modification by Different Aging Processes
Claudio Canevari\(^{(1)}\), Giusj V. Fichera\(^{(2)}\), Arianna Legnani\(^{(3)}\), Maurizio Licchelli\(^{(2,3)}\), Marco Malagodi\(^{(2,3)}\)
\(^{(1)}\) Civica Scuola di Liuteria, Milano; \(^{(2)}\) Università di Pavia, Laboratorio Arvedi, Cremona; \(^{(3)}\) Università di Pavia, Dipartimento di Chimica, Pavia

12:10 The Role of Tonewood Selection and Aging in Instrument “Quality” as Viewed by Violin Makers
Capucine Carlier, Iris Brémaud, Joseph Gril (University of Montpellier, Montpellier)

12:15 Automatic Detection of Worn Areas on Stradivari Violin Back Plates
Piercarlo Dondi\(^{(1,2)}\), Luca Lombardi\(^{(1)}\), Maurizio Licchelli\(^{(2,3)}\), Marco Malagodi\(^{(2,3)}\)
Fausto Cacciatori\(^{(4)}\) (1. Università di Pavia, Dipartimento di Ingegneria Industriale e dell’Informazione, Pavia; 2. Università di Pavia, Laboratorio Arvedi, Cremona; 3. Università di Pavia, Dipartimento di Chimica, Pavia; 4. Fondazione Museo del Violino Antonio Stradivari, Cremona)

12:20 Evolution in the Manufacture of the Basset Horn D’amour
Henri Boutin\(^{(1)}\), Gilles Thomé\(^{(2)}\), Sandie Le Conte\(^{(1)}\) (1. Musée de la musique, Paris; 2. Independent Musician and Instrument maker, Paris)

Stavroula Rapti, Maria Petrou, Anastasia Pournou (Technological Educational Institute of Athens, Athens)

12:30 The Art and Science of the Rediscovery of an Eighteenth-Century Recorder
Gabriele Ricchiardi\(^{(1)}\), Luca De Paolis\(^{(2)}\), Lorenzo Cavasanti\(^{(3)}\), Manuel Staropoli\(^{(4)}\)
\(^{(1)}\) University of Turin, Turin; \(^{(2)}\) LDP Recorders, L’Aquila; \(^{(3)}\) Conservatorio “Claudio Monteverdi” di Bolzano, Bolzano Bozen; \(^{(4)}\) Conservatorio di Musica “N. Piccinni di Bari”, Bari

12:35 Levels and Angulations of the Left Hand: A Contribution to Violinistic Technique
Eliseu Silva\(^{(1)}\), Christopher Bochmann\(^{(2)}\), José Xavier\(^{(2)}\), Pedro Fonseca\(^{(2)}\), Rui Garganta\(^{(2)}\)
\(^{(1)}\) Evora University, Evora 2. University of Porto, Porto
12:40 Characterization of Stiffness Components of Wood of Heterogeneous Plate Bending Tests

12:45 Lunch, Britten Theatre Foyer

Session 2a, Britten Theatre, Chair: Miyuki Matsuo

14.00 Bringing back the ‘Davidoff’ Stradivari Violin to Playing Condition: Measuring Changes,
Stéphane Vaiedelich (1), Sandie Le Conte (1), Sylvie Le Moyne (2), François Ollivier (2), Camille Simon-Chane (1), Florian Moreno (1), Jean-Philippe Echard (1) (1. Musée de la musique, Paris; 2. UPMC, Saint-Cyr l’École; 3. Art Graphique & Patrimoine, Joinville-le-Pont)

14.30 Effects of Playing on the Practical Performance of Reed Used for Woodwind Instruments
Hikaru Akahoshi, Ryo Nakanishi, Eiichi Obataya (University of Tsukuba, Tsukuba)

14.50 Influence of the Surface Condition in Bore of Woodwind Instruments on the Acoustic Impedance

15.15 Effects of Continuous Vibration on the Dynamic Viscoelastic Properties of Wood
Hikaru Akahoshi, Shuoye Chen, Eiichi Obataya (University of Tsukuba, Tsukuba)

15:40 Coffee break, Britten Theatre Foyer

Session 2b, Britten Theatre, Chair: Joseph Gril

16.15 Effect of Transitional Moisture Change
Iris Brémaud (Université Montpellier, Montpellier)

16.40 Hygro-Thermal Behaviour of a Historical Violin during Concerts
17.05 Hygro-Mechanical Fe-Analysis of Wooden Objects: Importance of Reliable Prediction of Water Transport
Daniel Konopka, Michael Kaliske (Technische Universität Dresden, Dresden)

17.30 Activity reports: Short Term Scientific Missions, FM, Training Schools, Chair: Sandie Leconte

18.15 Visit to the Royal College of Music Museum

19.00 Conference Dinner

20.30 Concert, Ensemble Florilegium, Britten Theatre

Thursday 10th September 2015

Session 3a, Britten Theatre, Chair: Pierre-André Taillard

09.00 Playing Historical Clarinets: Quantifying the Risk
Christina Young, Gabriele Rossi Rognoni (Courtauld Institute of Art, London; Royal College of Music, London)

09.25 Humidity in Woodwind Instruments Due to Playing: Effects and Risks for the Wooden Structure
Ilona Stein (Germanisches Nationalmuseum, Nuremberg)

09.50 Numerical Simulation of Piano Soundboard Strain
Jan Tippner, Václav Sebera (Mendel University in Brno, Brno)

10.15 Experimental Investigation of Non-Invasive Intervention
Marco Perez (Universitat Politècnica de Catalunya, Terassa)

10:40 Coffee break, Britten Theatre Foyer
Session 3b, *Britten Theatre*, Chair: Murray Campbell

11.15 3d Emendatio: Digital Improvement and Printing Of Musical Instruments  
V. Lorenzoni (1), Z. Doubrovsky (2) and J. Verlinden (2) (1. Foundation Estrade, The Netherlands; 2. Delft University of Technology, Delft)

11.40 Acoustical Performance of Original and Replica Baroque and Classical Bassoons: Design and Coupling of Contemporary Bocals and Reeds  
David Rachor (1), Bryant Hichwa (2) (1. Professor University of Northern Iowa, Cedar Falls; 2. Sonoma State University, Rohnert Park)

12.05 The Next Generation Concert Piano  
*Chris Maene and Wolf Leye*

12.30 Perceptive Study of Touch on a Pleyel Piano from the Collection of the Paris Museum of Music  
*Benoît Navarret, Maurice Rousteau (Musée de la musique, Paris)*

13:00 Lunch, *Britten Theatre Foyer*

14.30 Management Committee Meeting, *Parry Room*, Chair: Sandie Le Conte
The cultural background

Discussion on the cultural role of musical instruments is recorded at least since the second half of the 19th century, contemporary with the very appearance of an increasing interest towards the music of the past and of far cultures, and with the earliest public collections in this field.

The first systematic discussions to outline the scope and methods of Musikwissenschaft in general, highlight the practical relevance of historical musical instruments to understand musical performance of the past and to successfully lead to the recovery of early repertoire:

‘it is necessary to consider the manner in which the instrument or instruments are handled: we must examine the instrumentation, that is the manner in which musical groups are united or divided, counterpoised and blended. With this we must consider the performance – or rather the method required for the execution or performance, - the fingering required for a certain passage, the mode of playing, the intensity of the sounds in the various moments, the distribution of the different types of sounds, etc.’ (Adler, 1885)

The development of this line of thought led to the development of the early music movement and historically informed performance, which acquired particular strength in the first half of the 20th century.

Since very early in this process, concerns were raised for the effects of playing on musical instruments which were sometimes over three hundred years old. The Hills, in their fundamental study on Antonio Stradivari (1902) already warned against the risks of over-using historical instruments, and at the same time a few makers, among them Arnold Dolmetsch in London, began producing replicas of historical instruments in order to allow larger numbers of players to be involved in the rediscovery of early music.

Changing practices during the 20th century

Only gradually, particularly after World War 2 and through the activity of some key museums and musicians, an awareness of the impact of playing on musical instruments was generally acknowledged, leading to increasing concerns in the conservation of historical artefacts and the exploration of new approaches. At the same time musicians and restorers became more and more aware of the issues related to playing on original instruments: the recreation of the lost original sound of the instrument became a goal and new techniques were and are being explored in order to attain it, while ethical and philosophical discussions about the actual possibility, or indeed opportunity, to succeed in this direction gained international attention and breadth, also within the larger areas of musicology and aesthetics.

While the activity of CIMCIM – the International Committee of Musical Instruments and Music Museums and Collections – led to a wider discussion of the topic and the proposal of some shared guidelines, these remained confined to some museums, but did not reach an impact strong enough with the larger community of stakeholders interested in the use of early musical instruments: particularly musicians, restorers and makers.

At the same time, the expansion of the area of discussion, particularly to include the Near and Far East and the Americas – a phenomenon particularly evident in the past decade – highlighted the extent of the fragmentation and inconsistency in approaches and goals, both within similar institutions and professionals, and across them. The old tension between playing or non-playing, often discussed among museum professionals during the second half of the 20th century, came to be enriched with new perspectives and issues, and by the possibilities offered by scientific investigation, both to monitor and assist in a safer use of the instruments, and in producing alternatives when the use of originals is not possible.
A stronger collaboration towards shared policies

The last decade saw a number of projects carried out by individual institutions or local partnerships, which substantially contributed to the understanding of the behaviour and reaction of musical instruments when being used. At the same time an undeclared reassessment of the balance between conservation and use has led many museums to carefully open their policies to a careful but more frequent use of their collections. However, lack of coordination has led to several examples of duplication of research, and clustering of interest on certain areas (e.g. keyboard and bowed instruments), while others have remained almost entirely ignored.

This paper aims at offering an inclusive perspective on the dynamics, trends and current projects related to the use of historical musical instruments, with the aim of individuating areas of collaboration and gaps in current research, with the understanding that only a closer collaboration will lead to the development of a shared approach and understanding, able to combine conservation and use.

References

G. Adler, Umfang, Methode und Ziel der Musikwissenschaft, «Vierteljahrsschrift für Musikwissenschaft», n.1 (1885), pp. 5-20
CIMCIM, Recommendations for regulating the access to musical instruments in public collections: 1985, http://network.icom.museum/cimcim/
Hill, Hill, Hill, Antonio Stradivari: his life and work, London, Hill, 1902
PLAYING HISTORICAL INSTRUMENTS AT THE ROYAL ACADEMY OF MUSIC MUSEUM

Oliver Sandig and Barbara Meyer

Royal Academy of Music - Museum and Collections, United Kingdom

Introduction

We will consider the effects and consequences that playing has on the Academy’s historical and modern keyboard instruments and stringed instruments of the violin family.

The Royal Academy of Music was founded in 1822. The keyboard collection on public display comprises two harpsichords, twelve pianos and the oldest instrument from this collection, a virginal from the early 17th century. The Academy has approximately 150 keyboard instruments available to its students for practice, rehearsal and performances.

The stringed instrument collection comprises nearly 250 examples of its kind. Both collections showcase a wide cross section of examples from various European schools. The Rutson Collection, donated in 1890, contains Cremonese instruments from the ‘Classical period’, including fine examples from Antonio Stradivari’s workshop. The Academy also has the famous Stradivari violin Viotti ex-Bruce from 1709, acquired in 2005 through the ACE/DCMS Acceptance in Lieu Scheme and with the assistance of donors.

What is interesting is the way these two categories of instruments have developed. The differences between a virginal, a harpsichord, a fortepiano and a piano, demonstrate how each musical époque ‘invented’ its own keyboard instrument type. Violins, however, have changed very little and in fact those made between 1550 and 1750 in Italy became the blueprint for all subsequent violins and are still in use today playing contemporary music.

So how has playing impacted these instruments? Some researchers also suggest that playing an instrument changes the cell structure (hemicellulose) of the wood and ultimately improves its sound or playing qualities.

Other positive aspects of playing include:

- they can be heard
- they are regularly maintained

Yet over the last few hundred years mint examples of historical instruments have declined in numbers. So how has playing negatively impacted these instruments? The direct impact of playing has resulted in:

- wear and tear, leading to intrusive restoration
- accidents
- exposure to sudden changes in temperature and humidity
- string tension causing deformation and distortion on keyboard frames and string instrument bodies.

The desire to play instruments also resulted in an indirect impact causing the following:

- conversions, instruments of earlier periods being adapted to requirements of later periods and the use of different strings with higher tension
- ‘modernisation’ of the instrument to suit the musician’s requirements, current trends, commercial considerations (such as alterations in sizes etc.)

Today we value and protect the integrity of musical instruments - our understanding has changed. Late 1800 alterations to the size of valuable ‘classical’ Italian cellos or violas were undertaken to increase their market value whereas nowadays such alterations would not be undertaken and those done in the past have lowered the market value of the instrument.

Little detailed information regarding invasive alterations to historical instruments has been published and therefore much of the information about the making process, the instruments original size, shape, dimensions and varnish has been lost.

Methods

So the key question is how do we assess the actual impact that playing has on these instruments? There are no records to help us assess changes in sound – recordings only go back to the very late 19th century.
We can however assess the impact of the alterations in the structure, substrate and varnish that playing has prompted. Detailed condition assessments, documentation, correspondence etc. all help us establish what has been done to the substrates, the keyboard actions and surfaces. Photographs, illustrations and UV light help to compare instruments in mint condition with altered instruments.

The Academy’s Antonio Stradivari Viotti ex-Bruce 1709 violin serves as an example for an instrument in nearly mint condition.

Results

Playing and handling clearly has an impact on the physical, stylistic and acoustic properties of historical and modern instruments.

Consequently we need to review the instruments regularly, monitor access and usage, instruct the potential players, and keep a keen eye on climate control when instruments are in store or on display.

Overall, in-depth consultations are now considered to be a key aspect of responsible conservation.

An essential role in maintaining the longevity of our musical instruments is striking a knowledge-based balance between playing, maintenance, restoration and conservation.

Discussion

Even the most careful of playing causes potentially irreversible damage.

Does this raise concerns about continuing to play the remaining, rare fine instruments? Will they effectively become extinct?

To what extent should we allow access and where do we strike a balance between overprotecting and overusing the instruments?

But what happens if they never get played – does that preserve them sufficiently or do we think they need occasional careful playing to not lose their voice?

Underpinning all of these questions is how do we actually measure damage?

To what extent have the playing qualities been affected by invasive restoration?

Could the unproven but widely held belief that old instruments are ‘better’ than contemporary be successfully challenged, such that the use of ‘fine’ contemporary instruments may be one alternative to protect the ‘fine’ old ones from further use and deterioration?

Setting up a carefully guided project, using academy instruments, that ‘analyses’ their sound quality in all its parameters over a number of years or decades could be one way of obtaining useful insight into how an instrument changes when it is played.

Acknowledgements

Thank you to Peter Bavington, Ian Brearey, Angela Doane, Christopher Nobbs and Elizabeth Wells.

References

A comparison of Wood Density between Cremonese and Modern violins [C.S.Berend, T.M. Borman, PLOS July 2008]

Conservation, restoration and repair of Stringed Instruments and their Bows, Volume 1 [Ipci Canada, Montreal 2010]

Evolutionary Road, Part 1 and 2 [Roger Hargrave, Strad, February 2013, p.54-63, March 2013, p58-46]

Some aspects of Wood Structure and Function [Ephraim Segerman, Catgut Acoustical Society, 2001]
In the 1970s, several old stringed keyboard instruments in the Museum Vleeshuis were restored with the explicit intention to play them again. This framed perfectly in the philosophy of the early revival of historical keyboard instruments. The former museum director and the teacher of historical keyboard instrument performance at the local conservatory played both a dynamic role in the decisions taken at that time.

In that period, five instruments of the collection were made playable: three Antwerp harpsichords (Johan Daniel Dulcken, 1747, Jacobus Van den Elsche, 1763 and Joannes Petrus Bull, 1779), an Antwerp virginal by Johannes Couchet (1650) and a Viennese grand piano by Conrad Graf (1826). These instruments soon became important as to the image of the museum, which hereafter in musical circles was mainly associated with old keyboard instruments. The instruments were extensively used, not only for concerts and recordings, but also for education - even as tools for practice for students.

After ten to fifteen years later, the condition of the harpsichords deteriorated. Some instruments no longer did no longer allowed being played. The pianoforte was in those years seriously damaged during a recording.

Since then, the Van den Elsche and the Bull harpsichords have not been played anymore. The Dulcken harpsichord has been subjected to new interventions, and the Graf fortepiano has been restored again. Meanwhile, the Couchet virginal became rather problematic as concerns tuning and stability. However, until ca. 1999, musicians continued to play this instrument.

In 1999, the new museum director found major damage on the virginal, and decided playing must be completely stopped. A CT scan showed massive damage inside the instrument. This damage cannot be restored because, during the restoration in 1972, cracked as a result of sudden extreme drought. This triggered a new thorough restoration in 2004-05.

Shortly after there was a new rupture in an old glue joint in the inner structure of the Graf fortepiano. This led to a new thorough restoration between 2007 and 2012.

Since then, two stringed keyboard instruments are still frequently played: the Dulcken harpsichord and the Graf piano. However, due to the successive interventions since 1972, many important parts are no longer original.

Figure 1: CT scan of the Johannes Couchet virginal. Cracks in the pinblock.
The use of these instruments is very ambiguous. Since the latest restorations, both the Dulcken harpsichord and the Graf piano are considered to belong to the best sounding instruments of their kind. Numerous musicians ask permission to play both instruments. The two instruments do not belong to the museum, but are a part of a permanent loan from the Conservatory, their owner. The conservatory demands that both instruments can be played.

On the one hand, the beautiful sound of the two instruments presents a great added value for concerts and recordings in the museum. On the other hand, the museum realizes more than ever that the continuous use is destructive on the long-term. The question is whether the wonderful sound that attracts so many musicians is specific to the historical instrument, or also the result of the numerous interventions by the restorers. Are we only enjoying the quality of the original Dulcken and Graf or also the cumulative effect of the restorers’ skills? Perhaps, the creation of good copies could provide a solution to this dilemma.
PREVENTING THE PLAYED INSTRUMENTS SUICIDE

Vera de Bruyn-Ouboter

Norway, Ringve Music Museum

Introduction

The entire musical instrument is a combination of both: The physical material and the intangible Sound. By existing as a whole the instrument is destroying itself in the long term. Sound is as important as the instruments physical material and should be documented and experienced. But producing sound means risking the loss of physical material. Over decades and centuries, there might be little left of the primarily parts but a strongly restored and fragmentary instrument. This is not what museums aim, according to the rules of ICOM and to the conservation code of ethics (ECCO).

Musical instruments of collections of that are defined as objects with high preservation value underlay various requirements in preservation. There are restrictions for use with the aim to inhibit their ageing processes and all kind of changes to their material. In the following these processes are defined, a Risk – Gain analysis for the risk of damage by use is presented and suggestions for further research for reducing the risks are made.

Forces and mechanical stress

All instruments with membranes and strings kept in playing condition are exposed to force and mechanical stress. Membranes on drums or membranes on non European stringed instruments, all types of instruments of the fiolin family, guitars, harps and keyboard instruments. Looking closer at historic keyboard instruments: A regularly strung six octave fortepiano bears the weight of a full-grown male elephant [Michal Latcham, 2000]. Over time, due to the degradation of the material itself caused by the previously mentioned influences this stress will lead to the collapse of the wooden structure. A typical damage is f. eks. a deformed wrestplank which has been pulled inwards by the stress of the strings. The functionality of the hammer action is though reduced. Another example is the development of cracks around the tuning pins in the wrestplank which make the instrument impossible to tune and to play. A third damage is a deformation of the soundboard, pressed down by the strings on the soundboards bridge. The deformation can go so far that the bridge does not function any longer as boundary to the diapason. The instrument is not playable any longer. This kind of deformation, cracking and tearing can be found on all organic materials exposed to strain over long time.

Beside stress on stringed instruments or instruments with a membrane, the mechanical strain caused by the musician is a factor which effects all musical instruments by being played. Parts reduce themselves in contact to other parts in form of abrasion by friction. Handcontact to the musician with acidic PH content of sweat, causes chemical changes of the varnish and other materials on the surface.

Other weakening influences

Beside losses caused by playing, the instruments materials combinations attached to each other can develop chemical reactions. Aging processes are accelerated by too low, too high or changing humidity, light and UV, temperature or content of gasses in the environmental air. Resulting in degradation processes like corrosion of metal or breaking up molecular chains of organic material like textile the materials become brittle, less elastic and more susceptible for damages.
In wind instruments the humidity and temperature of the musicians' breath do cause big changes in the molecular structure from the inside, stressing and making them less elastic.

All these kinds of damages are well known in many years. There is little possibility to prevent the attended played instrument from stress and mechanical force when the material is weakened by the mentioned factors.

The best possibility to prevent damages is to act consciously and to supervise all decision making according to playing the museums object. An understanding of ongoing physical and chemical processes and risks should be examined in advance.

The Risk – Gain analysis

In connection with a sound documentation of musical instruments at Ringve Music Museum in Trondheim (Norway) 2011, a Risk - Benefit Analysis was developed to hinder damage to the instruments through playing. The analysis aims to compare the condition to what gains might be achieved through an audio recording. Through this Risk - Benefit Analysis, we try to create a compromise by opening a decision making process tied to individual instruments. As part of the music museums policy the analysis becomes an important tool for the development of conservation concepts tied to playability. It should always be carried out as collaboration between curator and conservator involving musicians as well as instrument makers and other specialists.

Research needed for the Risk assessment

The Risk – Gain analysis is based on a condition report with a detailed examination of the stability of the individual materials and the instruments functionality. By going into detail the risk for damages and alterations by playing has to be estimated. On this point there sometimes is need for research together with other specialists. In the following thee examples:

1. How can the risk of collapsing and deforming before raising force and tension be measured? An easy usable method for measuring/calculating tension and stress in a complex mixed materials musical instruments construction is needed.

2. Materials combinations which have developed chemical interaction are constructive weak points. Mainly are those metal parts weakening through corrosion. How to stabilise them before playing?

3. Can the sublimating solid Cyclododecan (developed for intermediate stabilisation of flaking painted surfaces) be used as intermediate treatment of the inside of a flute before exposing it to human breath? Or is there a possibility to develop a better fitting product?

Answers on these and more questions can help to improve the Risk – Gain Analysis and to prevent the played instruments suicide.

Acknowledgements

My acknowledgements go to my colleagues Mats Krouthén and Daniel Papuga, both curators at Ringve music museum, who were part of the development of the Risk – Gain analysis. An inspiring presentation at CIMCIM in 2002 by Corinna Weinheimer is a basic summary of all damages which can occur on musical instruments by playing.

References

RECOMMENDATIONS FOR ACCESSING MUSICAL INSTRUMENTS IN PUBLIC COLLECTIONS: 1985-2015

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Forty years ago to the present

It is exactly 40 years ago when the CIMCIM (the International ICOM Committee for museums and collections of musical instruments), a component of the International Council of Museums, published a document in which the principal issues that curators of musical instrument collections face daily were elucidated for the first time. Signed by six authorities of different nations and institutions, it was the result of previous experiences, and of a long debate.

The task of the museum or public collection is largely twofold: its responsibility for the safety and preservation of its instruments and its goal to further their study and disseminate the information thus obtained. In this manner the museum acts as a link between the craftsmen, performers and scholars of today and their counterparts whose work is represented in the collection.

Its content touched upon: Conditions of access; General protection from damage; Measuring tools and techniques; and, last but not least, “Playing”. This last was probably the most remarkable area of discussion, as it came after a long period in which museum instruments were usually allowed to be played, even after this had turned out to be outrageous for many items. It was assumed that “Instruments from public collections should not be allowed to be played for motives of idle curiosity or individual pleasure; nor should they be considered as practice instruments. The use of any museum instrument is connected with a clear risk of mechanical damage”. The positions, even though presented in an unusual way, taking into strong consideration a substantial distinction between public and private heritage.

Many years thereafter, a new text was published under the advisory assistance of the Canadian Conservation Institute and the editorship of Robert Barclay, with contribution from seven authors (three of them coinciding with those of the previous publication). The new text was affected by the experience developed in the meantime, but was substantially based on the same principles: “Present enjoyment is hard to resist, but since a museum artefact is held in trust for the future as well as the present, one should always consider whether a present use or restoration proposal will close off interpretation options for future curators and visitors. No matter how much it may please an influential individual or special interest group today, many of the objects in our care will be viewed and used by future visitors and scholars in ways that are different than those we imagine today. It is, therefore, clear that collections of musical instruments (and other functional objects) provide some problems for museum staff, which differ from those of fine art collections. Nevertheless, their treatment can and should be judged by exactly the same standards applied to treatments of paintings, sculpture, and the decorative arts.”

With the increasing number of museums involved in the business, and with the varying attitudes related to different experiences here and there, it may seem that nowadays curators are more attentive to the “sound experience” of the visitors. However, even today no official distinction is made with regard to two categories of instruments usually left aside from the previous classification: that of organs, and of course of old fine bowed instruments.

The first instruments are twinned by historical buildings, whose re-use is forced (at least) by economical reasons. The second constitute a unique case in the field of conservation, being unparalleled by artefacts of any kind, as no other objects are universally expected to be preserved “only” in functioning conditions. This is a case study for further research, which is tentatively affected by the present paper in an unusual way, taking into strong consideration a substantial distinction between public and private heritage.

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GUITARS IN DIFFERENT STATES

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The acoustic component in a documentation of a guitar

To show alterations on 19th century guitars within a period of time, a very detailed documentation is essential. It is seldom, to make a plucked instrument playable for a concert or a recording. At the beginning of such process one has to control the object carefully and to evaluate the arguments for or against actions very carefully. Sometimes the use of a replica is the best solution to make music audible. In recent years acoustic studies and audible tests show, that a copy of an old guitar with similar wood and the same sizes of components leads to good results. If the sound between copy and original is not comparable because of ones bad condition, the acoustic spectrum is.

![Figure 1: Acoustic spectrum of a copy of a 19th century guitar by the author](image)

In German-speaking countries some institutions operate since years with the acoustic as an objective measurable parameter for a report about an instrument. They also work with new and historical guitars. Some guitarmakers are familiar with a system for measuring the acoustic spectrum and they use it as an interpretation method during the process of building an instrument.

In fact the question is not about a development of a new innovative method to keep a record of a musical instrument. There are several examinations which make good research already possible. The hard thing is to find a good approach and guide lots of information.

If we want to get results of a closer look to a guitar life and if we have an idea about the factors which influence the condition of a guitar, we have not just to collect data about these factors very precisely and consistently, we have also to interpret them. The acoustical purview is a discipline with technologies not easily to understand but very profitable in this subject. The idea of a sound reconstruction might for a specialist nothing unapproachable.

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Towards a Standard for 3D-computed Tomography: the MUSICES Project

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Abstract

High-resolution, three-dimensional industrial computed tomography (3D-CT) is a preferred means for examining and documenting musical instruments in collections, as conventional investigation techniques are able to access and measure certain important constructional details not sufficiently, or in a risky way, or not at all.

The multitude of materials and their combinations as used in instrument construction as well as the very differing object sizes are, however, a constant challenge for this method, requesting frequently considerable efforts in time and costs for test runs.

Using a representative corpus of instruments of different types and sizes, the standard will provide guidelines enabling high-quality three-dimensional tomographies of a musical instrument, independently of a particular CT-facility, operator, or viewing software. A metadata model for 3D-CTs will be developed and integrated into the LIDO-standard.

A best-practice-guide, based on the experience acquired with the project will document paradigmatic workflows and shall act as support for making future 3D-CT digitization projects more efficient. Given the constructive complexity of musical instruments the standard is expected to be transferred to other groups of objects within a reasonable scale of modifications.
Introduction

It is generally known that the wooden musical instruments are covered by protective varnishes layers made by different organic compounds. Historically, the varnishes had the aim to protect the instrument by the external agents and to confer an aesthetic value to the object. The organic compounds were generally natural products and could be extremely heterogeneous, such as drying oils, essential oils, tree resins and gums, insect resins, dyes, various proteins or polysaccharides used alone or mixed together, possibly purified, pre-treated or diluted in a volatile solvent [Echard, 2008].

It’s even known as the playing routine of the musical instrument can induce different changes on the varnishes due to the contact with the player, with a strong degradation of the organic layers and a consequent widespread worn-out of the varnish. The main interaction is due to the acidity of the player skin, as well as the increase of the temperature, humidity and mechanical abrasion.

In order to study the different properties of the organic compounds, a natural varnish used on violins of the XVII century was recreated following an ancient recipe, with linseed oil and colophony mixtures with different ratios. The specimens were aged by using UR%, T, pH variation cycles and mechanical processes of surfaces abrasion. Measurements were carried out with a minimum of 32 scans. Observations of the cross-section specimens embedded in acrylic resin were carried out with an Olympus BX51TF polarized light microscope equipped with an Olympus TH4-200 lamp (visible light) and an Olympus U-RFL-T (UV radiation). Various cross-section and powder specimens were also studied with a FE-SEM Tescan Mira 3XMU-series scanning electron microscope equipped with an EDAX spectrometer at an accelerating voltage of 15–20 kV in high vacuum.

Figure 1: A cross-section SEM image of a wood specimen treated with a varnish layer.
Methods

Different layers of varnishes (oil and colophony 50/50) were applied on glass and wood specimens and were analysed before and after aging with exposition under acid atmosphere and solar lamp and with different cycles of temperature and UR%. The specimens were investigated by FTIR spectroscopy analysis through a Nicolet iN10 Thermo Fischer micro FT-IR spectroscope, in ATR mode with germanium crystal; the spectral range

Results

Several hypothesis about the reactions in the varnishes before and after aging processes were performed, on the basis of the literature data [Azémard, 2014], and of the results of spectroscopic and morphological investigations. A strong degradation of the varnishes was observed after acid exposition, with a strong loss of cohesion of the varnish and an evident chromatic variation of the surfaces. In addition, different signals ascribable to the development of new compounds were detected by FTIR technique.

On the contrary, the aging cycles by variation of temperature and UR% seem to produce a lower worn-out of the varnish layers.

Discussion

The results obtained in this experimental study seem to agree with literature data and, in particular, highlight as the contact of an oil varnish with the acidity of the player skin represents the first cause of the degradation of the varnishes, with an increase of the craquelure process and a consequent detachment of the film and loss of material.

Moreover, a significant increase of the degradation process was performed by the simultaneous effect of the mechanical abrasion and the high temperature and UR% on the violin surfaces, due to the continue contact with the player.

Acknowledgements

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THE ROLE OF TONEWOOD SELECTION AND AGING IN INSTRUMENT “QUALITY” AS VIEWED BY VIOLIN MAKERS

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Introduction

Resonance woods are the raw material used for the making of violin family: Norway spruce (Picea abies) is used for top plates and sycamore maple (Acer pseudoplatanus) is used for back plates [Bucur, 1992]. On the one hand, the mechanical/acoustical properties of these two preeminent wood for classical stringed musical instrument have been well studied. It is often recognized that high quality resonance spruce has low density, high modulus of elasticity, low damping and high anisotropy [Ono & Norimoto, 1983; Obataya et al. 2000]. When compared to “common quality” spruce wood, the resonance spruce shows atypical relationships between structural/visual features and mechanical/acoustical properties [Carlier et al, 2014]. On the other hand, physical acoustics and psychoacoustics studies were conducted on the behaviour of finished violins and the perception of their “quality” by players or listeners. However, while the link between the raw material and the finished instrument is made by luthiers, their practice and opinion has seldom been explored. According to the only psychosensory study on the subject [Buksnowitz, 2007], the selection of wood by violin makers would rather rely on visual criteria than on mechanical or acoustical properties that seem difficult to assess. It could also reveal the use of indirect indicators, and/or take into account personal or cultural preferences in wood choice [Brémaud, 2012].

Empirical knowledge of luthiers is precious and can help us to appreciate the concept of “resonance wood”. Therefore the objective of this ongoing 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.

Here we will focus on a survey conducted on the way instrument makers choose their wood, and their opinion about issues of time and aging.

Methods

To identify craftsmen’s opinions, practices, empirical knowledge and their main questions, a “socio-technical” survey on both qualitative and quantitative grounds has been created. The survey was developed as face-to-face interviews using a modular and detailed questionnaire. It was design in order to be applied to different instrument making specialities and to be used on other project. As a first step the survey concerned the violin-family luthiers of Montpellier and then was extended to the rest of France. Suppliers were also questioned. In a second step an exploratory study was extended to Iranian makers of traditional string instruments. Quantitative analysis of the questionnaire was first conducted (using Sphinx software) while qualitative analysis of interviews’ recordings (managed under Sonal software) is still in progress, include opinions about the effect of playing.

Results

Makers reckon they rely mainly on empirical processes (but also historical) for their practices. They consider resonance wood choice to be one of the most determining factors in sound quality of the instrument. Resonance wood choice and Design appears to be determining factors in both Sound quality and global quality of the instrument (figure 1). Lutherie’s work or varnish are considered more relevant to “global” than “acoustical” quality, while pre-stresses and adjustment are more related to “acoustical” notions.

Figure 1: Importance scale of different fabrication parameters in sound quality and quality of instrument

Empirical qualification criteria taken into account by violin makers to choose spruce wood are mostly based, by order of importance, on cutting, density,
percentage of latewood, growth ring uniformity and width. For maple, ring width seems to be the most important criteria for luthiers. Density, cutting plan and drying are also very important. Unlike spruce, colour appears more crucial for maple.

Most of the makers do not take into account the drying time before buying their wood. However they recommend a drying time equal to or higher than at least two years, before starting the fabrication. More than half of luthiers do not specifically seek for aged wood, even if they believe that the properties of their raw material can be changed by aging. When asked the question of “evolution of acoustical properties through time”, they consider such an evolution would be different depending on the instruments being played or not. The opinion on the effect of aging on different criteria of the instrument wood is more contrasted over the centuries (very positive effect or no effect) than when considering short term aging (Figure2). For aging over centuries, there is a consensus about a positive effect on visual criteria, while there is weaker agreement about acoustical effects, and physical/mechanical properties are not thought to be much changed. For short-term aging (years or few decades), luthiers think that it more consistently affect the different considered properties, although with smaller maximum importance. Acoustic properties (followed by physical/mechanical ones) are more though to “improve” over years/decades than over centuries.

Luthiers report a lot of interest in scientific approach of musical instruments, especially regarding resonance wood. They show different “profiles” of interests for research in various fields (historical, forest, material, acoustical or sensory aspects) and these different “profiles” might reveal some kind of “school of thinking”. Most of them would be interested in the development of simple tools usable in a workshop if they permit a better knowledge of the wood.

The perceptual criteria used for wood qualification can be visual, physic-mechanical, auditory and will require a more detailed study to evaluate the respective contribution of these different fields of perception.

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References

AUTOMATIC DETECTION OF WORN AREAS ON STRADIVARI VIOLIN BACK PLATES

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Introduction

In recent years, multispectral imaging techniques, as UV fluorescence, become an essential step of the preliminary analytical procedure on artworks, especially in the ancient musical instruments field. In fact, this imaging analysing technique can represent an important knowledge about the distribution, the retouchings and the worn out of the varnishes areas.

However, although this preliminary and non-invasive technique is essential in order to project a correct analytical campaign, there are a lot of limits in the interpretation of the results, with variables due to the equipment, capture and processing of images, as well as the interpretation of the distribution of the varnishes areas [Comelli, 2008].

It’s clear that there is a need to establish an analytical protocol in order to perform a correct method to select the different areas and to discriminate between several materials widespread present on the musical instrument surfaces.

The aim of this work is to develop a new software system in order to automatically select the different fluorescence areas by a chromatic selection and to directly characterize the different organic materials of the violin surfaces.

Methods

For the acquisition of the images we prepared a dedicated photographic set, following the protocol adopted by British Museum for the UV induced fluorescence photography [Dyer, 2013]. In particular we used a Nikon D4 camera, two wood lamps for providing the UV illumination, and a Kodak 2e gelatine filter, in substitution of the Schott KV418, currently dismissed.

UV fluorescence colours change in function of the materials and/or the paints present on the surface. The analysis of the acquired data shows that the areas where the wood and the wood filler are more evident and the paint coats are low or totally absent have always the same colour hue, with a different level of saturation directly proportional to the level of consumption. Starting from this consideration, small areas, that are certainly worn, have been manually labelled by an expert violin maker and then used as a training set for our system. This step was important to set the tolerance range for the chosen hue and the various saturation levels that correspond to different levels of worn. After the learning phase the system is able to find automatically all the regions of interest also in zones not directly evident looking the original photos due to perception illusion (e.g. in back where the consumption is very low and hided by nearest paint coats).

The algorithm uses HSV (Hue, Saturation, Value) a colour space more closed to human perception than RGB. In particular, in this case, only the first two channels have been considered, since Value (i.e. the brightness) has not relevant variations in areas with no painting.

During the computation, the fraction of the worn areas respect to the entire surface of the back is also automatically computed analyzing the distribution of resulting histogram.

The background of the photo is excluded by the analysis applying an edge detection filtering algorithm.

A set of parameters configurations for the system are available depending on characteristics of
photographic set, such as the position and number of the lamps, quality of the camera, and so on.

**Results**

We tested the system on the historical collection of Stradivari violins preserved in the “Museo del Violino” in Cremona (Italy). The detected areas are highlighted with three different levels of worn: high in red, medium in orange, low in yellow.

![Figure 1: Example of the application on the back of Antonio Stradivari Cremonese (1715). From left to right: visible, UV fluorescence, final result.](image1)

The program allows the user to visualize all of them or a subset, in order to focus only on the areas of major interest.

Figure 1 and 2 show the results obtained on the back of the violin “Cremonese” (1715): it can be seen as the more consumed areas are mainly concentrated in the bottom and only partially on the top left side. Low worn zones are more diffuse on the surface, with the exception of the middle-top area, which looks intact.

![Figure 2: A zoomed detail of the top area of figure 1.](image2)

The percentage of detected worn areas on the total of the back is around 29%, where 5% is the high, 7% the medium and 17% the low. This percentage is compatible with the judgement of expert people.

**Discussion**

The test on the historical collection proved that the proposed solution is effective to underline worn regions and it is robust to small alterations of environment setup between photos (e.g. changes of exposure or of the distance from the lamps).

The more critical regions (red and orange) have a high level of accuracy, with the only exception of the purfling that can be seldom wrongly classified due to their dark colour that masks the fluorescence. We are currently testing some specific corrections based on mathematical morphology, to totally exclude that zone from the analysis.

Instead false positives are more frequent in yellow areas because the region of transition between low consumed and painted zones could have overlapping ranges of hue/saturation. When such condition occurs could be useful to use an ad hoc setting configuration for refining the selection.

However, wrong classified regions occurs where there are heavy alterations of original structure of the instruments, so in any case they could suggest to the user the need of a more detailed analysis with different tools (i.e. XRF or FTIR) able to deal this ambiguity.

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**References**


EVOLUTION IN THE MANUFACTURE OF THE BASSET HORN D’AMOUR

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Introduction

In 2006, a project of instrument making was proposed by the Musée de la Musique in Paris, in order to make a facsimile of a basset-horn d’amour. The original instrument underwent several repairs and modifications between its manufacture, estimated at the last third of the 18th century, and 1840, so that its initial condition is not known.

Examining these modifications, comparing this instrument with other more recent basset-horns, and studying its acoustics allowed us to make assumptions about the evolution of the basset-horn making.

The basset-horn d’amour

The basset-horn originates from South Germany in the 1760’s. Initially its shape was curved and then became angled [Rice, 1986]. The basset-horn “d’amour” is a single reed instrument and its bore is cylindrical. It plays one third below the lowest note of the A clarinet. In particular, this instrument was used in several Mozart’s pieces from 1784 to 1791 [Deutsch, 1956] and more recently in Dvořák’s and Strauss’s works.

The instrument owned by the Musée de la Musique in Paris (ref. E.2200), cf. Fig.1, was made in Germany or Austria in the last third of the 18th century by an unknown maker. It is made of curly maple. Initially it featured eight keys made of brass, but two more were added later on. The mouthpiece is connected to a straight barrel and a straight upper joint, operated by the left hand. This part is separated from the lower joint by a bend of 114 degrees. This lower joint is composed of a small joint, operated by the right hand, and a large joint. Two right angled lower bends connect the small joint to a cylindrical bell. Its bore is a 70.5 mm diameter sphere, open on the lateral wall of the bell. The end of the bell is closed by a cap. The qualifier “d’amour” in the instrument name is due to the shape of the bell. The instrument, pitched in F, plays over a range of four octaves and is tuned in A450.

Evolution in the manufacture of the basset-horn

In Vienna, the basset horn experienced a fast evolution in the 1780’s and 1790’s, due to collaborations between Anton Stadler, clarinet player in the court, and maker Theodor Lotz [Poulin, 1982]. About 1791, Viennese maker Friedrich Hammig elaborated a straight basset horn with eleven keys, one specimen of which is kept in the Vleehuis museum in Antwerp, Belgium, cf. Fig.2.

Figure 1: Basset horn “d’amour” (last third of the 18th century), Curly maple, ten keys, and anonymous maker. It is kept in the Musée de la musique in Paris, France (ref. E.2200).

Figure 2: Basset horn “d’amour”, circa 1800, manufactured by Hammig Junior in Vienna, with an extension downwards (including C3 and B2 or Bb2). It is made of boxwood and ivory. Its bell is similar to the bell of the basset horn E.2200 in the Musée de la Musique, Paris. It is kept in the Vleehuis museum in Antwerp, Belgium (ref. AV.67.1.57).
Comparing the dimensions of both instruments and examining the modifications of the basset horn E.2200 of the Musée de la Musique in Paris show the evolution of the basset-horn manufacture in the end of the 18th century. The acoustic impedance of the basset horn E.2200 and its facsimile were measured using a method developed by Le Roux et al [2008]. The measurements show the influence of some manufacture modifications on the instrument sound.

First the bend between the upper and lower joint was shortened and then removed in the end of the 18th century, as well as the second bend of the lower part. Consequently the D/A and G/C tone holes were easier accessible. Then the shape of the barrel became curved to improve the comfort of playing, as shown in Fig.2 by Hammig’s instrument.

From the end of the 1790’s, the bore of the basset-horn became shorter and its diameter was extended in order to raise the instrument tuning. It reaches A450, in the case of the modified E.2200 basset horn. Its tone holes were also enlarged, which is typical from Viennese manufacture.

From the 1790’s, an improved keywork made the basset horn more ergonomic. Hammig’s instrument, cf. Fig.2, has three more keys than E.2200, allowing the player to play (written) C3 and B3 (or B♭3). Further, the D key in Hammig’s instrument is closed while it was open in previous instruments, so that (written) C3 can be played by pressing only one key.

The wooden cap of Hammig’s instrument fits the outside of the bell’s tenon joint, while it fits the inside of the tenon joint in the E.2200 basset horn. This solution reduces the risk of cracks and leaks.

Both instruments were particularly fragile around the bends of the lower part, probably because of water condensation in the bore. Directing the bell aperture towards the bottom of the instrument or using a harder material (e.g. ivory) would have strengthened the basset horn.

As a conclusion, the fast evolution of the basset horn “d’amour” between 1780 and 1840 mostly consisted in removing one and then two bends, increasing the bore’s diameter and improving the keywork. These modifications led to a more ergonomic instrument and a higher pitch tuning.

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References


REMOVAL OF IRON OXIDATION PRODUCTS USING CHELATORS: A PRELIMINARY APPLICATION ON A WOODEN GUITAR

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Introduction

Viewed through the perspective of artworks conservation, musical instruments are considered as "composites", since they consist of a combination of organic and inorganic materials, such as wood and metal elements often made of iron (screws, tuners, bridges, etc.). When musical instruments are found in wet or humid environments (relative humidity above 65%) or during handling and use, their iron components start to corrode. Corrosion products usually generate color alterations of the subsurface with which they have direct contact. Additionally, corrosion products can also promote further deterioration of substrates, as they are capable of catalysing various oxidation reactions. The corrosion of metal fastenings, in combination with the deterioration of the surrounding materials, can also result in materials' mechanical damage [Godfrey et al, 2002] and weakening and therefore threaten the structural integrity of objects [Baker, 1974].

Therefore, the removal of the iron corrosion products from the wooden substrate is often a necessary process when conserving wooden musical instruments.

Conventional methodology for removing iron corrosion products in conservation practice, includes the use of aqueous solutions of chelators, which are capable of bonding with insoluble iron ions in order to solubilise them and remove them from the stained substrate. There are many published studies on chelators used for the removal of iron corrosion products on substrates, such as paper, textile, stone, metal, paintings and waterlogged wood [Roger, 1981; Slavin, 1990; Burgess, 1991; Phenix & Burnstock, 1992; Chapman, 1997; Margariti, 2003; Rivers & Umney, 2003; Almkvist et al, 2005; Fors, 2008]. On the contrary, studies for chelators’ application on composite dry wooden objects are scarce, probably due to the fact that the majority of chelators are water soluble and commonly applied with immersion baths. Therefore they cannot be applied on porous hygroscopic and anisotropic materials such as wood, as this could promote further diffusion of corrosion products into material' matrix and induce uneven dimensional changes, resulting to distortion, warping, splitting of wood, dislocation of object’s parts etc. According to international standards, no musical instrument should be normally wet-cleaned [Museum and Galleries Commission, 1995] as it will certainly result in loss of original material, convicting the instrument to remain non-functional. Therefore, when cleaning dry objects like musical instruments, aqueous cleaning treatments with prolonged contact are not recommended. Minimum contact time with water, as well as blotting of the excess water is necessary [Rivers & Umney, 2003].

Finally, according to the ICOM-CIMCIM code of ethics [Odell & Karp, 1997] an effective conservation/restoration approach of musical instruments should intern to solutions towards their playability.

Based on the above, this study was set to investigate an alternative methodology for minimizing wetting of wood during chelators' application.

This work presents preliminary results on chelators’ effectiveness when applied on dry wooden mock-ups stained with iron corrosion products (fig 1).

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Figure 1: Detailed of a wooden mock-up stained with iron corrosion products

This work presents preliminary results on chelators’ effectiveness when applied on dry wooden mock-ups stained with iron corrosion products (fig 1).

Furthermore, it presents results obtained from the application of the most effective chelator on the stained areas of a wooden guitar, as a pilot study. This research is ongoing and is also experimenting with chelators application on wood via non aqueous solutions. However results are yet to be obtained.
Methods

Two chelators were tested. EDTA (ethylenediaminetetraacetic acid) and DTPA (diethylenetriaminepentaacetic acid), both 2.5% w/v in deionized water. The pH of the solution was adjusted with sodium hydroxide 1M, to 6.2 for EDTA and 6.8 for DTPA. The same chelators were also applied in combination with a reducing agent SDT (sodium dithionite) 5% w/v.

The four solutions were applied by two methodologies, a moistened cotton swab and a gel made by the addition of a thickening agent CMC (carboxymethylcellulose) 3-4% w/v.

For the evaluating the efficacy of solutions on restoring initial colour of the wood, wood mock-ups were measured before and after cleaning with a portable colorimeter Lovibond (model SP60 - RT Series).

Results and Discussion

Iron corrosion products appeared to be effectively removed from wood by both chelators applied. However colorimetry showed that EDTA was more effective than DTPA.

Both EDTA & DTPA were more effective when applied in combination with SDT. However, residues of Na & S ions due to SDT use, could promote future deterioration of substrates. Further investigation is required for the selective removal of these chemical elements from the wood substrate.

The application of the solutions with cotton swab was more effective than CMC gels.

Conclusion

The most effective chelator applied on the guitar wood in a pilot base was EDTA in CMC with SDT; however more data is required in order to conclude the suitability of this methodology.

It appears that a more holistic evaluation is required when a conservation material-methodology is applied on a musical instrument. Several parameters should be taken into account such as aesthetic appearance, physical integrity of the material and acoustic properties.

References

THE ART AND SCIENCE OF THE REDISCOVERY OF AN EIGHTEENTH-CENTURY RECORDER

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Introduction

The decline of the recorder after its baroque golden age has been thoroughly analyzed by musicologists and organologists. Far less studied is its persistency in the later musical culture. Recorder collections contain a relevant number of instruments dated from the last decades of the 18th century and well into the 19th century, documenting this persistency and adaptation to the new musical needs [Macmillan, 2008]. In some cases, the late popularity of the recorder has been a regional circumstance, like in the case of the Viennese Csakan or of some instruments for popular or military music in the Americas. Some other late recorders are unique and extravagant pieces which can be regarded as experiments or unsuccessful adaptations. However, we also find in the collections a fair number of “traditional” late recorders, some of which of very fine craftsmanship, which document a minor but diffuse use, eventually also professional.

One of these is the remarkable Noblet alto recorder of the Bate Collection of Musical Instruments in Oxford (collection #328).

This paper describes the process of making a modern copy of the instrument. The original instrument is not in good playing condition and mounts a low quality block (a consumable and interchangeable part in recorders). What should then a “copy” of this instrument be? We describe a complex process including, measurements, evaluation and tentative “reverse engineering” of wood deformation, and some artistic choices which had to be made in order to obtain a musically meaningful result.

Methods

The original instrument was manually measured to an accuracy of about 0.05mm. Deformation of round parts was assumed elliptic and measurements refer to the principal axes. A digital CAD model of the instrument was made, reducing elliptic sections to round average sections. The resulting model displayed apparent deformations which were analyzed and compared to modern construction standards (see discussion). In particular, a marked decrease in the bore diameter was observed in regions of the bore where the wood was cut perpendicular to the grain direction and at the same time likely exposed to high humidity fluctuations. A refined “reverse deformed” model was made, and used as the basis for the construction of a first set of copies. Fabrication of the block required some artistic decision, since a copy of the ancient block would have surely led to a poor performance of the instrument. The difficult decision was taken to build the block according to today’s knowledge, adapting it to the instrument body in order to produce the best sound and playability, as evaluated by renowned professional musicians. Fingering patterns of the original instrument were determined by the same musicians taking into account historical practice and playability, and the copies were tuned accordingly.

Results

The first set of copies, comprising three instruments, is shown in Fig.2. The instruments are naturally tuned at A= 430Hz, very close to the original pitch. They are playable in the usual recorder range two octaves and a third (F’-A’’’), producing a very distinctive clear timbre, relatively different form the typical baroque recorder sound. The instruments have a quick and flexible response which makes them apt to playing technically
complex music. They have been used in public concerts to perform duets and trios by W.A. Mozart and F. Devienne.

Figure 2: The first set of three copies.

Discussion

The process of copying an ancient instrument described above rises a number of questions both from the scientific and artistic points of view. The purpose of the copy was not only to preserve an object belonging to cultural heritage, but also to revive a “lost” cultural element, i.e. the sound of the instrument. This required the reconstruction of a fully functional instrument. Most features of the instrument were faithfully reproduced by the physical copy and by educated scientific guesses concerning the effect of ageing and usage on the wood. The latter could be further improved by the use of FEM simulations in future studies. In fact, it seems today feasible, although not immediately available, a simulation methodology in which permanent shrinkage is predicted according to either simulated or measured humidity distribution in the instrument, and in turn used to predict the effect on the final shape of the instrument surface. However, some details of the instrument, namely the so called “voicing” areas, had to be re-invented in order to build a functional instrument (and no simulation can overcome this lack of information). This was done according to the principle of “best fit” of the voicing to the instrument body.

The result is remarkable in several respects. Firstly, the fact that the reconstructed instrument present the correct pitch and tuning confirms that the choices made during “reverse engineering” of the instrument shape are correct. Concerning the sound, the copy exhibits a very distinctive sound, where the sound of the original is clearly recognizable. The marked difference with respect to the typical sound of early baroque recorders is particularly interesting. This sound bears some similarity with sound of the contemporary viennese Csakan, but keeping the warmth and flexibility of baroque recorders, and allowing to play complex music requiring an agile instrument with a consistent voice in all registers.

Summarizing, this copy experiment shows that an interdisciplinary work comprising modern craftsmanship, materials science considerations and expert musicianship are necessary for reviving the sound of an ancient instrument.

Acknowledgements

The Bate Collection of Musical Instruments at the University of Oxford and its Curator David Lamb are gratefully acknowledged.

References

LEVELS AND ANGULATIONS OF THE LEFT HAND A CONTRIBUTE TO VIOLINISTIC TECHNIQUE

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4. Faculty Sports of Oporto University, Portugal

Introduction

All violinists and violists face a general difficulty as they are instruments of non-fix intonation, which makes very difficult to play in tune in a regular way and as the posture is completely nonsymmetrical, with no outside support for the handling and performance of the instrument, it is quite easy to create wrong postures and wrong technics. The body library for violin technic is quite wide. We have registers from Leopold Mozart with his book A Treatise on the Fundamental Principles of Violin Playing (1756), later registers from a great violinist Louis Spohr (1852) in his book Grand Violin School, extended to the modern days by a famous violinist in his book The complete Violinist: Thoughts, Exercises, Reflections of an Itinerant Violinist. Yehudi Menuhin (1986) witch focus many subjects related to technic, study and the daily life of a violinist. But the matter about the biomechanics and ergo-anatomy of the left hand, referring the interdigital movements and the relationship of the left hand to the arm of the violinists is actually very limited. Many authors discuss different ways how to work on intonation as exercises or empiric opinions about possible problems like the books written by well-known pedagogues and master such as Carl Flesch (1939), Leopold Auer (1921), Simon Fisher (1997) or D.C Dounis (1925). The only schematic matter addressed by some authors to the functioning of the left hand and the relationship between fingers is related to the left hand patterns mentioned in different ways by William Primrose (1960), Robert Gerle (1983) and Barbara Barber (2008), which outlines the many interdigital patterns in a given hand position in the violin. However this approaches aren’t based in scientific and anatomical functional way and doesn’t suggest an ergonomic and mechanical understanding to deal with the different openings and distances and progressive decreasing intervals between fingers in the many positions of the left hand in the violin scale.

Based in our experience as concert violinist and pedagogue in many levels of violin teaching, and in the ergo-anatomic characteristics and biomechanics laws of the hand, presented in the book The Physiology of the Joints (I.A.Kapandji, 2007) and in the Atlas of Human Anatomy (Frank Netter, 2000).

We are proposing a conceptual understanding and functioning of the left hand so it is possible to answer in reasonable and verifiable way this main three questions so much important to all violinists.

1. How to control the positional structure of the hand in order to obtain the same ratio interval distances in different strings? Without muscle tension and in an organized manner?
2. How to control the opening of the fingers in great length intervals, without stretching and creating large palmar muscle tension which limits the performance?
3. How to control structurally the progressive reduction of the interval relationship between fingers on the violin scale, without recurrence to digital extensions that creates much discomfort and palmar tension?

To answer this three mainly important questions about the performance of the left hand in violinists and based in the main anatomic characteristics of the hand structure and functioning, we have suggested three possible answers which is intended to be investigated in laboratory.

For the first question we established the possibility of having four different basal levels for the action of the left hand in relation with the fingerboard which allows the same function of the hand for the four strings.

For the second questions and based in the condyloid shape of the metacarpophalangeal joint we suggested different levels of height in the same basal level, giving wider distances between fingers being able to play intervals of fifth, sixth minor and sixth major between first and fourth finger without the need of stretching them.

About the third question we suggest the hypothesis of working with hand angulation in a given basal
level in relation to the fingerboard, as a way of micro tuning the intervals between fingers in the different positions.

**Methods**

In a way to verify these principles it is intended to develop a methodology in the Oporto University of Sport and the LABIOMEP which is a laboratory of biomechanics residing in this university.

The methodology is being developed and it includes:

Electromyography analysis, using Delsys equipment to measure the muscle activity of the hypothenar and the Abductor digiti minimi muscle of hand of the fifth finger, the first interosseous and the Flexor digitorum profundus muscle of the fingers in the forearm.

Thermography analysis, using the camera FLIR SC7000 will be used to measure the arm and hand temperature during the exercises.

The pressure measurement System using Teskam equipment, will be putted between strings and the fingerboard in the different technics and positions. This system will measure the muscle resistance of fingers and the force they are able to put over the strings in the different positions.

The motion capture system using Qualysis equipment it’s a technology that will capture, through the placement of small reflectors in the different joints, the motion of the hand and arm related to the violin fingerboard. This technology will give a digital motion of all the segments and joints of the hand fingers wrist and arm when playing in real time all the exercises proposed.

All this equipment will be used during the playing of some exercises (Figure 1) written for this methodology and based in the main hypotheses of the research.

If verifying the hypotheses drawn previously it is intended to create a preliminary model capable of explain biomechanically the most comfortable, ergonomic and precise way for the performance and consequently for the learning of the left hand in violinists and violists.

*Figure 1: the score used in the research*

**Acknowledgements**

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CHARACTERIZATION OF STIFFNESS COMPONENTS OF WOOD FROM HETEROGENEOUS PLATE BENDING TESTS

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Abstract

This work presents a study on the characterization of longitudinal-radial orthotropic elastic properties of Pinus pinaster Ait. wood through a heterogeneous plate bending test. The proposed approach couples the deflectometry optical technique with the virtual fields method (Figure 1). Using this inverse identification method, all components of the bending stiffness matrix, governing the Love-Kirchoff classical plate theory, can be determined from a single test. The approach was firstly validated using a finite element model of the bending test considering five different loading cases. Experimentally, a procedure was implemented in order to coating the surface of the solid wood plate in order to guarantee the specular reflection required in the deflectometry technique. The curvature fields required in the identification problem were numerically reconstructed from the slope fields by means of a polynomial approximation. The curvature fields, together with the applied punctual load and the plate dimensions were then input in the virtual fields method for material parameter identification (Xavier et al 2007, Xavier et al 2009a; Xavier et al 2013). The values of the engineering constants obtained from the proposed approach were found in good agreement with regard to reference ones reported in the literature for the same species and determined from independent classic tensile and shear mechanical tests (Table 1) (Xavier et al 2004, Xavier et al 2009b).

![Figure 1: Schema of the plate bending test.](image)

<table>
<thead>
<tr>
<th>$E_L$ (GPa)</th>
<th>$E_R$ (GPa)</th>
<th>$L_R$</th>
<th>$G_{LR}$ (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>15.13</td>
<td>1.91</td>
<td>0.47</td>
</tr>
<tr>
<td>Mean</td>
<td>12.55</td>
<td>1.396</td>
<td>0.639</td>
</tr>
<tr>
<td>Std</td>
<td>5.319</td>
<td>0.237</td>
<td>0.371</td>
</tr>
</tbody>
</table>

Table 1: Engineering constants determined by the VFM.

References

BRINGING BACK THE ‘DAVIDOFF’ STRADIVARI VIOLIN TO PLAYING CONDITION: MEASURING CHANGES

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Introduction

The ‘Davidoff’ (dated 1708, inv. E.1111) is the first of the five Stradivari violins to have entered, in 1887, the collection of the Musée de la musique, Paris. Its previous owner was Vladimir Alexandrovitch Davidoff (1816-1886), a general and private counsellor of the Emperor of Russia. This amateur violinist, stayed (and died) in Paris in the 1880s: He is known to have visited the Conservatoire and the Musée, and he subsequently bequeathed the instrument to the institution, which received it in 1887.

The instrument is well-preserved in general: in particular, the one-piece slab-cut maple back and the headstock still reflect today the excellent craftsmanship of the Stradivari workshop during this period. The previous set-up of the instrument was from the second-half of the 20th century (i.e. none of these parts was original from Stradivari workshop). In order to have the instrument played by a violin soloist, several conservation treatments and set-up restoration works were carried out on the instrument at the Musée’s Conservation Department in the autumn of 2014. The objectives were, first, to optimize the musical functioning and playing condition to playing techniques of nowadays 21st-century players; second, to improve the visual appearance of the violin; while simultaneously fulfilling the specific deontological constraints involved in the material conservation of an historical artefact of a museum collection.

In this context, conservation treatments included among others, the removal of a part of the important varnish retouches on the soundboard, the cleaning and re-gluing of several cracks and purflings areas. The previous set-up was removed, properly preserved, and replaced. In particular the fingerboard, bridge, soundpost and tailpiece were changed (Fig. 1).

Methods

Several methods were used to document the physical state (geometry, vibrational properties, colour, etc.) of the instrument at several important steps of the work.

3D Scanner: A FARO Edge ScanArm ES equipped with a contact-less laser head is mounted on a 3-axes arm was used [Pinçon et al., 2014]. In the acquisition conditions used, the spatial resolution is of 35 lm and the acquisition rate of 45120 points per second (Fig. 2).
Figure 2: Contact-less laser 3D scan of the ‘Davidoff’ violin. The previous set-up (including fingerboard and soundpost) is removed.

Impact Nearfield Acoustical Holography (IPNAH): IPNAH is a non-invasive acoustical method based on the response of the vibrating source measured in term of radiating acoustic field with a microphones array (Fig. 3). The vibration behaviour of the source is deducted, in term of normal vibration velocity, using an inverse calculation method based on spatial Fourier transforms [Le Conte et al., 2012a,b, Le Moyne et al. 2012].

Figure 3: Impact Nearfield Acoustical Holography of the ‘Davidoff’ violin.

Reflectance multispectral imaging (RMSI) was used to investigate the changes in the reflectance properties of the soundboard produced by the retouches. Using a full-field MS imaging lab-designed system, described in [Simon-Chane et al., 2015], we collected 15-band MS acquisitions in the 400-750 nm range before and after the restoration (Fig. 4). We retrieve reflectance spectra for each pixel of the field-of-view using a calibration processing based on a neural network [Mansouri et al., 2005]. This enables us to evaluate the effect of the retouches on the soundboard in a calibrated colour space.

Figure 4: Reflectance MS acquisition of the ‘Davidoff’ violin. At the bottom right of the image is the camera seen from back and the 16-position automated filter-wheel (black cylinder).

Results

The several steps at which the acquisitions have been obtained will be described, before, during and after interventions and first results will be presented.

The correlation between the progress of the interventions and the metrological variations will be identified.

First IPNAH measurements had been performed in 2012 on the ‘Davidoff’ in 2012 [Le Conte et al., 2012b]. Here, the modifications in terms of frequency and intensity of different vibration modes of the instrument will be shown, and discussed.

The RMSI results will be discussed in terms of objectives quantification modifications of appearance.

Acknowledgements

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EFFECTS OF PLAYING ON THE PRACTICAL PERFORMANCE OF 
REED USED FOR WOODWIND INSTRUMENTS

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Introduction

Woodwind instruments such as clarinet and oboe are equipped with vibrating plates called “reed” made by a kind of reed (*Arundo donax*). Many musicians claim that the quality of reed changes irreversibly by prolonged playing [Stein 1958; Obataya 1996a], but the mechanism of such irreversible change has not been clarified yet.

Since woodwind instruments are played by the exhaled air of players, the materials of those instruments are exposed to alternate wetting and drying. It should be noted that the reed contains large amount of water soluble extractives, and the extractives affect the vibrational properties of reed [Obataya et al. 1999]. Therefore, the loss of extractives due to playing i.e. wet-dry cycles may affect the quality of reed.

Another explanation for the irreversible change in reed property is the recovery of cell collapse. It has been reported that serious cell collapse is induced in the reed during drying, but the collapsed cells can be recovered by alternate moistening and drying [Obataya 1996b; Obataya et al. 2004]. Such a recovery may indirectly affect the performance of reed.

In this study, the effects of wet-dry cycles and moist-dry cycles on the mechanical properties of reed were investigated.

Materials and Methods

*Arundo donax* harvested for the production of clarinet reed was used. Specimens of 70 mm(L) × 5 mm(T) × 0.5 mm(R) were prepared from peripheral part and inner part of the internodes. For wet-dry cycle and moist-dry cycle test, 9 and 15 specimens were selected, respectively.

The specimens for wet-dry cycles were dried on P2O5 under vacuum, and their absolute dry mass was measured. The specimens were then equilibrated at 25°C and 60% relative humidity (RH) for more than 3 days to determine their mass and vibrational properties. Next, the specimens were soaked in water under reduced pressure for 2 hours (wetting), followed by drying at 25°C and 60% RH. And then the vibrational properties of those specimens were determined. That wet-dry process was repeated 14 times. Finally, the specimens were soaked in water for 1 week to remove the water soluble extractives, and their absolute dry mass was determined.

The specimens for moist-dry cycles were moistened at 25°C and 100% RH in a desiccator under reduced pressure for 1 day (moistening). The specimens were then dried at 25°C and 60% RH for 1 day to determine their mass and vibrational properties. That moist-dry process was repeated 6 times.

Results and Discussion

Figure 1 shows the change in extractives content (EC) due to wet-dry cycles. The EC decreased by increasing number of wet-dry cycles. Due to these loss extractives, the mass of specimens decreased.

The dynamic Young’s modulus (*E’*) and the loss tangent (tanδ) of specimens decreased by wet-dry cycles. These changes are plotted against EC in Figure 2. Changes in *E’* and tanδ showed linear relationship with EC. That is, the loss of extractives is responsible for the changes in vibrational properties of reed during wet-dry cycles.

Changes in thickness of reed specimens are shown in Figure 3. The specimens became thicker by wet-dry cycles. Such a thickening was due to the recovery of cell collapse which had remained in the specimens.

For musicians, the rigidity of reed (vibrating plate) is an important factor affecting their performance. Since the bending rigidity (*E’T*) of reed depends on its thickness as well as *E’*, we need to consider the abnormal thickness swelling due to the recovery of cell collapse. Figure 4 shows the changes in *E’T* and resonant frequency (*f*) of the specimens during wet-dry cycles. In many cases, the *E’T* dropped in the early stage of wet-dry cycles, because of the loss of extractives accompanied with significant reduction in *E’*. In some specimens, the *E’T* was once reduced and then turned to increase by wet-dry cycles. Such an increase in *E’T* was due the abnormal thickening resulting in the increase in second moment of area *I*. On the other hand, the *f* values is proportional to the square root of *E’T*lim, and the decrease in *m* due to the loss of extractives was large enough to cancel the drop in *E’T*. 


Consequently the $f_r$ always increased during wet-dry cycles as shown in Fig.4 (b).

![Fig.1.](image1)

**Fig.1.** Change in extractives content (EC) of different reed specimens during wet-dry cycles. Circles, $\rho = 390$ kg/m$^3$; Triangles, $\rho = 483$ kg/m$^3$; Squares, $\rho = 563$ kg/m$^3$

![Fig.2.](image2)

**Fig.2.** Change in (a) dynamic Young’s modulus ($E'$) and (b) loss tangent (tan$\delta$) of *Arundo donax* specimens during wet-dry cycles plotted against extractives content (EC). See Fig.1 for legends.

![Fig.3.](image3)

**Fig.3.** Change in thickness of *Arundo donax* specimens during wet-dry cycles. See Fig.1 for legends.

![Fig.4.](image4)

**Fig.4.** Changes in (a) bending rigidity ($E'I$) and (b) natural frequency ($f_r$) of *Arundo donax* specimens during wet-dry cycles. See Fig.1 for legends.

The changes in vibrational properties and dimension during moist-dry cycles were qualitatively similar to those of wet-dry cycles, whereas the former is slighter than the latter. All these results suggested that the practical performance of woodwind reed would change irreversibly during continuous usage.

The recovery of cell collapse is a particular phenomenon in reed, but the loss of extractives can occur in the other woody materials. It should be noted that the extractives affect the mechanical properties of wood, and that these can be lost from the wood cell wall by moist-dry cycles, even in the absence of liquid water. Thus, the effects of moist-dry and wet-dry cycles are to be considered when the material contains water soluble and/or deliquescent extractives.

**Acknowledgment**

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INFLUENCE OF THE SURFACE CONDITION IN BORE OF WOODWIND INSTRUMENTS ON THE ACOUSTIC IMPEDANCE

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Introduction

Woodwind players typically play next to the bore resonances. The playability and the quality of woodwind instruments strongly depend on the frequencies, amplitudes and bandwidths of the bore resonances. The input impedance of woodwind instruments, which allows estimations of these characteristics, has been extensively studied [e.g. Backus, 1974; Wolfe, 2001]. The influence of the bore geometry on the impedance peaks is well known [Chaigne & Kergomard, 2008]. However, the playability of woodwind instruments is also affected by the surface condition inside the bore. Indeed makers and players typically use oil to seal the pores of the inner wall. Recently, at the Musée de la Musique in Paris, the input impedances of a historical (not played) serpent made by Baudoin and of an oiled facsimile of same geometry in a playable state have been measured. Their comparison revealed significative differences of Q-factors and amplitudes in the impedance peaks.

This study investigates the influence of the surface condition of wooden pipes on the characteristics of their impedance peaks.

Materials and methods

A corpus of six pipes was provided by maker Pierre Ribot. Three are made of maple, three of chequer tree. Each pipe is composed of two pieces, cut lengthwise, parallel to the trunk, and glued together. For each species, one pipe was immersed in oil; another was immersed twice, and dried for one week between both baths, and one pipe was not immersed. The bores of the pipes are approximately cylindrical of diameter between 24.05 and 24.25 mm and length between 338.5 and 339.5 mm.

Many methods of acoustic impedance measurement have been previously developed and reviewed [Dalmont, 2001a]. The one used in this study was developed by Le Roux et al. [2008]. For each measurement, one end of the pipe is placed in the plane of the open face of the measuring device, so that their axes coincide. The contact between the pipe and the sensor is sealed with silicone and petroleum jelly. The setup measures dimensionless impedances on this plane: $Z/(p_o c/S)$, $Z$ being the input impedance of the pipe, $c$, and $p_o$ the speed of sound and the density of air and $S$ the area of the cross section.

For each pipe the impedance spectrum is measured twice, between 20 Hz and 6 kHz, allowing estimations of the amplitudes, frequencies and Q-factors of the 12 lower resonances. The Q-factors are estimated by the quotient between the frequencies of the impedance peaks and their bandwidths at -3dB. These estimations are reproduced within 0.11% for the resonance frequencies, 1.9% for the Q-factors and 0.1 dB for the amplitudes.

Results

Among the pipes considered, the characteristics of impedance peaks undergo significative variations, as shown by the measurements of Fig.1.

![Figure 1: measured impedance of two pipes made of different wood species and with different surface conditions and theoretical impedance of a model of pipe. Each pipe has a diameter equal to 24.1 mm and a length equal to 339 mm](image-url)
For the 12 first peaks, the standard deviations of these variations are 0.6% for the resonance frequencies, 32% for the amplitudes, and 32% for the Q-factors. These values are compared with a simple model of uniform cylindrical pipe, open at its far end, with length correction [Dal mont, 2001b] and viscothermal losses [Fletcher & Rossing, 1991], see black curve in Fig.1. When the diameter and length sweep the same range as those of the real pipes, the resonance characteristics of the model undergo much smaller variations than the measured ones: the standard deviations are 0.1% for the resonance frequencies, 0.2% for the amplitudes and 0.2% for the Q-factors.

For both wood species considered, the measured amplitudes and Q-factors of the impedance peaks increase when the pipe has been immersed in oil, as shown in Fig.2. However the effect of a second immersion is relatively bigger on the resonance characteristics of the chequer tree pipes while it is negligible on the maple pipes.

![Figure 2: amplitudes (a) and Q-factors (b) of the impedance peaks of maple and chequer tree pipes having different surface conditions.](image)

As a result, immersing a wooden pipe in oil increases its resonance amplitudes and Q-factors significantly. Further, the number of immersions has different effects, depending on the wood species. Further studies show that the deviation of amplitude and Q-factors of the impedance peaks when the surface condition of the pipes is changed are linear functions of their frequency deviations. A model of acoustic propagation in a porous medium using Biot’s theory [Allard & Atalla, 2009] is introduced to discuss these results.

Acknowledgements

We thank the Agence Nationale de la Recherche for its support as part of the program Investissement d’avenir, of reference ANR-11-IDEX-0004-02, and Pierre Ribo, maker, for providing the corpus of wooden pipes.

References


EFFECTS OF CONTINUOUS VIBRATION ON THE DYNAMIC VISCOELASTIC PROPERTIES OF WOOD

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Introduction

Many musicians believe that the quality of wooden musical instrument is improved by playing. Such a “playing effect” is recognized in stringed instruments such as violins, as well as woodwind instruments such as clarinets. Although no convincing explanation has so far been given for that empirical knowledge, it is considered that the playing i.e. continuous vibration may affect the dynamic viscoelastic properties of wood.

The first systematic study on the playing effect was conducted by Sobue and Okayasu [1992]. They have precisely measured the dynamic Young’s modulus ($E'$) and the loss tangent ($\tan \delta$) of 7 different wood species during continuous vibration. They have found that the $\tan \delta$ was significantly reduced by the vibration irrespective of wood species and the amplitude of vibration, whereas the $E'$ remained almost unchanged. Subsequently Hunt and Balsan [1996] have reported that forced vibration involved slight increase in $E'$ and reduction in $\tan \delta$. All those results indicate that the acoustic properties of wooden instruments can change by continuous playing. Sobue and Okayasu have speculated that certain internal stress was induced by the drying of green wood, and the relaxation of such “drying stress” was responsible for the significant reduction in $\tan \delta$ due to the vibration.

Figure 1 exhibits a simple viscoelastic model to explain the drying stress and its relaxation. When a green wood (A) is dried, hydrophilic amorphous polymers such as hemicelluloses and lignin are shrunk by the dehydration, whereas crystalline cellulose remains unchanged. Since the crystalline cellulose is much more rigid than the amorphous polymers, the shrinkage of amorphous polymers is restricted by the surrounding crystalline cellulose. Consequently certain internal stress is induced in the wood cell wall (B). As the amorphous polymers are frozen in dry state, the remaining stress and distorted conformation of the amorphous polymers remain unrecovered.

The effects of drying on the viscoelastic properties of wood have been studied well. According to Furuta et al. [1998], green wood shows单glass-rubber transition at around 90°C, but additional transition appears at lower temperatures (50°C) when the wood is once dried and rewetted. That is, the distorted amorphous polymers are not relaxed unless they are hydro-thermally activated by boiling or steaming (heating in saturated water vapour), as shown in Fig.1 (B→A).

Fig.1. A viscoelastic model to explain the drying stress and its relaxation.

a, Viscoelastic part consisting of amorphous polymers; b, adsorbed water in the amorphous region; c, crystalline cellulose.

If the relaxation of drying stress is responsible for the changes in viscoelastic properties of wood due to continuous playing, no playing effect is expected in green wood or hydro-thermally treated wood where no drying stress remains or the remaining...
stress is already relaxed. In many cases, however, the experiments have so far been conducted in dry condition, and therefore, the effects of drying stress are still unclear.

In order to discuss the influence of drying stress, we have tested the $E'$ and $\tan\delta$ of spruce wood in saturated water vapour to prevent the samples from drying. Since green wood sample was not available, dry samples were steamed to relax the remaining drying stress, and the steamed wood samples were used instead of green wood.

**Materials and Methods**

Sitka spruce (Picea sitchensis) lumbers were cut into plates, 100 mm (L) × 10 mm (R) × 1 mm (T). One specimen was moistened at 100% relative humidity (RH) prior to steaming. The moistened samples were wrapped with moistened paper and enclosed in a plastic bag. The bag was then put in boiled water at 98°C for 3 minutes to steam the wood sample. Another dry specimen remained unmodified and conditioned at 25°C and 60%RH.

$E'$ and $\tan\delta$ of the wood specimens were determined by cantilever method. An end of the specimen was held by a brass clamp and the other end was tapped using a small glass ball. The deflection of specimen was detected using a laser displacement sensor. The $E'$ and $\tan\delta$ were calculated from the resonant frequency of the first mode and decrement curve, respectively.

The dry specimen was continuously vibrated by a magnetic driver at resonant frequency for 48 hours while its $E'$ and $\tan\delta$ were measured at 24, 48, 72, 96 hours after starting the continuous vibration. The testing condition was kept at 25°C and 60%RH.

In the same manner described above, the $E'$ and $\tan\delta$ of the steamed specimen were determined at 25°C and 100%RH. To keep the humidity around the sample, the equipment was installed in a closed box in which sufficient amount of water was placed in the bottom.

**Results and Discussion**

Dry specimen showed increase in $E'$ and decrease in $\tan\delta$ during continuous vibration, and then these values remained unchanged. In contrast, the continuous vibration affected little the $E'$ of steamed specimen. This fact implies that the playing effect is related to the relaxation of drying stress. On the other hand, the steamed wood showed decrease in $\tan\delta$ during vibration as dry specimen did. A possible reason for the reduction in $\tan\delta$ is insufficient relaxation of drying stress due to short steaming time (3 min.). Otherwise, certain stress was additionally induced by the cooling after the steaming treatment, and such a thermal stress might be relaxed by the continuous vibration. Further detailed experiments are necessary to prove the contribution of drying stress.

**Acknowledgements**

We are grateful to Aoyama Harp Co. providing spruce lumber used in this study. We also thank Dr. Sandie LeConte for her technical support.

**References**


EFFECT OF TRANSITIONAL MOISTURE CHANGE ON THE VIBRATIONAL PROPERTIES OF VIOLIN-MAKING WOOD

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Introduction
Wood is a very hygroscopic material. When submitted to different relative humidity (RH), which can typically be the case when an instrument is played in different places, the internal moisture content of wood will be changed. This is well known to result in dimensional swelling or shrinkage, and will also modify the wood mechanical or acoustical properties. The equilibrium moisture content (EMC) dependence of vibrational properties (specific modulus of elasticity $E'/\gamma$ which is related to resonance frequencies, and damping coefficient $\tan\delta$) has been well-studied for spruce wood along the grain [Obataya et al. 1998] and for various wood species in the three main directions of wood [Suzuki et al. 1980]. However, equilibrium state is only reached after a relatively long time (weeks), whereas the humidity changes encountered when an instrument is played in different places involve short time scales (hours) and are typically out-of-equilibrium. Previous research has shown the existence of transitional effects, notably on damping [Sasaki et al. 1988; Hunt and Gril 1996]. However these studies considered a single direction of anisotropy each, and wide steps of changes in relative humidity. The present work aims at observing transitional moisture effects on vibrational properties of violin-making woods (spruce and maple) over different steps and different histories of RH changes, in longitudinal and radial directions of wood.

Materials and methods
Material of Norway spruce (Picea abies [L.] Karst.) and of sycamore maple (Acer pseudoplatanus L.) was selected in order to reduce natural variability within the tested sampling. Longitudinal (12×2×150mm$^3$, RxTxL) and radial (150×2×12 mm$^3$, RxTxL) specimens were prepared with a fine planed surface. They were separated in 3 groups corresponding to 3 protocols of humidity changes:

-Adsorption: samples were first oven-dried (48h at 60°C followed by 2h at 103°C), then stored in a desiccator for 2 weeks, then at 20°C and 35%RH, 50%RH, 65%RH, 85%RH, for at least 3 weeks each time. 8 radial and 8 longitudinal samples for each species served to measure properties at equilibrium, while 2 radial and 2 longitudinal for each species served to monitor transitional changes.

-Desorption: samples were first immersed in water for 3 weeks, then stored (3 weeks or more until stable) at 85% RH, 65% RH, 50%RH and 35%RH. Same protocol/number of specimens as above.

-Various humidity paths: 18 radial and 18 longitudinal specimens of each species were used to explore transitional changes with all possible steps between the above RH conditions.

Vibrational properties were measured by non-contact forced vibration of free-free bars using a device and software developed at LMGC [Brémaud 2006; Brémaud et al. 2012]. Specific dynamic modulus of elasticity $E'/\gamma$ and damping coefficient $\tan\delta$ were measured at first resonance frequency in bending. Repeatability tests indicated an experimental error of ≤2%, and a point of measure could be taken every ≤1 minute.

Results and discussion
The equilibrium moisture content at different RH, as well as the hysteresis/difference between adsorption and desorption, was comparable between spruce and maple (Table 1).

<table>
<thead>
<tr>
<th>EMC(%) at RH</th>
<th>35%RH</th>
<th>50%RH</th>
<th>65%RH</th>
<th>85%RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spruce/adsorption</td>
<td>5.5</td>
<td>7.9</td>
<td>10.4</td>
<td>17.4</td>
</tr>
<tr>
<td>Maple/adsorption</td>
<td>5.6</td>
<td>8.1</td>
<td>10.3</td>
<td>17.3</td>
</tr>
<tr>
<td>Spruce/desorption</td>
<td>7.1</td>
<td>10.1</td>
<td>13.1</td>
<td>20.5</td>
</tr>
<tr>
<td>Maple/desorption</td>
<td>6.9</td>
<td>10.1</td>
<td>13.3</td>
<td>21.1</td>
</tr>
</tbody>
</table>

Table 1: Equilibrium moisture content (EMC, measured after ≥3 weeks in stable conditions) of spruce and maple at different RH conditions.

Regarding moisture dependence of vibrational properties at equilibrium (Figure 1), the general trends were comparable to previous results [Obataya et al. 1998]. The differences between adsorption and desorption were small (once taken into account the hysteresis in EMC), with the exception of longitudinal damping in maple (maybe due to some extraction during water saturation). Damping in maple was slightly less affected by high moisture than for spruce. Mostly, properties in
radial direction were clearly more modified by elevated moisture than in longitudinal direction, resulting in a strong increase in the degree of anisotropy.

Figure 1: Dependence on Equilibrium moisture content EMC of specific modulus and damping and their longitudinal/radial anisotropy. (Triangles) spruce; (circles) maple; (filled symbols) adsorption; (open symbols) desorption.

When changing conditions of humidity, frequency and dimensions evolved together with internal moisture content of wood. On the contrary, a transitional increase in damping was always observed, whether the humidity decreased or increased (Figure 2). The peak value of this increase in damping occurred from 30 minutes to a few hours after changing conditions (depending on RH steps and direction of specimens). Then damping slowly decreased when evolving towards equilibrium state, which took 2-4 weeks, that is, after moisture content itself was stabilized. Moreover, this transitional increase in damping had a bigger amplitude when smaller steps in ambient RH were applied (Figure 3). For relatively small RH steps (e.g. 35-50% RH or 50-65% RH), transitional changes in damping clearly exceeded the differences between initial and final equilibrium values.

Figure 2: Example of transitional variations in (circles) damping, (diamonds) frequency, (squares) mass and (triangles) radial dimension, along time after changing RH conditions. Longitudinal spruce specimens.

Conclusion

When wood is at equilibrium state, increases in relative humidity conditions reduce specific modulus of elasticity and increase damping, as is well known. Their anisotropy between longitudinal and radial direction is even more affected, which should modify vibration modes of instruments’ plates. The transitional increase in damping occurring within a time scale of one/few hours seems even more relevant to instrument playing conditions, all the more so that its amplitude is more pronounced over smaller differences in RH, typically in the range of 35-65% that could be encountered in normal concert places.

Acknowledgements

The first author initiated these experiments in the end of 2012 when a Post-Doc at EMPA, Switzerland, and continued the work at CNRS-LMGC from 2013. We thank Francis Schwartz and René Steiger for providing access to EMPA climatic rooms, and Patrick Langbour and Daniel Guibal for providing access to climatic equipment in CIRAD Montpellier.

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HYDRO-THERMAL BEHAVIOUR OF AN HISTRICAL VIOLIN DURING CONCERTS

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Introduction

Hydro-thermo-mechanical behaviour of an historical wooden instrument is an essential requirement to understand its behaviour under conservative conditions and during playing when it is allowed/allowable. The use of an instrument without short-time consequences depends first on the state of conservation of its structure (it should be strong enough) and second on the hydro-thermal stresses during its use or displaying. Swelling and shrinkage produce significant stresses, especially in transversal direction, that could damage the object integrity. To investigate the state of conservation as well as the playability of the Guarneri “del Gesù” violin (1743) known as the “Cannone”, several experimentations were performed. A structural assessment and the computation of the deformative field under load were achieved in [Fioravanti et al. 2012]. The hydro-thermal conditions of conservation were assessed in [Goli et al. 2012] and the mechanical time-dependant behaviour in constant and variable relative humidity studied in [Fioravanti et al. 2013]. A hydro-thermal survey of the internal and external conditions of the violin during concerts was performed as well and some results are presented in this paper.

Method

To assess the hydro-thermal impact of a concert on the violin, effect of an exposition to a new environment and effect of the musician, a series of nine concerts was monitored. The violin mass was measured immediately before and at the end of each concert. The environmental conditions of the concert room were measured as well as the microclimatic conditions inside the violin itself. The measure of the environmental conditions was performed with a conventional data-logger, while for the violin interior a special wireless chinrest was developed as from [Goli et al. 2011]. The specially designed and instrumented chinrest is shown in Figure 1.

Results

The average conservation conditions inside the display case were 52.5% of relative humidity (RH) and a temperature (T) of 22°C. In Table 1 are reported the average values of relative humidity and temperature inside and outside the violin during each monitored concert.

<table>
<thead>
<tr>
<th>#</th>
<th>Text RH (%)</th>
<th>Text T °C</th>
<th>Int RH (%)</th>
<th>Int T °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.1</td>
<td>28.9</td>
<td>55.9</td>
<td>24.2</td>
</tr>
<tr>
<td>2</td>
<td>40.8</td>
<td>37.9</td>
<td>46.8</td>
<td>26.4</td>
</tr>
<tr>
<td>3</td>
<td>41.4</td>
<td>29.0</td>
<td>45.8</td>
<td>26.1</td>
</tr>
<tr>
<td>4</td>
<td>42.9</td>
<td>26.8</td>
<td>44.2</td>
<td>24.4</td>
</tr>
<tr>
<td>5</td>
<td>47.4</td>
<td>26.3</td>
<td>50.1</td>
<td>24.4</td>
</tr>
<tr>
<td>6</td>
<td>61.7</td>
<td>26.5</td>
<td>54.5</td>
<td>23.5</td>
</tr>
<tr>
<td>7</td>
<td>50.9</td>
<td>25.4</td>
<td>53.2</td>
<td>23.3</td>
</tr>
<tr>
<td>8</td>
<td>55.3</td>
<td>19.4</td>
<td>52.2</td>
<td>16.5</td>
</tr>
<tr>
<td>9</td>
<td>38.8</td>
<td>22.1</td>
<td>42.6</td>
<td>17.0</td>
</tr>
</tbody>
</table>

Table 1: Average violin internal and external temperature and relative humidity during nine concerts.

In terms of equilibrium moisture content (EMC), the average conservation condition is estimated at 9.65% of moisture content according to [Simpson 1998]. In Table 2 are reported the computed average values of EMC inside and outside the violin during each monitored concert as well as the mass...
variation between the start and the end of the concert. The time the instrument was kept out of
indication of the time of exposure to a different thermos-hygrometric condition.

<table>
<thead>
<tr>
<th>#</th>
<th>EMC int (%)</th>
<th>EMC ext (%)</th>
<th>M (g)</th>
<th>TOC (hh:mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11.1</td>
<td>10.0</td>
<td>0.38</td>
<td>3:00</td>
</tr>
<tr>
<td>2</td>
<td>7.7</td>
<td>8.5</td>
<td>-0.65</td>
<td>2:45</td>
</tr>
<tr>
<td>3</td>
<td>7.8</td>
<td>8.4</td>
<td>-0.37</td>
<td>2:45</td>
</tr>
<tr>
<td>4</td>
<td>8.1</td>
<td>8.2</td>
<td>-0.39</td>
<td>2:00</td>
</tr>
<tr>
<td>5</td>
<td>8.7</td>
<td>9.1</td>
<td>-0.25</td>
<td>4:00</td>
</tr>
<tr>
<td>6</td>
<td>11.2</td>
<td>9.8</td>
<td>0.47</td>
<td>3:15</td>
</tr>
<tr>
<td>7</td>
<td>9.3</td>
<td>9.6</td>
<td>-0.15</td>
<td>4:15</td>
</tr>
<tr>
<td>8</td>
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<td>9.6</td>
<td>0.08</td>
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</tr>
<tr>
<td>9</td>
<td>7.6</td>
<td>8.1</td>
<td>-0.86</td>
<td>4:30</td>
</tr>
</tbody>
</table>

Table 2: Average violin internal and external EMC, violin mass variation and Time Out of display Case (TOC) for the nine concerts.

Discussion

In order to verify the possibility to model the global hygro-thermal behaviour of the violin during concerts, it was studied the mass variation during the different concerts as a consequence of the following parameters:

- RH as the difference between the average conservation RH and the violin internal averaged RH during a concert (1);
- RH as the difference between the average conservation RH and the environmental averaged RH during a concert (2);
- EMC as the difference between the average conservation EMC and the violin internal averaged EMC during a concert (3);
- EMC as the difference between the average conservation EMC and the environmental averaged RH during a concert (4).

The phenomena was studied in terms of being able to result in a reasonable logarithmic fit. This kind of regression is the one expected to explain the phenomena (deriving from Fick’s law diffusion of water vapour). Among the whole cases the best fit resulted between the conservation RH and the environmental RH during the concerts with a normalised root-mean-square deviation (CVRMSD) of 26.1% (case 2). The experimental data and the logarithmic fit are shown in Figure 2.

Conclusions

In the present work the mass variation of an historical violin measured at the display case opening and at the end of the concert was studied. The general principle is that the mass variation is widely dependent on the difference between the hygro-thermal conditions inside the display case and the conditions measured during the concert. During playing the environmental conditions of the room were monitored as well as the conditions inside the violin. The fitting of the data with a logarithmic trend, being the one expected, has shown that among the various parameters considered (RH, EMC, inside and outside the violin) the difference between the average RH inside the display case and the average environmental RH is the parameter that better describes the mass variation. This research is a first step in the study of predictors of mass variation of a violin during a concert. Other step needs to be performed in order to associate to a given mass variation a potential risk for the instrument and thus guidelines for the conservation.

Acknowledgements

Authors would like to thank Dr. Laura Malafatto and Anna Rita Certo both working at Genoa Municipality for their cooperation and willing to perform this research. All our gratitude to the violin players Feng Ning, Mario Trabucco, Peter Sheppard Skærved, and Salvatore Accardo for having accepted to monitor their performances. Bogaro & Clemente had manufactured the dedicated chinrest. Mr. Danilo Dini was a valuable help to adapt the electronic and the sensors to the chinrest.

References


HYGRO-MECHANICAL FE-ANALYSIS OF WOODEN OBJECTS: IMPORTANCE OF RELIABLE PREDICTION OF WATER TRANSPORT

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Introduction

In conservation of music instruments, climate conditions while storing or performing are of major importance, since a change in moisture content (MC) in wood could lead to cracking or other damages. While playing the instrument, fast humidity changes and large MC-gradients over the cross-section lead to high internal stresses. Furthermore, the material behaviour changes dramatically with changing MC, e.g. in hygro-expansion (swelling and shrinkage), strength and mechano-sorptive creeping [Kollmann, 1982; Niemz, 1993; Reichel, 2014; Toratti, 1992]. Modelling of MC-dependent mechanical characteristics as well as the transport of moisture beneath the fibre saturation area (FSA) are necessary for a suitable numerical simulation of, e.g. stresses during a concert in terms of the finite element method (FEM).

This abstract gives an insight into transport-modelling and its relevance in the scope of hygro-mechanical coupling and load-bearing analyses, i.e. its influence on stresses during humidity changes.

Methods

The transport of moisture below FSA is dominated by the three transport phases of water vapour emissivity, diffusion and sorption (see Fig. 1). Fick’s law of diffusion is commonly used in its time-dependent formulation

\[
\frac{\partial c}{\partial t} = \nabla \cdot (D \nabla c),
\]

This assumption is suitable for steady-state moisture diffusion. The moisture flow is proportional to the gradient of the moisture concentration \(c = \rho_0 \cdot m\), with the diffusion coefficient \(D\), the density in absolute dry conditions \(\rho_0\) and MC \(m\). In transient simulations, this merely gives an approximation of the real transport behaviour. Discrepancies of the simulation compared to experimental tests are often named as “non-Fickian behaviour” (e.g. [Avramidis, 1987]). The larger the gradient of \(c\), the more pronounced are the deviations. Diffusion is homogenised to only one transport process. Beneath the FSA (normal conditions), moisture diffusion in the porous medium wood has to be divided into the two parallel processes of water vapour diffusion in wood pores

\[
\frac{\partial c_b}{\partial t} = \nabla \cdot (D_b \nabla c_b) + \dot{c}, \quad \frac{\partial c_e}{\partial t} = \nabla \cdot (D_e \nabla c_e) - \dot{c}. \tag{2a, 2b}
\]

Both processes interact via sorption term \(\dot{c}\). Theory and models for the anisotropic \(D\) and \(\dot{c}\) in phenomenological or multi-scale approaches are presented e.g. in [Eitelberger, 2011; Frandsen, 2007; Krabbenhøft, 2004].

Water uptake from the ambient air is considered by a surface emissivity model of water vapour. Three different models for the utilisation of clear and varnished wood are explained in [Reichel, 2014].

In a transient hygro-mechanically coupled formulation, deformations \(u\) and water concentrations \(c_i\) are evaluated in one monolithic equation system

\[
\begin{bmatrix}
K_{u,u} & K_{u,c_b} & 0 \\
0 & K_{c_b,c_b} & K_{c_b,c_e} \\
0 & K_{c_e,c_b} & K_{c_e,c_e}
\end{bmatrix}
\begin{bmatrix}
u \\
c_b \\
c_e
\end{bmatrix} = \begin{bmatrix}
F_{\text{ap}} \\
0 \\
0
\end{bmatrix} - \begin{bmatrix}
F_{\text{nr}} \\
F_{c_b} \\
F_{c_e}
\end{bmatrix}, \tag{3}
\]

with the components of the compliance matrix \(K_{ij}\) and the vectors of external minus internal loads on the right side. For a fully coupled model, the influence of the loading state on transport processes, primarily on moisture diffusion ("hygro-elastic effect" [Skaar, 1988]), has to be considered additionally (e.g. [Niemz, 1993]). In the case of large strains, the pore volume changes significantly, whereas for usually investigated small strains, the hygro-elastic ef-
Example and Results

In the example, visualised in Fig. 2, a 1-phase and a 2-phase diffusion approach are compared concerning simulated stress-development by the MC-gradient during a relative humidity increase from $RH = 0.65$ to $RH = 0.95$. A modelled boundary layer to the ambient air (cf. Fig. 1), a 3-parameter sorption and diffusion models published in [Schirmer, 1938; Skaar 1981] are applied. Due to the anisotropic swelling in $r$ and $t$, strains are constrained leading to stress concentrations. The former approach leads to significant higher stresses, esp. in the critical directions $r$ and $t$; whereas the latter shows as well peaks.

Discussion

Both transient approaches capture the stresses induced by constrained strains. In comparison, a steady-state analysis, where just the ultimate configuration would be regarded, leads to an underestimation of maximum stresses. On the other side, 1-phase diffusion leads to an overestimation and, thus, to unrealistic results as well. The results underline the importance of reliable transient moisture transport simulations in load-bearing FE-analyses considering changing climate.

A close-to-reality approach has to include the water vapour transport. Since a validation is missing here, it is referred to [Eitelberger, 2011; Frandsen, 2007] for the applied diffusion models.

References


![Figure 2: Comparison of different transient diffusion models on a hygro-mechanically loaded clear spruce wood sample for an increasing relative humidity from RH = 0.65 to RH = 0.95.](image-url)
PLAYING HISTORICAL CLARINETs: QUANTIFYING THE RISK

Christina RT Young (1), Gabriele Rossi Rognoni (2)


Context

It has been stated that the conservation and use of historic woodwind instruments is problematic because they are in very different states of preservation, and they are made from a wide variety of materials. Furthermore, their method of playing incurs rapid changes of temperature and relative humidity, the results of which can be catastrophic. This unpredictable behaviour makes clear guidelines for using early woodwinds impossible to establish (Barclay 1997). This level of uncertainty in the development of damages has led to the widespread assumption that woodwind instruments in public collections should not generally be played under any circumstance. On the other hand instruments in private collections have been extensively used by musicians without evident damages being noted, and many of the damages that are found on historical instruments are not apparently related to playing. The paper presents research in progress which at this stage has concentrated on clarinets.

Survey of Damages and Measurement of Moisture Gradients

A survey of the damages that can be found in historic clarinets in UK museum collections has been conducted. The damages have been classified in the attempt to identify their potential cause. This has included split ferrels (metal and ivory), cracks in the wood associated with the key fastenings, cracks in the different sections of the bore. Specifically, identifying cracks in the barrel and the bell which appear to relate to differential moisture or temperature gradients between the outside and the inside of the clarinet when played.

A database has been setup to collate documentation, images and information gathered during the project (eventually to be online). Within the UK the following collections have been considered: Museum of Music (RCM), the Musical Instrument Museum (Edinburgh University), The Bate Collection and The Horniman. Other collections in Europe and the USA will be contacted and potentially involved in the project, particularly: Cite de la Musique (Paris), Germanisches Nationalmuseum (Nuremberg), Staatliches Institut für Musikforschung Preussischer Kulturbesitz (Berlin) and the Metropolitan Museum of Art (New York). The UK collections are being investigated first. ICOM-CIM CIM (International Committee for Museums and Collections of Musical Instruments) will be a platform from which to communicate and discover the relevant international collections as further research develops. The focus initially has been on the Sir Nicholas Shackleton collection at the University of Edinburgh, an extensive collection of over 900 clarinets and sections of clarinet ranging in date from 1750 to 2003 (Myers, 2007).

Although there are many publications on the acoustics of clarinets only one paper exists, to the authors’ knowledge, which includes experimental work measuring breath moisture in woodwind (Stein 2004).

The research presented in this has measured the temperature and moisture gradient, and the rate of moisture uptake specifically imposed on clarinets when played: it takes into account different materials used in their construction and different configurations of the parts for both wooden modern and period instruments. In particular, clarinets made from boxwood and/or mixed wood as the moisture uptake is high and more differential expansion is expected. Preliminary testing was performed with a Noblet N 25 year old Grendilla wooden clarinet. This instrument has been regularly played and was used to gain an understanding of the rate of change in RH before subjecting historical instruments to moisture gradients. Figure 1 shows that a single blow in the lower register will lead to the RH at the bell end of the instrument going from 38%RH to 65%RH in seconds. This is also pitch dependent suggesting that it relates to increased air flow and hole coverage. The bell of the clarinet is of particular interest because it is turned from one block of wood crossing over the growth rings which may account for the splits following the grain. There also appears to be a
difference of opinion as to how much splits in the bell affect the quality of the sound. Values of 95%RH are measured inside the barrel after a single breath. The wetted reed inserted into the mouth piece results in an increase in RH of at least 20-30%RH.

The testing on “model” and historic clarinets has included accurate measurement of the relative humidity inside and outside the bore at different points. The sensor used for measuring the ambient relative humidity and temperature is a EL-USB-2-LCD+ and measurement of RH and temperature inside the bore is a low profile temperature and humidity iCelcius 20 probe which sits inside the clarinet without restricting airflow when played. Airflow measurements inside the bore were also made with a hotwire anemometer. Measurement of the change in internal bore diameter was made with a telescopic bore gauge and Micro-Mag internal measuring micrometer. Using published data on the moisture response of different woods, an attempt was made to correlate the experimental results with the specific behaviour of different clarinets. This correlation takes into account the contribution of metal components and individual structure of the instrument; in order to reach a better understanding of long term dynamics of degradation and assessment of risk.

Non-invasive techniques and more accurate measurement methods are being investigated including the feasibility of using CT scanning. The aim of which is to dynamically measure the deformation of whole instrument when artificial breath moisture is introduced. There is a problem of scanning clarinets with the keys in position because they mask the X-rays over parts of the wood. Removing the keys leads to a change the internal stresses that would be present in the real case. However, to understand the bell end of the instrument CT offers the best possibility of imaging changes in dimension associated with the wood structure. Electronic Speckle Pattern Interferometry (ESPI) at the Courtauld and other mechanical methods at ICL are also being explored to measure deformations and strain distributions.

**Impact**

The results of this research on clarinets will serve as the basis for a more extensive study of different typologies of woodwind instruments, and will set the methodological framework and research methods also for the further development in this direction. The long term aim will be an increased understanding of the behaviour of materials, and the creation of a benchmark system to guide curators and musicians in the assessment of the risks related to playing historical clarinets: the effect and best procedure of conditioning, practical ways to quantify risk and guide the decision making process.

**References**


Humidity in woodwind instruments due to playing: Effects and risks for the wooden structure
Ilona Stein
German National Museum, Nuremberg, Germany

This study was made in 2001 for a thesis at Cologne Institute of Conservation Science (University of Applied Sciences Cologne). It was inspired by a question that every once in a while appears in collections of musical instruments: Is it allowed to play old woodwind instruments which haven’t been used for a long time and which shall be preserved for the future? Is it possible to minimize the risks that go along with the moisture input?

The study focuses on the analysis of the effect humidity has on an instrument. Theoretical considerations based on the physics of the wooden structure together with exemplary experiments should especially answer the question of a certain time limit of playing that can prevent damage for the instruments.

Effects while playing a woodwind instrument

The player generates air of 36°C and 100% RH which above all effects the mouthpiece and the part of the tube close to it. As experiments showed, immediately liquid water due to condensation is present. According to the type of woodwind instrument characteristic damages give evidence of processes caused by high moisture.

To describe the fundamental reactions to the moisture input a simplified model of a tube is used: Humidity is absorbed by the wooden wall of the inner bore and is transported to the dryer regions of the outward wall. (Liquid water is more rapidly absorbed by the wood than steam.) Consequently a swelling process is initiated which, because of the moisture-gradient in the wall, leads to strain and stress as schematically shown in Fig. 2.

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After a certain time of water absorption from the inner of the bore, the tube will have reached the maximum degree of swelling. This results in an increase of the outer as well as the inner diameter. (Fig. 3)

Fig. 3: Dimensional change after full absorption of humidity.

After playing the instrument the drying process begins. Now basically a reaction vice versa to the swelling takes place.

These theoretical considerations were confirmed in a series of experiments where the dimensional changes were measured (Measuring equipment: FLUT-Woodwind Bore Gauge System, Version 1.00).
Different reactions according to the different parameters of the tubes (size, wood, hydrophobicity) were observed.

The amount of the dimensional changes was evaluated. It was compared to:
1. the recommended limits for climatic changes in public collections of art and cultural heritage.
2. to the yield-point of wood.
Also critical situations during the process were investigated.

**Conclusion**

The swelling reaction of the wood is instant. Therefore no time limit of playing can be given to be free of damaging risks. The amount of swelling depends on different factors. Methods of hydrophobicity, which do not change the document character of the historical instrument, should be further investigated. Over all the condition of the instrument (hydrophobicity, beginning micro-cracks, continuity of use) is a central factor for risks.
EXPERIMENTAL INVESTIGATION OF A NON-INVASIVE INTERVENTION ON A TORRES GUITAR

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3 Guitar-Maker, Granada, Spain

Introduction

Guitar FE09 - MDMB 626 is one of the best-known Antonio de Torres instruments and is an excellent sounding example of a guitar with tornavoz. Tornavoz is a sound-hole tube for lowering the first resonance mode to improve the low-frequency response of the instrument [Hess, 2013]. Although the instrument is in "playable conditions", the back plate has a deformation and cracks which are undoubtedly the result of the pressure exerted by the tornavoz supports (see Fig. 1). This instrument belonged to the guitarist and composer Miguel Llobet (1878-1938) who concertised and recorded with it and it was said to be his favourite of the 40 guitars he possessed. When he acquired the guitar around 1916 it already had the cracks caused by the pressure of the tornavoz sound-posts [Romanillos, 1997]. Furthermore it is known that Llobet chose not to have the cracks repaired, as he feared it might result in a change in the sound.

Figure 1: Detail of the sound-hole and tornavoz supported by wooden soundposts resting on the back.

Over the last hundred years experts have chosen not to have the cracks repaired as it might result in a change in the sound. In 2010 a new restoration was carried out by Luca Waldner, but access to the inside of the guitar is very limited and once again it was explicitly decided not to repair the cracks respecting in turn the unwillingness of Llobet. On the occasion of a recent recording by the guitarist Stefano Grondona, he stated that guitar sounded different with strips of masking tape covering the cracks, something which the restorer also suggested. This observation was in general agreement with informal listening tests performed during the recordings. Although subjective evaluations and claims abound, no quantitative data is available to determine the effect of this modification. This paper provides the results of an experimental campaign aimed at assessing the effect upon the vibration response of this eventual non-invasive intervention.

Experimental method

Modal testing was performed on the top and back plates before and after adhering strips of masking tape along the cracks. An undulated foam surface was employed to reproduce controllable and repeatable boundary conditions (see Fig. 2). The vibration signals were measured and recorded as time series and processed into inartance FRF data. A mono-axial accelerometer was attached with bee wax to a reference point on the top plate near the bridge location, whereas the miniature rubber hammer transducer roved around exciting the soundboard at 119 locations on the top and at 162 points on the back, both evenly distributed.

Figure 2: Assembly made for modal testing.
Results and conclusions

Two experimental approaches were addressed, the modal and the frequency domain correlation. The former provides correlation data of individual modal parameters but presents the main drawback of being dependent on user intervention since it requires significant post-measurement analysis. In contrast, the latter merges the correlation of multiple parameters shifts but has advantage of not being user dependent, thus becoming a promising, powerful and attractive tool for nondestructive evaluation.

Results allow conclusions to be drawn regarding the influence of the intervention. In comparing the frequencies and quality factors (see Table 1), significant changes appear. With respect to the back plate, estimated modal frequencies increase, the differences being larger for the crack mode and higher frequency modes, where the modes are associated with local responses. In contrast, quality factors decrease, leading to an increase of damping. The hypothesis behind this observation is that strips of masking tape cause a slight increase in the stiffness of the back plate limiting its mobility and thus increasing the modal frequencies (see Fig. 3). This argument agrees with the results obtained from the FRFs. Comparison of the vibration responses of the modified back plate with the baseline response reveals a decrease in the amplitude response level together with a widening of the peak bandwidth. This leads to an increase in damping whereby the quality factors decreases, a feature that is generally viewed as not desirable in musical instruments.

![Table 1: Modal parameters of back plate (muted-strings) before and after placing strips of masking tape covering the cracks.](#)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Back</th>
<th>Modified Back</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ω [Hz]</td>
<td>Q</td>
<td>ω [Hz]</td>
</tr>
<tr>
<td>RB</td>
<td>88.7</td>
<td>23.5</td>
<td>88.7</td>
</tr>
<tr>
<td>CRack</td>
<td>128.9</td>
<td>19.2</td>
<td>138.2</td>
</tr>
<tr>
<td>1(b)</td>
<td>223.3</td>
<td>20.4</td>
<td>227.9</td>
</tr>
<tr>
<td>2(b)</td>
<td>246.7</td>
<td>35.6</td>
<td>250.8</td>
</tr>
<tr>
<td>3(b)</td>
<td>292.9</td>
<td>28.7</td>
<td>298.9</td>
</tr>
<tr>
<td>4(b)</td>
<td>333.8</td>
<td>38.0</td>
<td>337.9</td>
</tr>
<tr>
<td>5(b)</td>
<td>355.7</td>
<td>28.7</td>
<td>379.2</td>
</tr>
<tr>
<td>6(b)</td>
<td>382.3</td>
<td>28.7</td>
<td>392.7</td>
</tr>
<tr>
<td>7(b)</td>
<td>403.8</td>
<td>26.3</td>
<td>420.9</td>
</tr>
<tr>
<td>8(b)</td>
<td>441.0</td>
<td>43.6</td>
<td>464.7</td>
</tr>
<tr>
<td>9(b)</td>
<td>500.2</td>
<td>61.3</td>
<td>509.8</td>
</tr>
</tbody>
</table>

Lower incidence was observed on the top plate with exception of the low frequency mode. Overall, with exception of the first mode, frequency shifts are below the audible range and their associated quality factors do not show a conclusive behaviour. A major variation is observed in the fundamental mode which decreases around 2% and significantly increases its quality factor. The hypothesis behind this result is that strips of masking tape close the airflow through crack on the back. Assuming that fluid acts as an added mass, it is straightforward to prove that it has the effect of decreasing the frequency. This could lead to an increase in the coupling of the plates and thus to an increase in the amplitude response level. This remark agrees with the results obtained from the FRFs. Furthermore, a narrowing of the peak bandwidth is observed, leading to a decrease in damping and a quality factor increase.

![Figure 3: Experimentally determined resonance mode shapes of back plate before placing strips of masking tape covering the cracks.](#)

The complete restoration of the instrument comes into question depending if the guitar is considered as a musical instrument rather than a cultural heritage oeuvre. There is no doubt that the instrument in its pristine state had no cracks. However, the design configuration employing soundpost is particularly prone to crack even after restoration. Consequently, according to the musical purpose, the original structure configuration should eventually be re-adapted by removing the soundpost and unavoidably installing a transverse bar on the top plate. The consequences of this high impact intervention from the cultural heritage point of view are obvious.

Acknowledgements

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References

NUMERICAL SIMULATION OF PIANO SOUNDBOARD STRAINING INDUCED BY HUMIDITY CHANGES

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1. Mendel university in Brno, Czech Republic

Introduction

FEM (Finite Element Method) makes possible solving multiphysical problems at complicated geometry and anisotropic material model of wood. With the help of parametric modeling it is very easy to reconfigure models (geometry, conditions, material), so it enables performing sensitivity and what-if analyses.

Acoustic properties of piano were studied e.g. by Suzuki and Nakamura [1990], Boullon [1988], Hall [1992], Chaîgne and Askénfelt [1994] and others. Giordano [1997] published numerical model of piano soundboard and its vibrational properties were described by FEM. Giordano et al. [2004] created physical model of piano, Berthaut et al. [2003] used FEM for description of low-frequency dynamic behavior of piano soundboard with ribs and orthotropic material model. Hashimoto and Umetani [2000] built coupled model of bridge and soundboard and solved combined effect of these parts. Cuenca and Caussé [2007] made detailed numerical analysis of interaction of soundboard, bridges and strings. Ortiz-Berenguer et al. [2008] described natural frequencies of grand piano soundboard with use of ANSYS. Effect of string pressure to natural frequencies of crowned soundboard with ribs was by Mamou-Mani et al. [2008].

Methods

The numerical simulation of behavior of the piano soundboard, ribs, bridges and wooden frame has been performed with use of the Finite Element Method (FEM) in an ANSYS software. An important step was to build a material model of spruce wood derived especially from the mass, natural frequency of samples and literature data. These models were verified in simplified cases (clear orthotropic specimens). The model of heat transfer in wood under constant conditions of humidity combined with the dimensional changes of wood was constructed in ANSYS. This FE model was constructed for the isothermal moisture diffusion in wood with influence to the dimensional changes of wood as the analogy of heat and moisture movement in the wood. Stress-strain relationship for linear-elastic material (Hooke’s law) including internal (initial) stress and stresses induced by hygroexpansion is given by:

\[
\sigma = [D] (\epsilon - \epsilon_w - \epsilon_\Omega)
\]  

where: \([D]\) is elasticity matrix, \(\epsilon\) is elastic component of strain, \(\epsilon_w\) is moisture component of strain and \(\epsilon_\Omega\) is initial strain. Generally, the moisture flow \(r\) is described by Fick’s law:

\[
r = -d \nabla w
\]  

Diffusion of moisture \(w\) is assumed as anisotropic and diffusion coefficient \(d\) is a tensor. Moisture strains could be described by change of moisture content \(w\) and coefficient of thermal expansion or hygroexpansion \(\alpha\) (swelling/shrinkage of wood):

\[
\epsilon_w = \alpha w
\]  

From the 2nd thermodynamic law and Hooke’s law with decomposition of strains (equation 1) the stress - strain - moisture coupling could be described by constitutive hygro-elastic equation:

\[
\sigma = [D] (\epsilon - [D] (\alpha \Delta w))
\]  

Numerical model of the soundboard was designed for bare boards, ribbed boards and boards with bridges. These models correspond to stages in the manufacture of piano and describe impact of individual components on the behavior of boards.
Definition of material model is based on literature data [Bucur 1995, Požgaj et al. 1997, Skaar 1988, Siau 1995]. In the case of mechanical-moisture analysis the material parameters are computed for constant temperature condition, then the dependence on moisture content is defined. Analogously, for the case of thermal-mechanical problem, the parameters are defined for constant moisture content and dependence on temperature is defined.

**Results and Discussion**

FE analyses works with the change of parameters of material model by temperature or moisture content (MC). Soundboard will change its dimensions (or the stresses will be induced in the material) with the sorption/desorption of MC in relation to changes of environment (humidity, temperature).

![Figure 2: Dimensional changes of soundboard - nodal displacements [m] perpendicular to board - with increasing (left) or decreasing (right) of MC by 2%](image)

The MC influence dynamic behavior of soundboard by the ways. Firstly by changing of material parameters with changing of MC, secondary by pre-stress generation. The moisture stresses in heterogeneous construction of soundboard with ribs are induced even by homogeneous MC distribution. Decreasing of MC (inducing especially tension stresses) cause the increasing of most of natural frequencies. The influence of MC change in very wide range (theoretically from 0% to 20%) on first fifty natural frequencies was studied. The relationships are linear, with increasing of moisture content the natural frequencies are decreasing. The influence of MC is strong in the case of density and moduli of elasticity (especially longitudinal and radial normal modulus). For example, the influence of MC on first natural frequency is given by regression equation (coefficient $R^2$ close to 1):

$$y = 0.307 \cdot x + 30,7167$$

The influence of MC is stronger in higher order natural frequencies. Influence of temperature is relatively low but not totally negligible. For example extreme temperature change of 30 °C induce the change of 4th natural frequency of about 4 Hz.

General declaration of parametric models allows changes in design, material composition, etc., enabling the deployment of optimization calculations, study of factors’ influence on the behavior of the board. In terms of FEM, use of different mesh, software capabilities, model assumptions and simplifications were studied.

**Acknowledgements**

Research proceeds in cooperation with company Petrof Ltd., Czech Republic.

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3D EMENDATIO:

DIGITAL IMPROVEMENT & PRINTING OF MUSICAL INSTRUMENTS

V. Lorenzoni (1), Z. Doubrovsky (2) and J. Verlinden (3)


Introduction

The main objective of the Industrial Design faculty at Delft University of Technology is to design and improve user defined products and develop workflows for customizable products. In the last years, 3D printing techniques (also known as Additive Manufacturing) have been increasingly adopted for this aim and TU Delft has gained a world-lead experience in the use and development of such techniques [1,2]. These techniques have been recently applied for the manufacturing of saxophone mouthpieces [4], in a project that involved aerodynamic researchers at the aerodynamic department of the TU Delft aerospace faculty [3]. The aim of the project is to develop and improve the design of the music instrument's parts and to provide novel strategies for preservation of cultural heritage and to comply with musicians' requirements.

Problem statement

Preservation of cultural heritage

- Historical musical instruments that are currently played on are subject to wear and will irremediably be lost over time.
- Other unique (original) instruments are kept safe (for the sake of preservation) and are therefore out of reach for musicians and the community.

Musicians' requirements

Musicians often have the need to explore new sounds by modifying their instrument or part of it in order to find the set-up that best fits them in terms of sound and playability.

- The research is often expensive and based on available items in the market, with no much room for personalization.
- On the other end some musicians request handcrafted parts by specialized manufacturers that are very high cost and low repeatability. Furthermore the standard manufacturing techniques entail waiting queues of 4-8 weeks.

- In other cases musicians use vintage parts that are usually expensive and unique. When these items are lost or damaged it is not possible to replace them and it is hard for the musician to find a valid replacement.

Proposed methodology

At present, 3D printing is gaining interest while it is improving in terms of speed, quality, and price, and is getting more accessible. Developments in digital manufacturing allow the production of complex geometries at relatively low cost.

To address the problems described above, we have proposed and initiated a three-fold approach: “Translatio – Imitatio – Emendatio”. At the core of this approach is a continuously expanding digital repository of saxophone mouthpieces. In later stages the content of this repository can be expanded to other instruments as well.

Translatio

The “translation” element of the repository focuses on digitization, preservation and curacy.

A part of the activities is to obtain original mouthpieces and to go through the process of 3D scanning, processing and digitalization of the scanned data in order to make it suitable for 3D printing.

Owners of unique or historical pieces, but also mouthpiece makers, will be able to submit a mouthpiece for 3D scanning and digitizing. In this case, the repository provides an opportunity to archive and preserve the cultural heritage (the unique mouthpiece), while the owner of the mouthpiece is able to obtain a 3D printed copy of this mouthpiece, fabricated on demand.

Imitatio

The “imitatio” element of the repository makes currently unavailable mouthpieces available to musicians worldwide.

If the IP status of the originally scanned mouthpiece allows, some mouthpieces within the repository can be made available for purchase by consumers (who...
are not owners of the original piece). In that case, customization of specific elements of the mouthpiece, such as the tip opening, becomes essential. In order to facilitate customization, the mouthpiece needs to be completely reverse engineered. This step includes making a parameterized 3D file based on the 3D scanning with a variable tip opening and eventually chamber size.

On the consumer side, the musician is provided with an (online) interface where he can make a selection form different mouthpieces and tip-openings. Once an order is placed, the specific geometry generated from the parametric model and the mouthpiece is fabricated and shipped.

**Emendatio**

The “emendatio” element of the repository is a platform for improving existing mouthpieces and going beyond what is possible in traditional manufacturing and utilizing the benefits of 3D printing.

Using the knowledge from user testing and aero-acoustic measurements, we aim at optimizing the sound and playability of the mouthpieces. The goal is to be able to create geometrical modifications to match the player’s requirements. This can yield completely new mouthpieces with novel internal geometries that utilize the benefits of 3D printing.

“Emendatio” requires the development of a more elaborated interface for the consumer, where the musician can input his requirements and preferences in terms of style, sound, and playability. This input data then needs to be translated into the final mouthpiece geometry before it is 3D printed and shipped.

Figure 1: Schematic of model with generation of the repository.

This three-tier repository can be framed in an ecosystem in which mouthpiece owners can send in their original mouthpiece, which is then reverse engineered to be part of the repository. If the owners are the original mouthpiece makers, we offer tickback payments, effectively creating an “appstore” model in which we ensure the quality of the reverse engineering and printing while their reputation and fame is tied to a specific mouthpiece design. A similar arrangement can be made with museums that have a large collection of original saxophone parts in depot (for example: the museum “La Maison de Monsieur Sax”, Dinant, and “Cité de la musique”, Paris).

**Application**

The generation of the digital repository at TUDelft has already started in 2012 and several mouthpieces have been digitalized by the team. Variations and improvements have been made to the basic design according to the musicians requests and the results of the aerodynamic experiments described in [4].

The authors have successfully shown the newly designed mouthpieces at the North Sea Jazz festival 2012, with a positive feedback from musicians and manufactures. Professional musicians, Joure Pukl (NY) and ArtVark (NL), are still performing daily on them.

Experiments have recently been carried out at the University of Music and Performing Arts in Vienna on a panel of mouthpiece designs to quantify the difference in radiated sound and ease of play. The results will be presented at the Third Vienna Talk on Music Acoustics, 16–19 Sept. 2015

**Acknowledgements**

Special thanks are given to Sandra Carral and Alex Hofmann of the University of Vienna for carrying out the experiments on some of our mouthpiece designs.

**References**


David Rachor (1), Bryant Hichwa (2)

1. Professor Emeritus, University of Northern Iowa, USA; 2. Bryant Hichwa, Professor Emeritus, Sonoma State University, USA

Background

In our recent study of original and replica Baroque and Classical bassoons (93 original, 17 replicas and 44 redesigned bassoons) we optimized the acoustic lengths of 13 fingerings (Bflat1-F3). [Hichwa, 2015] The optimized results deduced from this acoustic model include 1) acoustic length (AL) of bocal + bocal extension, 2) Benade adjacent tone-hole position correction, 3) Hichwa-Benade 2nd adjacent tone-hole position correction, 4) 180° boot-joint turn around correction of large bore notes (Bflat1-G2), 5) bell correction to C2 tone-hole. This non-linear acoustic model has now been combined with an impedance model to better understand the drivers to improve the bassoon acoustic system.

Bocals

One of the major issues confronting researchers attempting to model historical bassoons is the lack of original bocals and reeds. Our initial model calculated the acoustic lengths relative to the top of the Wing Joint (WJ), giving a combined length of the bocal and bocal extension. A more complete acoustical impedance (Z) approach now provides a mechanism to evaluate specific bocals and reeds. Our segment program incorporates the measurements of 110 bassoons and builds the entire instrument for the impedance program including the bocal and a multi-segment reed. The impedance program calculates the experimental values of the harmonics for 30 fingerings (Bflat1-G4) and compares these results with the theoretical values.

We attempted to measure the inside diameters of original bocals, but found the data to be inconsistent. We identified 26 period bocals designed to be played on replicas of Baroque and Classical bassoons. Period bassoon makers’ ability to design and fabricate these replica bocals proved crucial in this analysis.

Reeds

Our calculation of the “playing” state reed volume is likewise critical to the analysis. We designed a reed model with seven adjustable shape parameters to match the volume of the missing bocal extension. These adjustable parameters have implications for the player of replica bassoons since each player’s approach to embouchure is different.

Table

<table>
<thead>
<tr>
<th>Bassoon Name</th>
<th># of Originals Analyzed</th>
<th># of Replicas Analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eichentopf</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Grenser A</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Grenser H</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Porthaux</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Prudent</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Scherer</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1: Representative # of Original and Replica Bassoons Analyzed In The Comparative Study

Impedance Calculation Results

For each fingering (BFlat1-G4), we combine the position (frequency) and magnitude of the impedance peaks. The results were incorporated according to the method of Grothe. [Grothe, 2014] Typically, 4-6 harmonics were included for the lower frequencies prior to the onset of the cut-off frequency, while for the higher frequencies, 2-4 harmonics dominate prior to the cut-off.

The database size allows extraction of statistically meaningful results. This is especially meaningful when multiple bassoons fabricated by the same original maker are compared and contrasted with replicas as seen in Table1.

In our presentation we will also demonstrate that changes in coupling (bocal shape, length and initial diameter) between the WJ and bocal enhances
acoustic performance. The result is an in-depth fundamental understanding of historical bassoon acoustics which in turn can be used to fabricate an improved acoustic system on replica period bassoons.

References


THE NEXT GENERATION CONCERT PIANO

Chris Maene, Wolf Leye

(Piano builder, Belgium)

Introduction

The modern concert piano is not the result of an evolution from primitive to perfect, but rather a product of change that has followed the evolution of the composers. From the invention around 1700 and the further development until 1900, there were many different highlights in piano manufacturing that coincided with the great composers.

If we take into account the evolution of piano manufacturing and the music that has been written for these instruments, we can distinguish three types/highlights:

1. Early, ca. 1650-1810 (Scarlatti, Bach, Mozart, Haydn, etc.)
2. Middle, until ca. 1840 (Schubert, Chopin, Liszt, etc.)
3. Late, until ca. 1900 (Brahms, Schumann, Debussy, etc.)

Nowadays all this music is being played on one same type of instrument: the modern concert piano.

But from the beginning of the 20th century, the piano is being standardised (in particular after the model of Steinway). This standardization of sound, results in an impoverishment of sound diversity. Today, almost every piano on a concert stage, shows the same main characteristics.

At the same time we notice that pianists today are mainly playing music from before 1900 (music from Bach to late romance, 1685 – 1900). A modern concert grand is an anachronism in the performance of this music.

In response to this growing impoverishment, pianists are looking for alternatives. And so, from the 1950s, some musicians started playing on historic instruments (originals and copies). But these instruments aren’t always easily accessible and/or available, demand a different approach to maintenance and playing technique, and concert halls are often not build to suit their volume. As a result not all pianists see these historic instruments as a good solution/alternative.

From this situation came the wish to build a new concert piano, based on historic keyboards, but with the comfort (action, touch, volume, transport convenience) of a modern piano.

To realise this we will go back to the principle of the straight strung piano (the strings of the bass are not crossed over the treble strings, they are parallel with them). This results in a sound which isn’t homogeneous (like with cross stringing), but a sound with three “registers”: bass, medium, treble.

In 2014-2015 we already made a first modern straight strung piano, commissioned by and in cooperation with pianist-conductor Maestro Daniël Bärenboim.

The objective is to build 3 concert pianos on which 3 centuries of piano music can be played, taking into account the sound colour from the corresponding periods.

Methods

First we need to examine how piano manufacturing has evolved, what the technical characteristics are of piano manufacturers in the past, etc. Therefore, we will make an analysis of 25 historic concert piano’s on the basis of:

1. The string plan (string lengths, thickness, striking point, tension, breaking point, etc.)
2. The frame (design, placement, casting method)
3. The soundboard (thickness, ribs, wood, grain direction, etc.)
4. The case (shape, reinforcement beams, wood)
5. Keyboard and action (the relation of the components, the size and weight of the hammerheads)
Results

The first modern instrument with straight stringing from the experiment with Maestro Daniel Bärenboim has already been finished. The results are visible and audible. The further research is still in progress. By the end of September 2015 we will have additional results. The final goal is to have three new concert pianos, each instrument with its own, unique sound, build with the tradition of the past and the innovations of the present.

Presentation (Conference)

The above will be presented (by Wolf Leye, with PowerPoint, incl. photos and if possible sound fragments) during the conference with special attention to:

1. The development of the piano from wooden case to modern concert piano.
2. The comparison between a concert piano with cross stringing and a concert piano with parallel stringing.
3. The artisan building of a concert piano.
PERCEPTIVE STUDY OF TOUCH ON A PLEYEL PIANO FROM THE COLLECTION OF THE PARIS MUSEUM OF MUSIC

Benoît Navarret (1)(2), Maurice Rousteau (3)

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Introduction

The Pleyel piano E.991.16.1 (Inv. No.) from the collection of the Paris Museum of Music was made in 1842 [Pleyel, 1842]. It is an archetype of the romantic piano built by the Pleyel firm in the nineteenth century. This instrument was acquired with all its original parts (keyboard, hammers, strings, soundboard, etc.). However, a fac-simile of the hammers was produced in 2005, at the museum request, to make the piano usable for concerts and recordings [Stern, 2010]. The restoration work has raised some problems inherent to the patrimonial status of this instrument: conservation and preservation of authenticity, from both making processes and sonic potential point of view, were considered very carefully. Later, the laboratory of the Museum undertook mechanical engineering studies on original and fac-simile hammers. Wood density measurements showed some differences. It was then decided to choose more similar woods and plan another restoration work. A second fac-simile was ordered in 2014 to the French piano maker Maurice Rousteau. To find out if this modification was relevant, a perceptual study was set up with fortepianists who were invited to express their feelings while playing this piano. So, our study was based on a multidisciplinary approach (mechanical engineering, sensory analysis, linguistics analysis and musicology) in order to improve the knowledge of the instrument, as well as practices and expectations of musicians.

Methods

Interviews management

Nine pianists participated in the study. The interviews, which lasted about 1 hour 30 minutes each, took place in a well-lit room, usually used for rehearsals and tuning of the museum instruments. They were invited to come for two or three sessions (depending on their availability). The purpose of the study was explained to the musicians only at the end of the last session, so as not to influence their assessments. The tuning of the piano was checked before each session and some settings were made according to Claude Montal’s recommendations book [Montal, 1865]. The musicians first played freely the instrument. Then, they had to talk about their own evaluation criteria for such a piano and provide the definition of each specific word they used to describe it [Navarret, 2013][Paté, 2014]. Next, they were asked to perform two works of the repertoire (one imposed, and the other at the choice of the pianist) and play the total chromatic scale with the eighty notes of the keyboard for subsequent studies that the laboratory could lead.

Figure 1: New hammers of the Pleyel piano E.991.16.1 from 1842 (collection of the Paris Museum of Music). Fac-simile made in 2014 by the French piano maker Maurice Rousteau.
Discussion

A more thorough analysis of verbal data has to be done. For instance, we have to continue the semantic analysis of the pianist vocabulary and the comparison of discourses about fac-simile hammers. However, first results showed musicians expectations and how they used to evaluate this type of piano. It gave an accurate description of the sound rendering of the Pleyel piano E.991.16.1 of the collection of the museum, and yielded an extensive corpus of verbal data and recordings for further studies.

Acknowledgements

I would like to thank Maurice Rousteau for the entire restoration work and the maintenance of this piano; the nine fortepianists who so generously participated in the study: Joanna Choi, Mathieu Dupouy, Jean-Sébastien Dureau, Knut Jacques, Luca Montebugnoli, Aya Okuyama, Soo-Hyun Park, Alain Planès et Natalia Valentin; Stéphane Vaiedelich and Sandie Le Conte for entrusting me with this mission; Jean-Claude Battault and Thierry Maniguet for logistical support and contribution to the elaboration of the experimental protocol; Emmanuelle Audouard, Delphine Delaby and Daria Fadeeva for musicians contact.

References


Results

Four evaluation criteria were common to all pianists: sonic properties of each musical range, the key action mechanism, dynamics and pedal response. In addition, the romantic Pleyel piano was described as very different from the modern piano in terms of touch (because of the action mechanism), heterogeneity of ranges (they said that modern pianos were more homogeneous from low to high notes) and dynamics response (the threshold of “saturation” of a romantic piano was lower than that of a modern piano). Furthermore, some musicians and piano makers previously described the touch of this Pleyel piano as relatively heavy. So, the main purpose of the study was to verify this hypothesis. The study showed that musicians did not use the term “heavy touch”. However they were sensitive to various properties of the keyboard touch (or the key action mechanism). Thus comments on “the attention to pay to the articulation of the musical phrasing”, “latency between key release and fall of the hammer” or “the difficulties to control soft nuances” might be in relation to the sensation of heaviness. Of course, they said this piano was well suited to compositions by Frédéric Chopin (1810-1849), but more broadly, to works with high differentiated ranges.

Verbal data analysis

The sessions were recorded to constitute a corpus of sound samples and to make the transcription of the interviews. The processing of verbal data analysis was based on a semantic analysis [Cheminée, 2009][Dubois, 2009] of several complementary corpus: evaluation criteria of musicians, vocabulary definitions, feelings expressed about the Pleyel piano from 1842, shared knowledge about Erard and Pleyel pianos (which were two famous firms in competition in the nineteenth century) and musical repertoires.

Figure 2: “Salle d’harmonisation”. Room of the Paris Museum of Music where the interviews of nine fortepianists took place in 2014.
**PRESENTER BIOGRAPHIES**

**Bär, Frank P. (f.baer@gnm.de)**

Frank P. Bär has been curator of the musical instrument collection in Germanisches Nationalmuseum in Nuremberg, Germany since 1997. He studied musicology and German linguistics at the University of Tübingen and holds a Ph.D. in musicology. Since 2006, he has been head of the museum’s research services department, and since 2014 also of the photo department. During the European community funded project MIMO – Musical Instrument Museums online – running from 2009 to 2011, he was responsible for coordinating the digitization of 45,000+ musical instruments in public collections and is now member of the MIMO Core Management Group. Within his duties as curator he also cares for the museum’s concert series “Musica Antiqua”, running since 1956, and organizes CD-recordings with instruments from the collection. He leads the DFG-funded projects “Collecting musical instruments – the Rück example” (2015–2018) and the GNM-part of MUSICES which develops a standard for the 3D-CT of musical instruments (2014–2017) together with Fraunhofer EZRT. Since 2013, he was a member of the advisory board of ICOM-CIMCIM.

**Boutin, Henri (boutin@lam.jussieu.fr)**

Henri Boutin is a post-doc researcher in music acoustics and active control applied to musical instruments. He studied at the French “grande école” ENSEA and the Polytechnic University of Madrid, with his undergraduate in electrical engineering. Then he specialized in signal processing, acoustics and computer science applied to music, through a master degree at UPMC (Univ. Paris 6) and IRCAM, and engaged in academic research with a PhD thesis in the LAM team (Lutheries Acoustique Musique) at UPMC.

His research interest has focused on the acoustics of musical instruments using skills in signal processing and acoustics. During his PhD, he designed active control methods to modify the sound of a xylophone bar and a violin equipped with piezoelectric transducers. For the past four years, he studied the lip vibration of trombone players, the vocal fold oscillation, and non-linearities in loudspeakers at low frequency, as a research associate at UNSW, Sydney. His current research concerns the acoustic effects of porosity in the bore of woodwind instruments. This study makes part of the FaReMi project, funded by Sorbonnes Universités and carried by the LAM team and the Centre de Recherche sur la Conservation.

**Brémaud, Iris (iris.bremaud@univ-montp2.fr)**

Iris Brémaud is CNRS researcher in the “Wood Team” of Laboratory of Mechanics and Civil Engineering in Montpellier. After training initially in plant biology and in guitar and lute making, in 2000 she specialised her work on woods for musical instrument making through her MSc in Wood Science and PhD in Mechanics. Her dissertation (2006) was on “diversity of woods used or usable in musical instruments making”. She subsequently continued research on this topic, focusing on cross-cultural views in instrument making and on the structure-chemistry-properties relationships in wood mechanics, as a Post-Doc researcher at Kyoto Prefectural University, then at INRA-National Institute for Agronomical Research in Nancy, then at EMPA-Swiss Federal Laboratories for Materials Science and Engineering. Since 2013 she is permanent research scientist at CNRS-National Centre of Scientific Research.

Her current research in Montpellier aims at a systemic approach of wood behaviour, diversity and cultural uses, by relating fundamental wood rheology to botanical origin and to traditional knowledge of wood craftsmen, still with a focus on musical instruments making. Ongoing works involve several PhD and Post-Doc subjects in link with national and international projects. Iris Brémaud initiated and organized the 1st International Symposium “Wood Science and Craftsmanship” held in 2014. She is also part of the Steering Comity of COST Action WoodMusICK and co-leader of WG1.
Chen, Shuoye (chenshuoye@gmail.com)

Shuoye Chen graduated from university of Tsukuba (bachelor of agriculture) in 2015, from April, 2015 joined the two-year master program in graduate school of life and environmental sciences, university of Tsukuba. His research topic is the new material development for Chinese traditional musical instrument and effect of playing (continuous vibration) on the vibrational property of wood.

de Bruyn-Ouboter, Vera (vera.de.bruyn@ringve.no)

Vera studies at the Institute of Conservation Sciences at the University of Applied Sciences Cologne. Title as Dipl. Restauratorin (FH) in 2000 with specialisation in conservation of wooden objects and musical instruments. Since 2005 she has a permanent position as only conservator at Ringve Music Museum Trondheim, Norway. The work at Ringve includes collection management, Risk management, preventive conservation and active conservation. In the last years there she had focus on finding rules for making on musical instruments playable in museums, 3D-CT as replacement for technical drawings and engaging for establish understanding that preventive conservation is a part of the entire museums challenge. There are fresh experiences with moving collections in connection with the new building of the Ringve in 2013 and organising the evacuating of ca 1000 objects during the fire in August 2015.

Goli, Giacomo (giacomo.goli@unifi.it)

Giacomo was born in 1973. He graduated in Forestry in 1999. He has a PhD in 2003 in Wood Science and Technology at the University of Florence (IT) and at the Ecole National Supérieure d’Arts et Métiers of Cluny (FR). He is actually a researcher in Wood technology and forest operations at the Department of Agricultural, Food and Forestry Systems of the University of Florence (IT). Main fields of interest: wood mechanics, wood physical and mechanical properties, wood in cultural heritage, monitoring systems for the cultural heritage field. In the field of cultural heritage study and conservation, he was involved in conservation projects regarding the violin Guarneri del Gesù 1743 – Cannone with the Musei di Strada Nuova and the Genova municipality and the Leonardo da Vinci’s - Mona Lisa panel painting with the Louvre Museum.

Konopka, Daniel (daniel.konopka@tu-dresden.de)

Daniel is a research assistant and PhD student at Technische Universität Dresden, Institute for Structural Analysis, aged 25. He studied civil engineering at Technische Universität Dresden until 2014. His research interests include: material modelling of time- and moisture-dependent mechanical behaviour of wood and numerical simulation of complex wooden structures, like pianofortes. Currently working on a project modelling and characterising the structural behaviour of wooden cultural heritage under hygro-mechanical loading.

Lorenzoni, Valerio (valeriolorenzoni@gmail.com)

Valerio Lorenzoni is an aerodynamic and aeroacoustic engineer with passion for musical acoustics. He has worked in aeroacoustics of wind turbines at Siemens Wind Power from 2011 to 2014. In 2012 has published his experimental work on the aerodynamics of saxophone mouthpieces and in the same year, he joined the group of the Delft University of Technology for design and 3D printing of musical instruments. Results of the application of 3D printing to musical instruments has been presented at scientific conferences (SMAC conference in Stockholm 2013) and at musical events with professional musicians (Den Haag Conservatory, North sea Jazz Festival).
**Malagodi, Marco (marco.malagodi@unipv.it)**

Marco graduated in Chemistry, and is currently a researcher of University of Pavia and the principal researches are focused on the characterization of wood artworks, of cleaning, consolidation and protection products, on the use of the main micro-invasive and non-invasive diagnostic techniques for the material characterization. He has experiences also as teacher thesis supervisor. The main research activities are related to the chemical area and concern the study of natural and synthetic products, normally used during restoration of Cultural Heritage. It featured different classes of synthetic resins and has carried out studies on the interactions with the painted surfaces and supports of different nature (wood, canvas, stone). He has carried out different campaigns of microclimatic conditions for the proper conservation of works of art, such as wood, cloth and stone. The studies have focused on the main control analysis and the effects of microclimatic variations on the artworks. Since the 2010 he is the coordinator of the Laboratorio Arvedi (University of Pavia) for the non-invasive analysis to perform on violins and stringed instruments.

**Maene, Chris (CM@maene.be)**

Chris Maene (1953) learned the craft of instrument making in the piano workshop of his parents in Ruiselede (Belgium). He built his first instrument at the age of 16 and has been building, restoring and collecting valuable instruments ever since. Currently he has collected over 200 unique pianos and fortepianos with a specific interest in concert grand models. They are often rare pieces and some of them are restored for concerts and CD recordings.

He has earned respect with the creation of many challenging and prestigious replica’s: the Steinway N°1 “Kitchen” fortepiano from 1836 (2006), the Ignaz Pleyel concert grand from 1843 (2010), the fortepiano specially made by John Broadwood in 1817 for Ludwig van Beethoven (2013), and many more. Apart from the many activities of the workshop, Chris Maene is also owner of the leading piano company in Belgium with 4 shops and 50 employees. Piano’s Maene is the exclusive distributor of Steinway in Belgium.

The extensive knowledge of historic instruments, combined with an equally comprehensive knowledge concerning modern instruments and a workshop with 10 staff members – each with their own specialty, is exceptional and offers the unique opportunity to develop a new type of modern piano. From 2013 to 2015 the Chris Maene workshop developed and built the Maene-Barenboim concert grand, based on Steinway & Sons.

**Meucci, Renato (renato.meucci@gmail.com)**

Renato Meucci, was born in 1958, and studied guitar and horn at the conservatories of Rome and Milan and classical philology at the University of Rome. After working as a free-lance horn player for some ten years, he turned to musicology and published papers in books and journals in various countries and languages. He is also the author of *Strumentario*, a unique book on the history of musical instrument making in the Western tradition (2nd ed., Venice: 2010).

Meucci has been teaching History of musical instruments as invited professor at the University of Parma (1994-2000) and Milan (2001-present) and Music history, as full professor, at the Conservatoire of Perugia (1994-99) and Novara (2000-present), where he assumed the position of dean in 2011. The American Musical Instrument Society has presented him with the Curt Sachs Award 2012, the most distinguished international recognition in organological scholarship.
Meyer, Barbara (b.meyer@ram.ac.uk)

Barbara has held the post Curator of Instruments at the Royal Academy of Music since 2012. As part of the Museum and Collection team, Barbara leads a team of skilled luthiers in preserving and maintaining the Academy’s collection. Amongst these 250 stringed instruments are some fine examples from the 17th century to the current day, including influential Cremonese makers.

Barbara trained in violin making in Cremona and Bologna, Italy between 1977 and 1983. She was awarded the Master Diploma in violin making from Düsseldorf, Germany in 1996.

Barbara has worked as a restorer/repairer, violin/cello maker and workshop manager in Germany, Spain and England between 1991 and 2011. From 2000 to 2001 Barbara taught violin making in Yogyakarta, Java, as part of a Spanish-Indonesian educational project. Since 2002 Barbara has been based in the UK restoring and maintaining fine instruments. With an MA in Screenwriting from the University of the Arts London, Barbara has produced a few documentaries/films. As part of her latest project she travelled with a small team across Argentina and Uruguay, interviewing female poets prolific during the Peron era. The film was premiered in Madrid this year.

Moens, Karel (Karel.Moens@stad.antwerpen.be)

Karl studied musicology at the KU Leuven and focused his research mainly on the study of ancient stringed instruments (16th to 19th century) and iconographic interpretation of musical motifs. From 1978 to 1999 he was research assistant at the Musical Instruments Museum in Brussels. Since 1980 he worked regularly in foreign museums with grants and research assignments (FRG, GDR, Austria, Switzerland, Czechoslovakia, France, Italy, Britain, Portugal, the Netherlands and the United States). He he participated or was responsible for more than twenty exhibitions in Belgium and abroad.

Karel Moens wrote more than 100 scholarly publications, mainly about the development and authenticity problems of ancient European stringed instruments and the iconographic interpretation of musical instruments.

Since 1999 is the curator of the Museum Vleeshuis in Antwerp. In 2006 the museum was fully renovated. It is fully dedicated to the musical life in the Antwerp, from the late Middle Ages to the present.

Nakanishi, Ryo (ryo.stv0113@gmail.com)

Ryo Nakanishi graduated from university of Tsukuba (bachelor of agriculture) in 2015, from April, 2015 joined the two-year master program in graduate school of life and environmental sciences, university of Tsukuba. His research topic is the mechanical property of reed used for Japanese woodwind instrument.

Perez, Marco (marco.antonio.perez@upc.edu)

Marco is a Post-doc Researcher and Adjunct Lecturer at Universitat Politècnica de Catalunya · BarcelonaTech (Spain).

He holds a PhD in Mechanical Engineering (2012) and a degree in Music (2009). In 2010 he spent a doctoral research period at the University of Colorado in Boulder (USA). His research and professional interests involve continuum mechanics, experimental mechancis and numerical modeling. General research areas include: composite materials, damage identification and numerical modelling, vibration analysis and non-destructive testing. He is currently working on the structural modifications assessment and damage identification through frequency domain correlation.
Rachor, David (rachor@uni.edu)

David Rachor has enjoyed a career spanning both bassoon performance and woodwind organology. He has travelled extensively presenting bassoon performance masterclasses, as well as historical reed lectures at the Bate Collection, the Conservatorio di Milano, and the Bruckner Hochschule. Rachor has concertized on period bassoon both in Europe and the United States, and has performed with Les Grandes Hautboys (Angoulême), Le Concert Spirituel (Paris), and the Lyra Consort (Minneapolis). Previously, he served as visiting professor of Baroque bassoon at the Conservatoire National Supérieur de Musique de Paris. Rachor was founder and co-director of the Milwaukee Renaissance Band. His current area of research concerns the development of an acoustic model of the Baroque and Classical bassoon. Rachor, Emeritus Professor of Bassoon at the University of Northern Iowa, holds the doctorate in bassoon performance from Indiana University in Bloomington. Presently, he makes his home in Tempe, Arizona, and plays woodwinds with the Medieval/Renaissance group Batholomew Faire.

Silva, Eliseu (eliseu7silv@gmail.com)

Eliseu Antunes Pereira Gomes da Silva, is a violinist and conductor born in Oporto. Prize winner of many national and international violin competitions and has performed many concerts in countries such as Spain, France, Germany, Italy, Switzerland, Japan, Netherlands, Belgium, Malta, China, Hong Kong, Macau, among others. He was invited by professor Uwe-Martin Heiberg, for a postgraduate degree, at Hochscule Fur Musik Hanns Eisler Berlin. He studied with emblematic professors rooted in the most well known schools of violin, such as Doctor Max Rabinovich, Valentin Stefanov, Gerardo Ribeiro and Sergey Kravachenko. Concluded all courses of study with the highest ratings, for which he received many awards and grants. He did a postgraduate degree in performance and finished a Master in Pedagogy and other Master in Instrumental Teaching at the same university. Currently, he is a PhD student at the Évora University in Musicology, performance and Interpretation, and is developing a project about violin performance in cooperation with LABIOMEP and the Sports Faculty of Oporto. Recorded for Deutch Gramophone, Remunich Label, Portuguese Radio Antenna 2 and did a recent release with portuguese composers. He is a Maestro and musical Director in the Oporto Youth Orchestra of Bonjóia and teaches at Oporto Music University of Arts.

Rapti, Stavroula

Mrs Stavroula Rapti graduated from the Department of Conservation of Antiquities & Works of Arts (CAWA), Technological Educational Institute of Athens, and was awarded a Master’s degree (MA) in Textiles Conservation from Winchester School of Arts at the University of Southampton. She is currently a permanent Technical Staff at CAWA, and she has been teaching as an external collaborator in several conservation courses such as organic objects, ethnographic collections, wood and textile. She has participated in numerous Greek and European research projects as a principal investigator, such as LIFE, EPET II, ARCHIMEDES I & II, CULTURE, THALES dealing with the assessment of materials condition, deterioration mechanisms, and conservation materials and methodologies. She is currently undertaking her PhD research on chelating agents for removing iron corrosion products from various organic substrates, such as wood and textile. She has published numerous articles related to her research interests.
Rossi Rognoni, Gabriele (g.rossirognoni@rcm.ac.uk)

Gabriele Rossi Rognoni is curator of the Royal College of Music Museum in London. He currently serves as Vice-President of the International Committee of Musical Instrument Museums and Collections (CIMCIM) of ICOM (the International Council for Museums), Board member of the Galpin Society, of Fenton House Musical Instrument Collection and of the Museum of the Violin in Cremona. He recently ended his term as corresponding Board member of the American Musical Instrument Society.

Between 1998 and 2013 he was curator of the Medici collection at the Galleria dell’Accademia in Florence and adjunct professor of musicology and history of musical instruments at the University of Florence.


His work mainly concentrates on the history of musical instruments in Europe, with particular attention to bowed and keyboard instruments, and on the development of organology as a discipline between the 18th and 20th centuries.

Tippner, Jan (jan.tippner@mendelu.cz)

Jan Tippner was born in 1980, lives in Brno - Czech Republic. He studied Wood technology engineering (Ing. in 2003) and Technology of wood processing. Properties of wood and materials (Ph.D. in 2011, thesis: Numerical simulation of piano soundboard in cooperation with piano producer Petrof). Works as Research Assistant (main investigator in 2 projects, lecturer) at Department of Wood Science, Faculty of Forestry and Wood Technology, Mendel university in Brno. Has an experience in the field of dynamic mechanical problems related to anisotropic materials – composites, mainly wood & wood composites. His work is focused mainly in the numerical simulation with Finite Element Method and experimental methods too (e.g. acoustic tomography, modal analysis with micro-accelerometers, laser vibrometry). He is author of several scientific works in the field of testing of properties of wood, acoustic properties and nondestructive testing of wood.

Vaiedelich, Stéphane (svaiedelich@cite-musique.fr)

In one hand, Stéphane Vaiedelich was violin maker and his work obtained several awards in international violin making competition. In the other hand, he studied physical and musical acoustic at the Paris university of Pierre et Marie Curie and obtained his master degree in material chemistry in 1992 (Université de Toulon et du Var). Head of the Laboratoire de recherche et de restauration of the Musée de la musique since 2001 he received his master degree in conservation from La Sorbonne – Paris I, in 2002. Its research focuses on the music instruments conservation and Organology. It is dealing with the knowledge of wood material and others used according to their choice in instrument making. He regularly teaches in several schools and Universities.
von Rüden, Heidi (Heidi.vonRueden@gmx.de)


Xavier, José (jmcx@utad.pt)

J. Xavier graduated in Mechanical Engineering at University of Tras-os-Montes e Alto Douro (UTAD) in July 1999. In that year, he received the merit award from Fundação Engenheiro António de Almeida, intended to distinguish annually the student with the highest classification in each scientific area. He received the MSc degree at UTAD in Oct. 2003, in which he investigated the application of the Iosipescu shear test to wood. J. Xavier was honoured with a PhD scholarship and moved to Ecole Nationale Superieure Arts et Metiers (ENSAM) Chalons-en-Champagne in France. He received the PhD diploma at ENSAM in Nov. 2007 with final grade of trés honourable. In the PhD thesis, he investigated wood stiffness variability by a novel test method coupling the optical grid technique with the virtual fields method. Since July 2009-April 2014, he held a position as post-doc research assistant at CITAB/UTAD, supported by FCT throughout the Ciencia2008 program. In CITAB, he was responsible for the task dealing with mechanical behaviour of bio-based materials and structures. Since Feb. 2015 he hold a position as Invited Lecturer at the Engineering Department of UTAD (area of Mechanical Engineering - Applied Mechanics).

Young, Christina (christina.young@courtauld.ac.uk)

Christina Young is a reader in easel painting conservation and conservation science in the Conservation & Technology Department. She supervises structural conservation treatments for both canvases and panels. Christina is actively researching in the fields of fatigue and fracture of paintings, non-invasive monitoring techniques, methods/materials for structural conservation, the conservation of contemporary art, preventive conservation for historical woodwind instruments and the significance of scenic art. Christina has a BSc in Physics from Imperial College (ICL) and an MSc in Applied Optics. Following industrial research in the development of optical instrumentation she returned to ICL in 1993 as a Research Assistant in the Department of Mechanical Engineering. In 1994 she was awarded the Gerry Hedley Research Scholarship and gained her PhD in the “Measurement of the biaxial tensile properties of paintings on canvas” in 1996. Before joining The Courtauld she was Leverhulme Research Fellow at Tate Britain between 1997-2000. In 2010, she was a visiting Getty Scholar at the Getty Conservation Centre, Los Angeles. Since May 2013, she has been a visiting academic at Imperial College, London.