

3D PRINTING AND MUSICAL HERITAGE

Conference Programme

London, 18 March 2024

Royal College of Music Museum & Wolfson Centre in Music and Material Culture

The workshop brings together perspectives from projects focusing on the use of 3D printing for musical heritage, with particular attention to reproductions of historical and traditional musical instruments for performance, documentation and accessibility.

Speakers will discuss the challenges and opportunities encountered in experiences delivered so far by institutions in Europe and the US, in order to capture the current state-of-the-art in this fast-expanding area.

The day will end with a concert performed by RCM professors and students using 3D printed reproductions of instruments from the RCM Museum collections.

Programme

8:30 – 9:00

Morning Coffee

9:00 – 9:15

Welcome by Professor Colin Lawson, Director of the Royal College of Music

Session 1

Chair: Prof. Robert Adlington

9:15 – 9:45

Gabriele Rossi Rognoni, Gabriele Ricciardi, Federico Xiccato

(Royal College of Music, London / University of Turin)

3D Printing for Musicians at the Royal College of Music Museum

9:45 – 10:05

Jean-Philippe Échard (Musée de la Musique, Paris)

Thinking the Musical Instrument in 3D over Time at the Musée de la Musique, Paris

10:05 – 10:25

Áurea Domínguez

(Hochschule für Musik Basel / Fachhochschule Nordwestschweiz)

Digitally Manufacturing Fagottini at the Schola Cantorum Basiliensis: Reconstructing Historical Instruments according to Contemporary Requirements

10:25 – 10:45 **Claudia Fritz** (LAM, Institut Jean le Rond d'Alembert, Sorbonne Université / CNRS, Paris)
Perspectives of 3D Printing for Historically Informed Playing: The Case of Jacques Martin Hotteterre's E.999.6.1 Traverso from the Musée de la Musique Collection

10:45 – 11:00 Q&A

11:00 – 11:20 Coffee Break

Session 2

Chair: Prof. Gabriele Rossi Rognoni

11:20 – 11:40 **Jonathan Santa Maria Bouquet** (University of Edinburgh) and **Zexuan Qiao** (Queen's University Belfast)
New Parts to Play Old Instruments

11:40 – 12:00 **Ricardo Simian** (Oslo School of Architecture and Design AHO)
Complexity and Craftiness in 3D Printed Musical Instruments

12:00 – 12:45 **PANEL DISCUSSION: Measurement and Modelling**
Zexuan Qiao (Queen's University Belfast)
Integrating Measurement and Additive Manufacturing Techniques for Reconstruction of Historical Border Pipes
Heike Fricke (Musikinstrumentenmuseum der Universität Leipzig)
Multimodal Research Data: Sustainability, Subsequent Use, and Engagement
Brett Clark (Natural History Museum, London)
Micro-CT's Melody in Preserving and Replicating Musical Treasures

12:45 – 13:45 Q&A

13:00 – 14:00 Lunch Break
Demonstration of Surface Scanning

Session 3

Chair: Dr. Heike Fricke

14:00 – 14:20 **Simon Waters** (Queen's University Belfast / Orpheus Instituut Gent)
Modelling: Imaginative Descriptions of Real Things

14:20-14:40 **Jamie Savan** (Royal Birmingham Conservatoire, Birmingham City University)
The 3D-Printed Cornett: Reflections on a Decade of Experimentation and Performance

14:40 – 15:00 **Jay Loomis** (Brown University, Providence, Rhode Island)
3D Printing Functioning Replicas of Indigenous Wind Instruments in Museum Collections: Ethical and Technical Considerations

15:00 – 15:15 Q&A

15:15 – 15:30 Coffee Break

Session 4

Chair: Prof. Gabriele Ricciardi

15:30 – 15:50 **Robert Bigio**
On the Interpretation of Measurements

15:50 – 16:10 **Peter Worrell**
From Design to Production

16:10 – 16:40	FLASH PAPERS Gonçalo Cruz Jun Kai Pow Bálint Szabó Dominik Ukolov Tim Southon, Nicholas Southon
16:40 – 17:00	Final Discussion
17:30 – 18:15	PRE-CONCERT TALK Colin Lawson, Ingrid Pearson, and Ashley Solomon (coord.) <i>Exploring 3D Printing of Original Instruments from a Player’s Perspective</i>
18:30 – 19:30	CONCERT in the RCM Performance Hall (only for in-person attendance)

Speakers and Abstracts

3D Printing for Musicians at the Royal College of Music Museum

Gabriele Rossi Rognoni, Gabriele Ricchiardi, Federico Xiccato
(Royal College of Music, London, UK / University of Turin, Italy)

Between 2023 and 2024 the Royal College of Music Museum has collaborated with the University of Turin to explore the opportunities offered by 3D printing techniques to create accurate copies of historical woodwind instruments aimed at advanced and professional musicians.

The project, generously supported by a grant from the DCMS/Wolfson Museum and Galleries Improvement Fund included the micro-CT scanning of eight woodwind instruments from the collection, analysis and virtual restoration when required and prints in a variety of materials and finishes.

Copies are now being evaluated to compare their physical and acoustical properties to the originals and to assess the reaction of musicians and audiences to their use.

Gabriele Rossi Rognoni is Curator of the Royal College of Music Museum in London and Chair of Music and Material Culture at the same institution where he also coordinates the activity of the Wolfson Centre in Music and Material Culture.

His research interests focus on the intersection between humanities and hard sciences and on the social study of music through non-textual sources such as musical instruments and iconography.

Gabriele Ricchiardi is Associate professor of Physical Chemistry at the Department of Chemistry, University of Turin and Director of the NIS inter-department Centre for materials research at the same University. His research activity is devoted to materials science studies in a variety of fields ranging from industrial materials (catalysts, adsorbents, glasses) to cultural heritage (ancient pigments, materials for musical instruments. He founded the “3D Early Winds” (3DEW) collective with engineer Federico Xiccato and flutist Manuel Staropoli, pioneering 3D-printing of historical wind instruments since 2016.

Thinking the Musical Instrument in 3D over Time at the Musée de la Musique, Paris

Jean-Philippe Échard

(Musée de la Musique, Cité de la musique - Philharmonie de Paris and Centre de Recherche sur la Conservation, CRC-UAR 3224 (CNRS, MNHN, MC) – Sorbonne Université, France)

Technological developments in recent decades have led to the emergence of 3D scanning and 3D printing as the most contemporary approaches to the dimensional documentation and material replication of historical musical instruments. Based on the work carried out by the research team of the Musée de la Musique, over the last three decades, this paper will show how these dynamics fit into broader issues such as those of conservation (particularly with regard to keeping instruments in playable condition), static and dynamic mechanics, and the transfer of knowledge between researchers, instrument makers, engaging the experience of musicians, listeners, and museum visitors. The three-dimensionality of the instrument must therefore be linked to the temporal dimension, on a wide range of scales, from the deformation of the object's structure over the centuries, or when it is set into vibration, to the scale of the milli- or micro-second.

Jean-Philippe Échard is curator of stringed instruments at the Musée de la musique in Paris since 2014. He trained as a chemist, with a degree from the École Nationale Supérieure de Chimie, Paris (1998) and a doctorate from the Muséum National d'Histoire Naturelle (2010) on 16th-18th-c. varnishing techniques in instrument-making. He conducted research as a conservation scientist on musical instruments in the laboratory of the Musée de la musique (1999-2004 ; 2006-2013) and on easel paintings at the National Gallery of Art, Washington DC, USA (2004-2005). Échard's current research is focused on organology in its cultural, social, economic, material context. His recent contributions mostly relate to the history and heritage values of musical instruments. He is the author of two books *Le violon Sarasate, stradivarius des virtuoses* (2018), and *Stradivarius et la lutherie de Crémone* (2022) as well as numerous papers and articles.

Digitally Manufacturing *Fagottini* at the Schola Cantorum Basiliensis: Reconstructing Historical Instruments according to Contemporary Requirements

Áurea Domínguez

(Hochschule für Musik Basel /Fachhochschule Nordwestschweiz, Switzerland)

Research into *fagottini*, carried out in Basel between 2017-2023, provided the basis for reconstructions of 18th and 19th century small bassoons using digital technology, including 3D-CT scanning and additive manufacturing. The paper discusses the findings of this research project, including how the results can be used in pedagogy and historical performance practice.

Áurea Dominguez is a researcher and performer specializing in historical sound technologies and innovative approaches to organology in wind instruments, such as the use of CT scanning and 3D printing as research tools.

Perspectives of 3D Printing for Historically Informed Playing: The Case of Jacques Martin Hotteterre's E.999.6.1 Traverso from the Musée de la Musique Collection

Claudia Fritz [1], Marguerite Jossic [2], Corto Bastien [1], Lidia Chang [2], Olga Kannavou [1], Stéphane Vaiedelich [2], Thierry Maniguet [2]

([1] LAM, Institut Jean le Rond d'Alembert, Sorbonne Université / CNRS, Paris, France;

[2] Equipe Conservation - Recherche, Musée de la musique, Cité de la musique – Philharmonie, Paris, France)

This paper compares two methods for replicating a traverso attributed to Jacques Martin Hotteterre: the conventional approach of crafting a wooden facsimile by a contemporary artisan and the innovative technique of 3D printing a facsimile using polymer materials. Comparison is made through acoustical measurements and perceptual tests conducted with professional musicians and a variety of listeners.

Claudia Fritz is a CNRS-researcher, in the Lutherie-Acoustics-Music team of the Institut Jean Le Rond d'Alembert, at Sorbonne Université (Paris). In close collaboration with instrument makers and players, her research aims at

investigating the correlations between player/listener perceptions and measured acoustical properties of musical instruments.

New Parts to Play Old Instruments

Jonathan Santa Maria Bouquet, Zexuan Qiao

(Senior Conservator, Heritage Collections, University of Edinburgh, UK / Queen's University Belfast, UK)

A project focused in the documentation and producing 3D models of bagpipes from the musical instrument collection of the University of Edinburgh yielded an unexpected yet interesting biproduct. This paper will explore an innovative approach to employing 3D printed components to restore functionality to historic bagpipes without interventive treatments.

Jonathan Santa Maria Bouquet is responsible for the conservation of the Musical Instrument Collection of the University of Edinburgh. Jonathan has a background in instrument making and restoration and holds a PhD in Music from the University of Edinburgh.

Complexity and Craftiness in 3D Printed Musical Instruments

Ricardo Simian

(Oslo School of Architecture and Design AHO, Norway)

The design, production, and evolution of musical instruments is a complex topic at the intersection between acoustics, technology, culture, aesthetics, and tradition, amongst many other elements. Within this paper we review the current state of affairs for the integration of additive manufacturing technologies into this environment through five case studies.

With a background in music, cultural management, engineering, and start-up innovation, **Ricardo Simian** is a PhD fellow at AHO Oslo researching applications of 3D printing technologies in design.

Integrating Measurement and Additive Manufacturing Techniques for Reconstruction of Historical Border Pipes

Zexuan Qiao

(Queen's University Belfast, UK)

This paper investigates the synergy between measurement and modelling techniques in the realm of reconstruction. It details techniques such as manual measurement, CT scans and the conversion of measurements into data and technical drawings, alongside a design approach balancing original characteristics with 3D printing optimisation.

Zexuan Qiao is a current PhD candidate at Queen's University Belfast researching historical woodwind instruments. His expertise in interaction design and architecture informs the pursuit of reconstructing bagpipes, enriching culture through additive manufacturing and modelling.

Multimodal Research Data: Sustainability, Subsequent Use, and Engagement

Heike Fricke

(Forschungsstelle DIGITAL ORGANOLGY e.V. am Musikinstrumentenmuseum der Universität Leipzig, Germany)

This paper gives an overview of the research data gained in two subsequent research and digitization projects at the Musikinstrumentenmuseum der Universität Leipzig, which have been funded by the German Ministry for Education and Research over the past six years. A special emphasis will be on visual research data concerning historical instruments and sound information carriers.

Heike Fricke is a musicologist and organologist leading the projects TASTEN and DISKOS at the Forschungsstelle DIGITAL ORGANOLOGY at Musikinstrumentenmuseum der Universität Leipzig, as well as projects on provenance research.

Micro-CT's Melody in Preserving and Replicating Musical Treasures

Brett Clark

(Natural History Museum, London, UK)

Micro-CT is a powerful tool in conservation, facilitating the accurate reproduction of culturally significant artefacts. This presentation showcases its value in 3D modelling historical musical instruments at macro and micro scales. Micro-CT is a tool for safeguarding and sharing cultural artifacts globally.

Brett Clark has over ten years of experience in micro-CT scanning and 3D modelling. Brett has collaborated with various museums and institutions while based at the Natural History Museum, London.

Modelling: Imaginative Descriptions of Real Things

Simon Waters

(Queen's University Belfast, UK / Orpheus Instituut Gent, Belgium)

Historical musical instrument studies has tended to focus on the physical specifics of individual instruments. Contemporary technologies of modelling and data comparison afford different approaches to the interpretation of the output and goals of a particular workshop or maker. This paper will examine both the broad implications of such methodological change, and the practical ramifications of learning from modelling multiple instruments.

Simon Waters had a successful career as a composer of electroacoustic music for contemporary dance in the 1980s and 1990s. His involvement with analogue and then digital recording technology led him to develop an increasingly complex relationship with music's entanglement with its supporting technologies. Recently he has been particularly engaged by the workshop practices of woodwind instrument makers in 18th century London, leading to his appointment as Visiting Fellow in Material Culture at the RCM.

The 3D-Printed Cornett: Reflections on a Decade of Experimentation and Performance

Jamie Savan

(Royal Birmingham Conservatoire / Birmingham City University, UK)

In 2014 Ricardo Simian and I published an article in *Early Music* presenting some initial findings from our first experiments with 3D-printing technology to produce functional models of historical cornetts. A decade on, this paper will reflect on some of the implications of this research for our understanding of historical performance practices, the use of 3D printed instruments in professional practice, and the opportunities afforded by the technology for innovation in contemporary instrument design.

Jamie Savan is Professor of Performance-led Research in Music at Royal Birmingham Conservatoire, where he currently leads the AHRC-funded research project 'Aural Histories: Coventry c.1451-1642' investigating the experience of music within digital reconstructions of historical performing spaces. A professional cornettist with some of the world's leading period-instrument ensembles, he has been experimenting 3D-printed cornetts and their application in research and performance since 2012.

3D Printing Functioning Replicas of Indigenous Wind Instruments in Museum Collections: Ethical and Technical Considerations

Jay Loomis

(Brown University, Providence, Rhode Island, USA)

In this paper Jay Loomis discusses ethical and technical considerations of 3D scanning and printing playable replicas of Indigenous wind instruments in museum collections, for research and repatriation. Collaboration with Indigenous experts is central to his work and he is developing protocols so that Indigenous nations and individuals can modify his processes to suit their own needs and interests.

Jay Loomis plays and constructs flutes out of wood, ceramics, and 3D printed materials using 3D modelling software to design and explore the acoustic architectures of wind instruments. His doctoral research focuses on son jarocho music in Veracruz, Mexico.

On the Interpretation of Measurements

Robert Bigio

A historical instrument may be reproduced either in its present state, including any distortion or later alteration, or by determining its form when new. This is the case both for reproductions made by traditional methods and by 3D printing. Measurements must be interpreted, and an examination of the tools and techniques used by early makers can inform the interpretation.

Robert Bigio is a London-based flute maker and restorer. He has a particular interest in historical tools and manufacturing methods. He is also a writer on the history of the flute and is the editor of the *Journal of the American Musical Instrument Society*.

From Design to Production

Peter Worrell

The learning curve needed to take an existing design of musical instrument, made in the traditional way and to convert it into a 3D printed instrument. This presentation discusses the focus group that was formed to aid with the design and method, considering different forms of manufacture, and explores the amount of experimentation needed to arrive at solutions and possible avenues of progression.

Peter Worrell is a woodwind instrument maker, specialising in flutes and clarinets. Experience in designing new instruments and keywork. More recently working with charities to make adaptive instruments.

From Object to Project. From Project to Object.

Materialisation and Author's Intentions

Gonçalo Cruz

(University of the Arts Helsinki / Sibelius Academy of Music, Finland)

From intention to action, and from action to accomplished object, information is lost and gained. When producing technical drawings of a physical object, the surveyor is attempting to travel the return path from object to project. Replicating musical instruments raises the question of what the project, or original intention of the maker, was.

Gonçalo Cruz is Musician, Researcher, and Maker of Bagpipes & Woodwinds. He holds both a bachelor's and a master's degree in architecture. Currently, he is Doctoral researcher at the Sibelius Academy, "Forgotten Bagpipes - Redesigning the Säkkipilli in Finland".

Prototype of an Indonesian Bamboo Idiophone

Jun Kai Pow

(Uppsala University, Sweden)

The *angklung* is an Indonesian bamboo idiophone made up of tubes and branches. Because of the humid tropical climate of the region, the instrument is subjected to biological decay. While printing using PLA/PETG as base material is more sustainable, one of the challenges lies in setting the eight parts in equal proportions in order to produce a single pitch.

Jun Kai Pow, PhD, is a researcher in Musicology at Uppsala University. He specialises in the music history and ethnomusicology of twentieth-century digital culture. He is interested in issues of gender, sustainability and decoloniality in music and other media.

Walrus Pipes and Waving Panpipes:

3D Printed Instrument Designs For Speculative Community Music

Bálint Szabó

(Moholy-Nagy University of Art and Design, Budapest, Hungary)

Musical instruments play a fundamental role in speculative music creations. In 2022, I started a 3D printed instrument project with the goal to create wind instruments for speculative community music. The present study reveals the complete design process of two wind instrument families developed throughout the project: the *Walrus Pipes* and the *Waving Panpipes*.

Bálint Szabó is a composer-musician and interdisciplinary researcher. His main artistic focus is non-standard musical tuning systems. His artistic work is manifested in his solo project [Gosheven](#), and in his band [Decolonize Your Mind Society](#).

Multimodal Virtual Enhancement of 3D Printed Musical Instruments

Dominik Ukolov

(Leipzig University / University of Jena, Germany)

This study investigates possible applications of Mixed Reality (MR) to enable photorealistic virtual textures and interaction tracking on 3D printed musical instruments. It focuses on the physical object as a tactile foundation for an immersive engagement with multimodal instrument data based on the standard for Virtual Acoustic Objects (VAO).

Dominik Ukolov is a doctoral candidate at the Research Center DIGITAL ORGANOLGY, located at the Musical Instrument Museum of Leipzig University. He primarily focuses on multimodal virtualization and transfer concepts.

Portable Photogrammetry of Violins for Less than £1,000

Timothy Southon, Nicholas Southon

Using a standard DSLR camera, £150 of software, a turntable and some black velvet, we created high quality 3D models of violins by photogrammetry. The system can be taken to museums and workshops to investigate instruments, providing detailed information about artefacts, and giving luthiers the information to understand and copy the instruments.

Timothy Southon was an MRI researcher for 13 years while his son, **Nicholas**, has a PhD in 3D Printing. They have been trying to 3D scan instruments for 17 years.

Exploring 3D Printing of Original Instruments from a Player's Perspective

Ashley Solomon, Colin Lawson, Ingrid Pearson
(Royal College of Music London, UK)

What value can these exact 3D-printed copies offer to players? What is their relevance today? Professor Ashley Solomon discusses the relevance of these important questions with Professor Colin Lawson CBE and Area Leader in MMus Performance Dr Ingrid Pearson.

Combining a successful career across both theory and practice, **Ashley Solomon** is Head of Historical Performance and recorder Professor at London's Royal College of Music. He has given masterclasses and lectures worldwide and co-founded the baroque ensemble Florilegium.

Colin Lawson is Director of the Royal College of Music. He has an international profile as a period clarinettist and has played principal clarinet in most of Britain's leading period orchestras, with whom he has recorded extensively and toured worldwide.

Ingrid Pearson is the Area Leader for the MMus in Performance and Programme Leader for the BSc in Music and Physics. She performs as a clarinettist in the arenas of historical and contemporary performance, and her publications encompass iconography, musical listening, organology, as well as aspects of teaching and learning in the Conservatoire environment.

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