Music Encoding Fundamentals and their Applications

Timothy Duguid
Raffaele Viglianti
Welcome to DHSI 2019!

Thanks for joining the DHSI community!

In this booklet, you will find essential course materials prefaced by some useful information about getting settled initially at UVic, finding your way around, getting logged in to our network (after you’ve registered the day before our courses begin), and so on.

Given our community’s focus on things computational, it will be a surprise to no one that we might expect additional information online for some of the classes - your instructors will let you know - or that the most current version of all DHSI-related information may be found on our website at dhsi.org.

Do check in there first if you need anything that’s not in this coursepak.

To access the DHSI wifi network, simply go into your wireless settings and connect to the “DHSI” network and enter the password “dhsi2019”.

And please don’t hesitate to be in touch with us at institut@uvic.ca or via Twitter at @AlyssaA_DHSI or @DHInstitute if we can be of any help ....
DHSI Wi-Fi

Network name: DHSI
Passkey: dhsi2019
The 2019 schedule is just taking shape nicely! A very few things to confirm, add, etc, still but this is the place to be to find out what is happening when / where ...

**Sunday, 2 June 2019 [DHSI Registration + Suggested Outings]**

If you’re here a day or two before we begin, or staying a day or two afterwards, here are a few ideas of things you might consider doing ....

Suggested Outing 1, Botanical Beach (self-organised; car needed)

A self-guided visit to the wet, wild west coast tidal shelf (and historically-significant former research site) at Botanical Beach; we recommend departing early (around 8.00 am) to catch low tide for a better view of the wonderful undersea life! Consider bringing a packed lunch to nibble-on while looking at the crashing waves when there, and then have an afternoon drink enjoying the view from the deck of the Port Renfrew Hotel.

Suggested Outing 2, Butchart Gardens (self-organised)

A shorter journey to the resplendently beautiful Butchart Gardens and, if you like, followed by (ahem) a few minutes at the nearby Church and State Winery, in the Saanich Penninsula. About an hour there by public bus from UVic, or 30 minutes by car.

Suggested Outing 3, Saltspring Island (self-organised; a full day, car/bus + ferry combo)

Why not take a day to explore and celebrate the funky, laid back, Canadian gulf island lifestyle on Saltspring Island. Ferry departs regularly from the Schwartz Bay ferry terminal, which is about one hour by bus / 30 minutes by car from UVic. You may decide to stay on forever ....

Suggested Outing 4, Paddling Victoria's Inner Harbour (self-organised)

A shorter time, seeing Victoria's beautiful city centre from the waterways that initially inspired its foundation. A great choice if the day is sunny and warm. Canoes, kayaks, and paddle boards are readily rented from Ocean River Adventures and conveniently launched from right behind the store. Very chill.

And more!

Self-organised High Tea at the Empress Hotel, scooter rentals, visit to the Royal BC Museum, darts at Christies Carriage House, a hangry breakfast at a local diner, whale watching, kayaking, brew pub sampling (at Spinnaker's, Swans, Moon Under Water, and beyond!), paddle-boarding, a tour of used bookstores, and more have also been suggested!

**Monday, 3 June 2019**

Your hosts for the week are Alyssa Arbuckle, Ray Siemens, and Jannaya Friggstad Jensen.

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**9:00 to 4:00**

Early Class Meeting: 4. [Foundations] DH For Department Chairs and Deans (David Strong Building C124, Classroom)

Further details are available from instructors in mid May to those registered in the class. Registration materials will be available in the classroom.

**3:00 to 5:00**

DHSI Registration (MacLaurin Building, Room A100)

After registration, many will wander to Cadboro Bay and the pub at Smuggler's Cove OR the other direction to Shelbourne Plaza and Maude Hunter's Pub OR even into the city for a nice meal.

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**7:45 to 8:15**

Last-minute Registration (MacLaurin Building, Room A100)
8:30 to 10:00

Welcome, Orientation, and Instructor Overview (MacLaurin A144)

- Welcome to the Territory
- Welcome to DHSI: Ray Siemens, Alyssa Arbuckle
- Welcome from UVic: Jonathan Bengtson (University Librarian), Alexandra D'Arcy (Associate Dean Research, Humanities)

10:15 to Noon

Classes in Session (click for details and locations)

1. [Foundations] Digitisation Fundamentals and their Application (Clearihue A103, Lab)
2. [Foundations] Introduction to Computation for Literary Criticism (Clearihue A102, Lab)
3. [Foundations] Making Choices About Your Data (Digital Scholarship Commons, McPherson Library A308, Classroom)
4. [Foundations] DH For Department Chairs and Deans (David Strong Building C124, Classroom)
5. [Foundations] Developing a Digital Project (With Omeka) (Clearihue A031, Lab)
9. Out-of-the-Box Text Analysis for the Digital Humanities (Human and Social Development A160, Lab)
10. Sound and Digital Humanities (Cornett A120, Classroom)
11. Critical Pedagogy and Digital Praxis in the Humanities (Clearihue D132, Classroom)
12. Digital Humanities for Japanese Culture: Resources and Methods (McPherson Library A003, Classroom)
13. Conceptualising and Creating a Digital Edition (McPherson Library 210, Classroom)
14. Retro Machines & Media (McPherson Library 129, Classroom)
15. Geographical Information Systems in the Digital Humanities (Clearihue A105, Lab)
16. Introduction to IIIF: Sharing, Consuming, and Annotating the World’s Images (Cornett A121, Classroom)
17. Web APIs with Python (Human and Social Development A170, Lab)
18. Ethical Data Visualization: Taming Treacherous Data (Cornett A128, Classroom)
19. Linked Open Data and the Semantic Web (Cornett A132, Classroom)
20. Pulpability and Wearable Computing (McPherson Library A025, Classroom)
21. The Frontend: Modern JavaScript & CSS Development (Clearihue A030, Lab)
22. Modelling Virtual Realities. A Practical Introduction to Virtual (and Augmented) Reality (McPherson Library A025, Classroom)
23. Information Security for Digital Researchers (David Strong Building C114, Classroom)

12:15 to 1:15

Lunch break / Unconference Coordination Session (MacLaurin A144)
(Grab a sandwich and come on down!)

Discussion topics, scheduling, and room assignments from among all DHSI rooms will be handled at this meeting.

1:30 to 4:00

Classes in Session

4:10 to 5:00

Abstract: Drawing from Numbered Lives (MIT 2018), this talk will consider a long history of sex-number entanglement in Anglo-American Cultures. Drawing on historical and contemporary objects and practices, Wernimont will ask "in what ways do theories of biopower, critical gender and critical race studies, and media studies" suggest that we can understand this set of entanglements and their impacts. NB: While relevant, this talk will not include discussions of sexual trauma or violence. It will include frank discussion of sex acts and various ways of translating sexual behavior into numbers.

5:00 to 6:00

Opening Reception (University Club)

Tuesday, 4 June 2019

9:00 to Noon

Classes in Session

12:15 to 1:15

Lunch break / Unconference

"Mystery" Lunches

1:30 to 4:00

Classes in Session

DHSI Conference and Colloquium Lightning Talk Session 1 (MacLaurin A144)
Wednesday, 5 June 2019

9:00 to Noon
Classes in Session

Lunch break / Unconference
*Mystery* Lunches

Presentation: An Introduction to Scholarly Publishing with Manifold (MacLaurin A144)
Lunch included for those who register here

12:15 to 1:15
This presentation introduces Manifold Scholarship, a Mellon-funded digital publishing platform developed by the CUNY Graduate Center, The University of Minnesota Press, and Cast Iron Coding. Manifold allows you to create beautiful, dynamic open access projects that can include text, images, video, embedded resources, and social annotation. We will provide an overview of Manifold and demonstrate how faculty, students and staff in the digital humanities can use Manifold to publish open access scholarly works, conduct and participate in peer review, and create custom edited versions of public domain course texts and OER.

1:30 to 4:00
Classes in Session

DHSI Conference and Colloquium Lightning Talk Session 2 (MacLaurin A144)
Chair: Kim O'Donnell (Simon Fraser U)

4:15 to 5:15
- Catherine Ryu (Michigan State U), "Tone Perfect: Developing a Multimodal Audio Database for Mandarin Chinese as an Open Source"
- Kenzie Burchell (U Toronto Scarborough), "Making Responsible Reporting Practices Visible: Comparing newswire coverage of humanitarian crises in Syria"
- Jessica Linzel (Brock U), "The Shopkeeper Aristocracy: Mapping Trade Networks in Colonial Niagara"
- Kirsten Painter (U Washington), "From Bogatyr to Bread: Digitization & Online Exhibition of Rare Russian Children's Books at the U Washington"
- John Barber (Washington State U), "A Mighty Span"

6:00 to 7:00
"Half Way There!" [An Informal, Self-Organized Birds of a Feather Get-Together] (Felicitas, Student Union Building)
Bring your DHSI nametag and enjoy your first tipple on us! [A great opportunity for an interest group meet-up ....]

Thursday, 6 June 2019

9:00 to Noon
Classes in Session

Lunch break / Unconference
*Mystery* Lunches

12:15 to 1:15
[Instructor lunch meeting]

1:30 to 4:00
Classes in Session

DHSI Conference and Colloquium Lightning Talk Session 3 (MacLaurin A144)
Chair: Kim O'Donnell (Simon Fraser U)

4:15 to 5:15
- Colleen Kolba (U South Florida), "What Comics can Teach our Students about Multimodal Literacy"
- Trish Baer (ETCL; U Victoria), "Preserving Digital Legacies: Archived Websites and Digital Discoverability"
- Suchismita Dutta (U Miami), "The Importance of Archival Transcription for Genre Building"
- Jeffrey Lawler (California State U, Long Beach), "Twining our way through the Past: Video Game Authoring as History Pedagogy"
Friday, 7 June 2019 [DHSI; ADHO Pedagogy SIG Conference Opening]

9:00 to Noon Classes in Session

12:15 to 1:15 Lunch Reception / Course E-Exhibits (MacLaurin A100)

1:30 to 1:50 Remarks, A Week in Review (MacLaurin A144)

2:00 to 3:00 Joint Institute Lecture (DHSI and ADHO Pedagogy SIG Conference):
   Matt Gold (CUNY Graduate Center and Association for Computers and the Humanities): “Thinking Through DH: Proposals for Digital Humanities Pedagogy”
   Chair: Diane Jakacki (Bucknell U) (MacLaurin A144)

  Abstract: How do we teach digital humanities, and how should DH be taught? What, indeed, should we teach when we teach DH? This talk will present a proposal for grounding digital humanities pedagogical practice in the research interests of our students and the epistemological foundations of our methods rather than through an approach grounded more central in data and methods.

3:30 to 5:00 Joint Reception: DHSI and ADHO Pedagogy SIG Conference (University Club)
   E-Poetry Event (Chris Tanasescu)
   Watch this space for details, including how to participate!

Saturday, 8 June 2019 [Conference, Colloquium, and Workshop Sessions]

8:00 to 9:00 Conference / Workshop Registration (MacLaurin A100)

The day’s events are included with your DHSI registration. If you’re not registered in DHSI, you’re very welcome to join us by registering here as a Conference / Colloquium / Workshop participant. We’ll have a nametag waiting for you!

Coffee, Tea, &c?

Looking for some morning coffee or tea, or a small nibble? Options and hours of operation for weekend campus catering are available here. Mystic Market usually opens around 10.00.

9:00 to 4:00 DHSI Conference and Colloquium Sessions
   ADHO Pedagogy SIG Conference Sessions
   Right2Left Workshop Sessions

9:00 to 4:00 All Day DHSI Workshop Session (click for workshop details and free registration for DHSI participants)

9:00 to 4:00 55. Introduction to Machine Learning in the Digital Humanities [8-9 June; All day, each day] (David Strong Building C124, Classroom)

9:00 to 9:10 Informal Greetings, Room Set-up (Lobby, outside Hickman 105)

Session 1

DHSI Colloquium and Conference (Hickman 105)
Digital Humanities & Literature, Chair: Kim O’Donnell (Simon Fraser U)
- Youngmin Kim (Dongguk U), “Transdiscursivity in the Convergence of Digital Humanities and World Literature”
- Caroline Winter (U Victoria), “Digitizing Adam Smith’s Literary Library”
- Kaitlyn Fralick (U Victoria); Kailey Fukushima (U Victoria); Sarah Karlson (U Victoria), “Victorian Poetry
9:10 to 10:30
ADHO Pedagogy SIG Conference (Hickman 110)
Chair: Katherine Faull (Bucknell U)
- Aaron Tucker and Nada Savicjevic (Ryerson U), “Write Here, Right Now: An Open Source eTextbook for the Flipped Classroom”
- Heather McAlpine (U Fraser Valley), “Digital Meters: Using Text Encoding to Teach Literature in the Undergraduate Classroom”
- Tiina H. Airaksinen (U Helsinki), “Digital Humanities in Cultural Studies: Creating a MOOC course for University Students and A-Level Students”

Right2Left Workshop (Hickman 116)

10:30 to 10:40
Break

10:40 to Noon
Session 2

DHSI Colloquium and Conference (Hickman 105)
Digital Humanities & Society, Chair: Eleanor Reed (Hastings C)
- Joel Zapata (Southern Methodist U), “Uncovering the Southern Plains’ Mexican American Civil Rights Movement”
- Brendan Mackie (U California, Berkeley), “Visualizing Long-Term Cultural Change: An Example From The Birth of Civil Society”

ADHO Pedagogy SIG Conference (Hickman 110)
Chair: Laura Estill (St Francis Xavier U)
- Jane Jackson (Chinese U of Hong Kong), “Interrogating digital spaces for intercultural meaning-making”
- Christopher Church, Katherine Hepworth (U Nevada, Reno), “We’re STEAMed! A call for balancing technical instruction and disciplinary content in the digital humanities”

Right2Left Workshop (Hickman 116)
- Edward “Eddie” Surman (Claremont Graduate U), “Qualitative Digital Text Analysis and #Right2Left Languages: A Demonstration of Atlas.ti using the Hebrew Bible”

Noon to 1:10
Lunch (We recommend Mystic Market on weekends!)

1:10 to 2:30
Session 3

DHSI Colloquium and Conference (Hickman 105)
Digital Humanities & Community, Chair: Claire Carlin (U Victoria)
- Pia Russel (U Victoria); Emily Stremel (U Victoria), “Mentorship and disability: Supporting disabled employees in digital humanities”
- Amy Lueck (Santa Clara U), “Virtually Emplacing Indigenous Memory”
- Md. Shehabul Alam (National U Bangladesh), “Integrating Library Service with Union Information and Service Center: A Joint Initiative towards Digital Bangladesh”
- Veronica Gomez (Instituto de Humanidades y Ciencias Sociales (IHuCSo) - UNL-CONICET), “Latin American E-literature and Location: The Nation Revisited in Electronic Literature Organization (ELO)”

ADHO Pedagogy SIG Conference (Hickman 110)
Chair: Chris Tănăsescu (UC Louvain)
- Laura Estill (St Francis Xavier U), “One Assignment, Three Ways: Assessing DH Projects in a Literature Course”
- Shu Wan (U Iowa), “A digital ‘historical gaze’ of Chinese students in Iowa, 1911-1930”
- Francesca Giannetti (Rutgers U, New Brunswick), “So near while apart: Correspondence Editions as Critical Library Pedagogy and Digital Humanities Methodology”

Right2Left Workshop (Hickman 116)
- Najla Jarkas (American U Beirut) and David Joseph Wrisley (NYU Abu Dhabi), “RTL Software Localization and Digital Humanities: the Case Study of Translating Voyant Tools into Arabic”
2:30 to 2:40

Break

Session 4

DHSI Colloquium and Conference (Hickman 105)
Digital Humanities & Media, Chair: Caroline Winter (U Victoria)
- Olivia Wikle (U Idaho), "Listening with Our Eyes: Using Topic Modeling, Text Analysis, and Sound Studies Methodologies to Explore Literary Soundscapes"
- Olin Bjork (U Houston-Downtown), "Dramatic Redundancy: Interactive Transcripts and Multimodal Performance Editions"
- Ashleigh Casserelle-Stanfield (U Chicago), "Sonifying Hamlet and Reading the Room"

ADHO Pedagogy SIG Conference (Hickman 110)
Chair: Aaron Tucker (Ryerson U)
- Youngmin Kim (Dongguk U), "Teaching Digital Humanities and World Literature in Class"
- Alice Fleerackers, Juan Pablo Alperin, Esteban Morales, Remi Kalir (Simon Fraser U, U Colorado Denver), "Online annotations in the classroom: How, why, and what do students learn from annotating course material?"
- Andie Silva (York C and Graduate Center, CUNY), "Keeping It Local: Undergraduate DH as Feminist Practice"

Right2Left Workshop (Hickman 116)
- Joanna Byyszuk (Institute of Polish Language, Polish Academy of Sciences, Warsaw/Computational Stylistics Group) and Alexey Khismatulin (Institute of Oriental Manuscripts, Russian Academy of Sciences, Saint Petersburg), "Attribution of Authorship for Medieval Persian Quasidas with Styometry"
- Ilan Benattar (New York U), "Right2Left Biblical Translations in Jewish Textual History: Case Studies in Judeo-Arabic and Judeo-Spanish"

8:00 to 5:00

DHSI Registration (MacLaurin Building, Room A100)
The day’s events are included with your DHSI registration. If you’re not registered in DHSI, you’re very welcome to join us by registering here as a Conference / Colloquium / Workshop participant. We’ll have a nametag waiting for you!

Coffee, Tea, &c?
Looking for some morning coffee or tea, or a small nibble? Options and hours of operation for weekend campus catering are available here. Mystic Market usually opens around 10.00.

9:00 to 4:00

All Day Workshop Sessions (click for workshop details and free registration for DHSI participants)
- 55. Introduction to Machine Learning in the Digital Humanities [8-9 June; All day, each day] (David Strong Building C124, Classroom)
- 56. Pedagogy of the Digitally Oppressed: Anti-Colonial DH Methods and Praxis [9 June; All Day] (Hickman 116, Classroom)
- 57. Natural Language Processing and Network Coding Apps for Text & Textual Corpus Analysis in the Humanities [9 June; All Day] (David Strong Building C114, Classroom)

AM Workshop Sessions (click for workshop details and free registration for DHSI participants)
- 59. 3D Visualization for the Humanities [9 June; AM] (Cornett A229, Classroom)
- 60. It’s All Relational: AbTeC’s Indigenous Video Game Workshops as Storytelling Praxis [9 June; AM] (Cornett A121, Classroom)
- 61. Spatial DH: De-Colonizing Cultural Territories Online [9 June; AM] (Clearihue D130, Classroom)
- 63. Creating a CV for Digital Humanities Makers [9 June; AM] (David Strong Building C108, Classroom)

9:00 to Noon

PM Workshop Sessions (click for workshop details and free registration for DHSI participants)
- 65. Indigenous Futurities in the Classroom and Beyond [9 June; PM] (Cornett A121, Classroom)
- 66. DHSI Knits: History of Textiles and Technology [9 June; PM] (Fine Arts 109, Classroom)
- 68. Linked Open Datafication for Humanities Scholars [9 June; PM] (McPherson Library A003, Classroom)
- 69. Stylo - WYSIWYM Text Editor for Humanities Scholars [9 June; PM] (McPherson Library A025, Classroom)

Lunch (We recommend Mystic Market on weekends!)

Noon to 1:00

PM Workshop Sessions (click for workshop details and free registration for DHSI participants)
- 70. History Pedagogy Using Scalar [9 June; PM] (Cornett A229, Classroom)
- 71. Linked Open Datafication for Humanities Scholars [9 June; PM] (McPherson Library A003, Classroom)
- 72. Stylo - WYSIWYM Text Editor for Humanities Scholars [9 June; PM] (McPherson Library A025, Classroom)

After the day, many will wander to Cadboro Bay and the pub at Smuggler's Cove OR the other direction to Shelbourne Plaza and Maude Hunter's Pub OR even into the city for a bite to eat.

Monday, 10 June 2019
Your hosts for the week are Ray Siemens and Jannaya Friggstad Jensen.

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<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>7:45 to 8:15</td>
<td>DHSI Last-minute Registration (<a href="#">MacLaurin A100</a>)</td>
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<td>8:30 to 10:00</td>
<td>Welcome, Orientation, and Instructor Overview (<a href="#">MacLaurin A144</a>)</td>
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<td>10:15 to Noon</td>
<td>Classes in Session (click for details and locations)</td>
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<td>30. [Foundations] Databases for Digital Humanists (<a href="#">McPherson Library 210</a>, Classroom)</td>
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<td>33. Digital Storytelling (<a href="#">Cornett A120</a>, Classroom)</td>
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<td>34. Text Mapping as Modelling (<a href="#">Cleanihue D131</a>, Classroom)</td>
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<td>35. Stylistometry with R: Computer-Assisted Analysis of Literary Texts (<a href="#">Cleanihue A102</a>, Lab)</td>
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<td>36. Open Access and Open Social Scholarship (<a href="#">Cleanihue D130</a>, Classroom)</td>
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<td>37. Digital Games as Tools for Scholarly Research, Communication and Pedagogy (<a href="#">Cornett A229</a>, Classroom)</td>
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<td>38. Queer Digital Humanities (<a href="#">David Strong Building C114</a>, Classroom)</td>
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<td>39. Parsing and Writing XML with Python (<a href="#">Cleanihue A108</a>, Lab)</td>
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<td>40. Introduction to Electronic Literature in DH: Research and Practice (<a href="#">Cornett A128</a>, Classroom)</td>
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<td>41. Surveillance and the Critical Digital Humanities (<a href="#">David Strong Building C108</a>, Classroom)</td>
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<td>42. Text Analysis with Python and the Natural Language ToolKit (<a href="#">Cleanihue A103</a>, Lab)</td>
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<td>43. Creating LAMP Infrastructure for Digital Humanities Projects (<a href="#">Human and Social Development A170</a>, Lab)</td>
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<td>44. Processing Humanities Multimedia (<a href="#">Human and Social Development A150</a>, Lab)</td>
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<td>46. Digital Humanities Pedagogy: Integration in the Curriculum (<a href="#">Cornett A121</a>, Classroom)</td>
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<td>47. Accessibility &amp; Digital Environments (<a href="#">Priestly Law Library 265</a>, Classroom)</td>
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<td>48. Agile Project Management (<a href="#">Cornett A132</a>, Classroom/Lab)</td>
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<td>49. XPath for Processing XML and Managing Projects (<a href="#">Cleanihue A105</a>, Lab)</td>
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<td>50. Endings: How to End (and Archive) your Digital Project (<a href="#">Priestly Law Library 192</a>, Classroom)</td>
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<td>51. Text Processing - Techniques &amp; Traditions (<a href="#">McPherson Library A025</a>, Classroom)</td>
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<td>52. Introduction to Humanities Data Analysis &amp; Visualization in R (HDA) (<a href="#">Human and Social Development A160</a>, Lab)</td>
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<td>53. Introduction to Network Analysis in the Digital Humanities (<a href="#">Cleanihue D132</a>, Classroom)</td>
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<td>12:15 to 1:15</td>
<td>Lunch break / Unconference Coordination Session (<a href="#">MacLaurin A144</a>)</td>
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<td>(Grab a sandwich and come on down!)</td>
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<td>&quot;Mystery&quot; Lunches</td>
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<td>1:30 to 4:00</td>
<td>Classes in Session</td>
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<td>Institute Lecture: Angel David Nieves (San Diego State U): &quot;3D Mapping and Forensic Traces of Testimony: Documenting Apartheid-Era Crimes Through the Digital Humanities&quot; Chair: Constante Crompton (U Ottawa) (<a href="#">MacLaurin A144</a>)</td>
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<td>Abstract: In 1989 the killing of a queer, 14-year-old youth in Winnie Mandela's house named Stompie Seipei (an event that few in South Africa are willing to recall, let alone discuss, in any detail) -- is perhaps one of the most glaring examples where the queer and activist community was suppressed or erased from anti-apartheid/liberation histories. Digital humanities may actually help both reconstruct and recover a history that is still very early in the telling, despite what is commonly believed about the liberation struggle and the contributions of queer activists in the dismantling of apartheid. Perhaps it could explain why a youth such as Seipei was killed -- or at the very least, provide a more complex and messy narrative that permits one to know more how the history of queer anti-apartheid activists was suppressed. This talk outlines a methodology for &quot;messy thinking and writing&quot; in the digital humanities that -- through a queer and feminist intersectional framework -- permits a more complex layering of oral histories and 3D historical reconstructions.</td>
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<td>5:00 to 6:00</td>
<td>Reception (<a href="#">University Club</a>)</td>
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Tuesday, 11 June 2019

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<tr>
<td>1:30 to 4:00</td>
<td>DHSI Conference and Colloquium Lightning Talk Session 4 (MacLaurin A144) Chair: Lindsey Seatter (U Victoria)</td>
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| 4:15 to 5:15 | • Ashley Caranto Morford (U Toronto); Kush Patel (U Michigan); Arun Jacob (McMaster U), “OurDHI’s anti-colonial: Questions and challenges in dismantling colonial influences in digital humanities pedagogy”  
• Julia King (U Bergen), “Developing Network Visualizations of Syon Abbey's Books, 1415-1539”  
• Luis Meneses (ETCL; U Victoria), “Identifying Changes in the Political Environment in Ecuador”  
• Alicia Brown (Texas Christian U), “Digital Cartography of the Ancient World”  
• Laura Horak (Carleton U), “Building the Transgender Media Portal”  
• Andrew Boyles Peterson (Michigan State U), “Last Mile Tracking: Implications of Rental Scooter Surveillance” |
| 6:00 to 8:00 | DHSI Newcomer's Gathering (Grad House Restaurant, Graduate Student Centre)  
Come down, buy meal and a beverage, and make some new friends! |

**Wednesday, 12 June 2019**

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<tbody>
<tr>
<td>9:00 to Noon</td>
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| 12:15 to 1:15| Lunch break / Unconference  
"Mystery" Lunches  
Presentation: An Introduction Jupyter Notebooks for Researchers (MacLaurin A144)  
This presentation introduces Jupyter Notebooks for researchers, via a partnership between Compute Canada and the Pacific Institute for the Mathematical Sciences (PIMS) including a large number of Canadian institutions. Read more here. Presenting is James Colliander, PIMS Director and team. |
| 1:30 to 4:00 | DHSI Conference and Colloquium Lightning Talk Session 5 (MacLaurin A144) Chair: Lindsey Seatter (U Victoria)  |
• Calin Murgu (New College of Florida), “Putting local metadata to strategic use: A Dashboard for visualizing 60 years of theses metadata”  
• Jason Lajoie (U Waterloo), “Queer Critical Making and the Logic of Control”  
• John Barber (Washington State U), “Zambezi River Bridge”  
• Kent Emerson (U Wisconsin-Madison), “Digital Mappa and the George Moses Horton Project” |
| 6:00 to 7:00 | "Half Way There (yet again)!" [An Informal, Self-Organized Birds of a Feather Get-Together] (Felicitas, Student Union Building)  
Bring your DHSI nametag and enjoy your first tipple on us! [A great opportunity for an interest group meet-up]  
... |

**Thursday, 13 June 2019**

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| 12:15 to 1:15| Lunch break / Unconference  
"Mystery" Lunches  
(Instructor lunch meeting) |
| 1:30 to 4:00 | Classes in Session                                 |
| 4:10 to 5:00 | Institute Lecture: Karina van Dalen-Oskam (Huygens Institute and U Amsterdam; Alliance of Digital Humanities Organizations): “The Riddle of Literary Quality: Some Answers” Chair: Aaron Mauro (Penn State, Behrend C) (MacLaurin A144)  
Abstract: What is literature, and can you measure it? That is the key question of the project The Riddle of Literary Quality. "The Riddle" is a research project of the Huygens Institute for the History of the Netherlands (Amsterdam) in collaboration with the Fryeke Akademy (Leeuwarden) and the Institute for Logic, Language and Computation (University of Amsterdam). The Riddle combines computational analysis of writing style with the results of a large online survey of readers, completed by almost 14,000 participants. In my talk, I will go into
some of the main results of the project.

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Music Encoding Fundamentals & their Applications
DHSI 2019

Timothy Duguid - tim.duguid@glasgow.ac.uk
Raffaele Viglianti - rviglian@umd.edu
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Welcome to music encoding! We are excited to have you on this course, and we hope it will allow you to expand your research workflows to include digital editing and analyses.

This document includes an annotated syllabus for the course, instructions for obtaining software that we will use in class, and a number of optional readings to contextualize music encoding and its applications.

This course will take place in a computer lab, and we suggest that all participants use the machines provided in that lab. The installation instructions are therefore for your reference so that you can replicate the course’s digital environment on your own machine.

The readings and tutorials are also provided for your reference.
Syllabus

The syllabus is subject to change and it is designed to be flexible to reflect the interests of the class.

Monday: MEI Basics
We will begin by introducing motivations and methodologies for text encoding and how they apply to music notation. Together, we will write our first MEI file by hand using Atom to obtain a working understanding of XML and the main components of MEI files.

Tuesday: MEI workflows
We will talk about creating an MEI file with MuseScore, improving it in Atom, and checking it via rendering it in a web browser. We will also discuss the role of customization and why it is necessary for text encoding disciplines. In the afternoon, we will explore more advanced encoding techniques for scholarly editions, performance analysis, and older music notation.

Wednesday: Metadata, linked open data, and audio
We will explore the MEI header and its rich model for talking about music-bearing objects and their performance. We will also explore connections between the header and linked open data on the web. Finally, we will learn how to align an MEI music score with a media (audio or video) file.

Thursday: Further uses for MEI data
We will learn how to use computational analytic tools such as jSymbolic and music21. In the afternoon, we will talk about using MEI for publishing digital scores, how they can be published alongside textual content encoded in TEI, and how digital scores can impact performance.

Friday: Publishing scores
Finally, we will learn how to put together a simple static site to publish your MEI-encoded file using Verovio. We will publish these sites to GitHub Pages.
Software

MuseScore

*MuseScore* is one of the best open-source music notation software packages available. It is supported by a growing community of scholars and musicians who often shares their created scores via the MuseScore Online Community Boards.

As opposed to Sibelius (see below), neither MuseScore nor Finale have a plugin that can generate an MEI file. However, both can export to MusicXML format, an interchange music format that can then be transformed into MEI. We will discuss how to do this in class.

Download MuseScore

Sibelius

*Sibelius* is music notation software. It is used by professional typesetters around the world, therefore, obtaining a license is expensive. Nonetheless, some academic music departments provide copies of Sibelius to faculty and students; it is worth checking with the music school at your institution.

Thankfully, Sibelius offers a 30-day free trial that we can use for this course. Even after the trial is expired, you will still be able to use Sibelius to export files to MEI, but you won’t be able to save files in the Sibelius format.

There is a plug-in that is able to export Sibelius music scores directly to MEI. Currently, Sibelius is the only music notation software able to do this.

Download Sibelius
Get the Sibelius for Windows or Mac from [https://connect.avid.com/Sibelius-Trial.html](https://connect.avid.com/Sibelius-Trial.html). If you are using a Linux machine, see the section on open source alternatives below and please get in touch with the instructors before DHSI.

Add the MEI plug-in
Download the plug-in from [https://github.com/music-encoding/sibmei/releases/download/v2.1.0/sibmei-2.1.0.zip](https://github.com/music-encoding/sibmei/releases/download/v2.1.0/sibmei-2.1.0.zip).
To install this plugin, copy or symlink the .plg files in the Sibelius Plugin directory on your machine. The specific location depends on your OS and version of Sibelius, see this page for instructions: http://www.sibelius.com/download/plugins/index.html?help=install.

Open Source alternatives

We do not recommend using other open source alternatives for this course, as doing so introduces substantial complications.

Atom

Atom is a text editor with support for a number of programming and markup languages, including XML. It is free and open source. Through a plug-in, it can be used to validate XML files against a schema—for example to make sure the file being edited follows MEI rules. The same plug-in also offers auto-completion suggestions, which makes it easier to figure out which MEI elements and attributes to use.

This section will guide you through a number of steps to install and configure Atom.

Download Atom

Atom can be downloaded at https://atom.io/. Versions are available for Windows, Mac, and Linux. Select and install the appropriate version for your operating platform, as you would any other application.

Install Java Development Kit (JDK)

The plug-in to validate XML requires Java code, a very common programming language. The JDK can be downloaded here: https://www.oracle.com/technetwork/java/javase/downloads/index.html. Make sure to select the correct platform (Windows, Mac OS, etc.) and follow the instructions to install it.

Add XML schema plug-in to Atom

- Open Atom and access its settings by hitting Ctrl + comma (Windows), or ⌘+comma (Mac)
- Select “Install”
- In the search bar, enter “linter-autocomplete-jing”
● When the corresponding result appears, click on “Install”
● If prompted to “install dependencies,” click “Yes”
● When the installation is complete, quit and restart Atom

Test XML schema plug-in

● In Atom, open a new file from the main menu bar: “File” → “New File.”
● Copy and paste the MEI template from this URL: https://gist.github.com/rafafazizzi/322536448f140b0f2f9a5b7b629bb327. The text is also included below, but copying from this PDF may cause issues; we recommend copy-pasting from the URL above.

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?><xml-model href="https://music-encoding.org/schema/4.0.0/mei-all.rng" type="application/xml" schematypens="http://relaxng.org/ns/structure/1.0"> <mei xmlns:xlink="http://www.w3.org/1999/xlink" xmlns="http://www.music-encoding.org/ns/mei" meiversion="4.0.0"> <meiHead> <fileDesc> <titleStmt> <title></title> </titleStmt> <pubStmt></pubStmt> </fileDesc> </meiHead> <music></music> </mei>
```

Commented [2]: we should fix this test too
Commented [3]: fixed and removed schematron declaration as it doesn’t seem to work properly (see chat)
The first lines (in grey above) (1) indicate that this is an XML file, and (2) associate this file with the latest MEI schema available online. In class, we will use a local schema for better speed.

- Navigate to “File” → “Save As...” to save the file with an “.xml” extension to activate the plugin (e.g. “test.xml”). Perform the operations below to make sure the plug-in is working properly.
- Check for error messages (indicated by a red-colored circle along the left-hand side) when the XML is not “well formed”, e.g. by removing a closing tag.

- Start typing a new attribute or element to get autocompletion suggestions.
jSymbolic

jSymbolic is a software application intended for conducting research in the fields of music information retrieval (MIR), music theory and musicology. Its primary purpose is to extract statistical information from musical data stored symbolically in file formats such as MIDI or MEI.

It can be downloaded from [http://sourceforge.net/projects/jmir/files/](http://sourceforge.net/projects/jmir/files/)

Python and Music21

Music21 is a powerful tool that can allow you to analyze single pieces and large corpora of music. However, it runs on Python. Therefore you will need to install Python, a few dependencies for Atom, and then the music21 library (preferably in that order).
1. Python installation

We recommend that you use the Anaconda Distribution of Python. To download and install Anaconda on Windows, MacOS and Linux, see https://www.anaconda.com/distribution/.

Note: It is a large distribution and will take some time to install!

2. Install music21 library

MacOS:
- Open up “Anaconda Prompt” through Finder
- In the prompt, type: `sudo pip3 install music21`
- It will prompt you for your password

Windows
- Find “Anaconda Prompt” in Start -> Anaconda and type: `pip install music21`
- It will automatically download and install a number of dependencies along with music21.
- When complete, launch “jupyter” which should also be located in Start -> Anaconda
- In the top right, click “New” and select “Python 3”
- Type: `import music21`
- Hit Shift + Enter
- If you see the following, you have correctly installed music21:

![Image of Python code execution]

3. Configure music21

MacOS
When you downloaded and installed music21, a new folder should have been created on your desktop. In that folder, double-click the file “installer.command”

The system will likely warn you about running it, but click on “Open”

A Python window will then open and the Configuration Assistant will start.

Follow the instructions under “All OS” to complete the configuration

**Windows**

- After entering testing your music21 installation (above), configure music21 by typing the following in the next line:
  ```python
music21.configure.run()
```
- Follow the instructions under “All OS” to complete the configuration

**All OS**

- When asked to install music21 in the standard location, enter “y” or “yes” and press return.
- You may be asked for your Mac password
- Installation will begin, and a large amount of text will display files being copied.
- Music21 will then ensure you have a MusicXML reader.
- If you have not installed Sibelius or Finale, you can enter “y” or “yes” to be taken to a website to download and install Finale Reader.
- If you have installed Sibelius or Finale installed, enter “n” or “no” and music21 will show a list of compatible readers. Select the program you wish to use.
- The remaining questions will ask if you wish to allow music21 to access the internet (up to you) and if you agree to the license for music21 and the included scores (answer ‘yes’).

**GitHub and GitHub Pages**

GitHub is an online service for versioning code, but can also be used to host simple websites through GitHub Pages. In this course, we will learn how to store MEI data on GitHub and publish a digital score website with GitHub Pages.
Getting Started

- Navigate to https://github.com and create an account. Follow the prompts to create a free GitHub account. Be sure to make the email address associated with your account public, so that you’ll later be able to publish a static site.
- Navigate to https://desktop.github.com to download GitHub Desktop. Then, open the application and sign in.

Git / GitHub operations

- **REPOSITORY**: code and data in one place
- **FORK**: make a copy of someone else’s repository to your account. We will provide an example repository that you will be able to fork
- **CLONE**: copy a repository to your machine
- **ADD**: add a file to be tracked by Git
- **COMMIT**: save local changes to your local clone
- **PUSH**: send your committed changes to your online repository on GitHub
- **PULL**: get changes from the online repository to your cloned repository
- **SEND PULL REQUEST**: contribute changes to an original repository that you forked

Publishing with GitHub pages

If your repository contains a website, you can publish it on GitHub pages. In your GitHub account (in your internet browser), navigate to your repository containing a website. Click on the “Settings” tab. Scroll down to “GitHub Pages” and pop-out “none” to select “Master branch.” Click Save. The page may refresh before offering you a link to your page.

MEI Tutorials

The following MEI tutorials are slightly adapted from “MEI 1st”, formally hosted on the MEI website. They are written by Maja Hartwik and Kristina Richts.

General MEI Document Structure

MEI provides an XML-based schema that describes music notation, using both XML elements and attributes. An element, often referred to as XML tag, is notated in angle brackets:

```xml
<elementName></elementName>
```
The name of an element is case sensitive, and every element consists of an opening and closing tag. The closing tag contains a solidus character (forward slash), which precedes the element name. An element may contain one or more other elements, XML comments, or text. Content is nested within the opening and closing tag of the element.

```xml
<elementName>
  <subElement>Text</subElement>
  <subElement>Text</subElement>
</elementName>
```

Elements must be nested properly, with the element opened last being closed first, in order to comply with the rules of XML.

An element may be described further by adding attributes to it. These attributes are attached to the element’s name in the opening tag, separated by a space character. Attributes can be listed in any order within a particular element. Whereas elements may be specified further by attributes, there is no mechanism for providing additional information about attributes. Therefore, attributes are less versatile than elements. In running text, attributes are often referred to by attaching a preceding @ character.

Elements lacking content between their opening and closing tags (containing nothing, not even spaces or tabs), may be written as empty elements:

```xml
<sb></sb> or <sb/>
```

In the last case, the backslash at the end of the element’s name indicates that the opening tag is also functioning as the closing tag. This mechanism is independent of the use of attributes.

An XML document following these general rules of XML is "well-formed". In addition to being well-formed, an XML document may be "valid" with regard to a schema, such as MEI, meaning that it also reflects the structure defined by that particular schema. The following instructions assume well-formed and valid MEI documents. Every MEI document consists of two main parts:

- the MEI Header and
- the MEI music.
1 The MEI Header

In addition to providing a means of electronically transcribing or encoding the musical content of a given piece of music notation, MEI enables the capture of information about this encoded material (title, source, related works, data about creation, etc.), using the MEI Header, represented by the <meiHead> element. While this part of the schema is modeled on the respective sections of the Text Encoding Initiative (TEI), the Encoded Archival Description (EAD), or other metadata encoding and transmission standard formats, it is specifically adjusted to address the needs of musicologists, music librarians, and others in the field.

Every MEI file requires a minimal header. The header in the example below provides information about the title of the digital resource and details of its publication status. Of course, other details may be specified using a variety of optional elements.

2 Music

2.1 Basic Structure of an MEI Document

The example below shows a typical, simple MEI document, using the <mei> document element, which consists of some metadata, represented by the <meiHead>, and the <music> itself. The <music> element is the container for the complete musical text and makes some important constituents available. The following example shows the mei document element with the appropriate namespaces (briefly, the namespace is a definition required for all XML documents), the required <meiHead>, and an empty <music> element.

```xml
<mei xmlns="http://www.music-encoding.org/ns/mei">
  <meiHead>
    <fileDesc>
      <titleStmt>
        <title>title of the encoded example</title>
      </titleStmt>
      <pubStmt/>
    </fileDesc>
  </meiHead>
  <music/>
</mei>
```

While the <music> element is required in this case, it may be empty. The <music> element is simply a placeholder for content that is not yet provided.
2.2 Body and Group
The structure below illustrates a musical text with a `<music>` element and the sub-element `<body>`. The `<body>` element must contain at least one segment, known as a “musical division” (`<mdiv>`).

```
<music>
  <body>
    <mdiv>
      <scoreDef meter.count="2" meter.unit="4"
       key.sig="3s">
        <staffGrp symbol="line">
          <staffDef n="1" label="Singstimme." lines="5"
            clef.shape="G" clef.line="2"/>
        </staffGrp>
        <staffGrp symbol="brace" label="Pianoforte.">
          <staffDef n="2" lines="5" clef.shape="G"
            clef.line="2"/>
          <staffDef n="3" lines="5" clef.shape="F">
          </staffDef>
          </staffGrp>
      </scoreDef>
    </mdiv>
  </body>
</music>
```

The `<score>` element contains a score definition (`<scoreDef>` element), which acts as a container for score meta-information (i.e., information related to the whole score, such as meter). The score definition (`<scoreDef>`) may, in turn, include one or more staff definitions (`<staffDef>`), which can be grouped by one or more staff groups (`<staffGrp>`). As shown in the example, the `<staffGrp>` element can be used to specify the symbol used to group a set of staves. It is also possible to encode staff groups within other staff groups. Specific information about individual staves of a score, such as clefs or key signatures, is encoded within staff definitions (`<staffDef>`). Names of single instrument voices may be encoded in staff definitions or in staff groups.

Multiple musical division (`<mdiv>`) may be encoded within a file. In describing the separate movements of a symphony, for example, separate `<mdiv>` elements are used to demarcate the different segments. `<mdiv>` elements may also be nested.
within another when the structure requires it, as in the following sample of an opera:

```xml
<music n="opera">
  <body>
    <mdiv n="act_1">
      <mdiv n="scene_1">
        <score/>
      </mdiv>
    </mdiv>
    <mdiv n="act_2">
      <score/>
    </mdiv>
    <mdiv n="act_3">
      <score/>
    </mdiv>
  </body>
</music>
```

The `<mdiv>` element is a critically important part of the structure of an MEI file. The content of the divisions is also significant, as that decision will enable one of two possible views: `<score>` and `<parts>`. Each of the elements may contain elements and attributes for describing features such as clefs, key signature, meter, etc.

If you would like to encode a single violin part, the main structure could look like this:

```xml
<music>
  <body>
    <mdiv>
      <parts>
        <part>
          <staffDef n="1" label="Violin" lines="5" meter.count="3" meter.unit="4" clef.shape="G" clef.line="2" key.sig="1s"/>
        </part>
      </parts>
    </mdiv>
  </body>
</music>
```
When encoding performer's parts, i.e. those of a string quartet, a separate <part> element must be created for each of the instrument voices. Each of these may include its own staff definition (<staffDef>).

In contrast to the <body> element, the <group> element enables the encoding of a group of essentially-separate musical texts. If, for example, you are encoding a collection of songs, you can nest one or more <music> elements, along with their respective <body>, <mdiv>, <score>, or other elements, within <group>, as seen in the example below.

```xml
<music>
  <group>
    <music n="song_1">
      <body>
        <mdiv/>
      </body>
    </music>
    <music n="song_2">
      <body>
        <mdiv/>
      </body>
    </music>
  </group>
</music>
```

As you can see, while the MEI basic framework is very simple, it can be used to model complex situations.

2.3 Front and Back

The elements <front> and <back> are children of the <music> element and are located on the same hierarchical level as the elements <body> and <group>. They are used to describe extensive introductory texts, for instance, those in critical editions and collected works. Both the <front> element and the <back> element require a mandatory division (<div>) child element, which itself requires a paragraph (<p>) child element containing the actual text you are encoding. An example of this hierarchical structure is illustrated below:

```xml
<music>
  <front>
    <div>
      <p><!-- introductory text here -->
    </div>
  </front>
</music>
```
2.4 Section

The `<section>` element is a child element of the `<score>` or `<part>` element and may be used to divide a score or parts into further linear segments, so-called sections. Within the `<section>` element, several methods of organization are possible, depending upon the notational style of the source material and the encoder's needs. A section can be described as the container for the actual musical data of an individual segment in a musical work.

```xml
<music>
  <body>
    <mdiv>
      <score>
        <section> <!-- musical data for this segment of the musical work -->
          <!-- musical data for this segment of the musical work -->
        </section>
      </score>
    </mdiv>
  </body>
</music>
```

Basic MEI Document Structure

A minimal MEI file should contain the following:

```xml
<?xml version="1.0" encoding="UTF-8"?>
```
Encoding Notation Basics

(This tutorial is adapted from "MEI 1st", written by Maja Hartwik and Kristina Richts)

Using the Basic MEI Document above, we will now focus on some of the basics of encoding music using the song "Don’t Worry, Be Happy".

1. Encoding of preliminary information

It is necessary to encode a number of elements before encoding the notes themselves. You may recall that we covered the child elements from <body> to <section> and explained the use of the <section> element in the chapter "Common Structure and Elements". So you should now add the elements <body>, <mdiv>, <score> and <section> (in this sequence) into the <music> element of your empty MEI file. Next, insert a <measure> element into the <section> element (recall that <section> contains the actual musical data). A <measure> element always requires a <staff> child element. Of course, you could encode multiple staves, but for now, let’s start with just one. The <staff> element requires a <layer> child element. Once again, you could encode more than one layer, but to keep things simple, we’ll begin
with a single layer, which contains a stream of musical events on a staff. So, at this
point, your `<measure>` element should contain a `<staff>` and `<layer>` element.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<mei xmlns="http://www.music-encoding.org/ns/mei">
  <meiHead>
    <fileDesc>
      <titleStmt>
        <title>Don't worry, Be Happy</title>
      </titleStmt>
      <pubStmt/>
    </fileDesc>
  </meiHead>
  <music>
    <body>
      <mdiv>
        <score>
          <section>
            <measure>
              <staff>
                <layer>
                </layer>
              </staff>
            </measure>
          </section>
        </score>
      </mdiv>
    </body>
  </music>
</mei>
```
Key signatures are encoded by using the \texttt{@accid} (accidental) attribute. The "f" stands for "flat", "s" for "sharp" and "n" for "natural".

2. Notes
A note has to be defined with its elementary attributes: \texttt{@pname} (pitch name), \texttt{@oct} (octave) and \texttt{@dur} (duration). The pitch name is just the typical A, B, C, etc. For the octave, the Acoustical Society of America adopted a system that numbers the octaves from the lowest to the highest. The following octave starting with middle C and extending up to treble-clef, third-line B would be octave 4.

![Octave diagram](https://commons.wikimedia.org/w/index.php?curid=1451757)

Finally, the duration value is the number of notes that would fit in a 4/4 measure. So, quarter notes would be 4; half notes, 2; whole notes, 1; eighth notes, 8; etc. The first note of the famous refrain of our song, a quarter note on E, would therefore be encoded as:

```xml
<measure>
  <staff>
    <layer>
      <note pname="e" oct="4" dur="4"/>
    </layer>
  </staff>
</measure>
```
3. Beams

The first note of the measure, which you've already encoded, is followed by two eighth notes on C:

```
<measure>
  <staff>
    <layer>
      <note pname="e" oct="4" dur="4"/>
      <note pname="c" oct="4" dur="8"/>
      <note pname="c" oct="4" dur="8"/>
    </layer>
  </staff>
</measure>
```

While this realization works, it creates two separate eighth notes. More commonly, successive eighth notes (along with smaller denominations) are grouped by beams. The `<beam>` element is realized as a grouping element around the two notes. Therefore, this is accomplished by encoding the notes and adding a `<beam>` element around them:

```
<measure>
  <staff>
    <layer>
      <note pname="e" oct="4" dur="4"/>
      <beam>
        <note pname="c" oct="4" dur="8"/>
        <note pname="c" oct="4" dur="8"/>
      </beam>
    </layer>
  </staff>
</measure>
```

*Note for oXygen users: If you select the note elements and use the shortcut Ctrl + E (or Cmd + E on the Mac), you will get a list of elements which can be legitimately wrapped around them. The `<beam>` element will be in that list.*
4. Rests

In order to finish the first measure of our song, we need to add some rests. Like a note, the <rest> element will be encoded with specific attributes. In this case, we need to encode the durations of the rests:

```xml
<measure>
  <staff>
    <layer>
      <rest dur="4"/>
      <rest dur="4"/>
      <note pname="e" oct="4" dur="4"/>
    </layer>
  </staff>
</measure>
```

You may have already noted that the refrain of “Don’t Worry, Be Happy” begins with a pick-up note. Or, to be more accurate, the quarter note falls on the fourth beat of one measure and the eighth notes fall on the downbeat of the following measure. We therefore need to be able to place the notes we have already encoded into their correct metrical positions.

```xml
<measure>
  <staff>
    <layer>
      <rest dur="2"/>
      <rest dur="4"/>
      <note pname="e" oct="4" dur="4"/>
    </layer>
  </staff>
</measure>
<measure>
  <staff>
    <layer>
      <beam>
        <note pname="c" oct="4" dur="8"/>
      </beam>
    </layer>
  </staff>
</measure>
```
5. Staff Definition (staffDef)

As you might have noticed, we haven't yet encoded the clef and meter information notated at the beginning of the measure. This information is commonly divided among different elements. For the meter, you should add `@meter.count` (top number in time signature) and `@meter.unit` (bottom number in signature) to a new `<scoreDef>` element preceding the `<section>` element. It is recommended that a staff definition, represented by the `<staffDef>` element, be encoded as a child of the `<section>` element. The `<staffDef>` element is briefly introduced in the General MEI Document Tutorial. To add the clef, use `@clef.shape` and you should also make sure the clef is placed on the correct line of the staff using `@clef.line`.

```xml
<score>
  <scoreDef meter.count="4" meter.unit="4">
    <staffDef clef.shape="G" clef.line="2"/>
  </scoreDef>
  <section>
    <measure>
      <staff>
        <layer>
          <rest dur="2"/>
          <rest dur="4"/>
          <note pname="e" oct="4" dur="4"/>
        </layer>
      </staff>
    </measure>
  </section>
</score>
```
The default key signature has no flats and sharps, so we do not need to include it. However, if we did, you would use @key.sig and indicate the number of flats or sharps ("1f" = one flat, "5s" = five sharps).

6. Name or number (@n)

The next step will be to add the remainder of the refrain, which is just a repetition of the first three notes. To help distinguish what is a growing number of measures, we will use the @n attribute to number the measures.

```xml
<staffDef clef.shape="G" clef.line="2"/>
<section>
  <measure n="1">
    <staff>
      <layer>
        <rest dur="2"/>
        <rest dur="4"/>
        <note pname="e" oct="4" dur="4"/>
      </layer>
    </staff>
  </measure>
  <measure n="2">
    <staff>
      <layer>
        <beam>
          <note pname="c" oct="4" dur="8"/>
          <note pname="c" oct="4" dur="8"/>
        </beam>
        <rest dur="4"/>
        <rest dur="4"/>
        <note pname="e" oct="4" dur="4"/>
      </layer>
    </staff>
  </measure>
  <measure n="3">
    <staff>
      <layer>
        <beam>
          <note pname="c" oct="4" dur="8"/>
          <note pname="c" oct="4" dur="8"/>
        </beam>
      </layer>
    </staff>
  </measure>
</section>
```
7. Lyrics

So far, so good! But to be able to sing the song, we need some text. So the next step will deal with some lyrics. The best way to encode lyrics is to add <syl> elements within <note> elements.

```xml
<measure n="1">
    <staff>
        <layer>
            <rest dur="2"/>
            <rest dur="4"/>
            <note pname="e" oct="4" dur="4"><syl>Don't</syl></note>
        </layer>
    </staff>
</measure>
<measure n="2">
    <staff>
        <beam>
            <note pname="c" oct="4" dur="8"><syl>Wor-</syl></note>
            <note pname="c" oct="4" dur="8"><syl>ry</syl></note>
        </beam>
        <rest dur="4"/>
    </staff>
</measure>
```

You can add @n to any element, and it is particularly helpful for distinguishing parts in a score.
8. Chords

Now you have successfully encoded three measures of notes and text in MEI. Congratulations!

Later on in the song, there are chords, accidentals and dotted rhythms. To simplify matters, the first image will show only the notes, without rhythm or accidentals. Chords must be encoded with a `<chord>` element around the `<note>` elements. If there are beamed chords, encode the beam first, then the chords, and finally the notes. Encode the following as measure 10.

```
<measure n="10">
  <staff>
    <layer>
      <rest dur="2"/>
      <beam>
        <chord>
          <note pname="e" oct="4" dur="8"/>
          <note pname="g" oct="4" dur="8"/>
        </chord>
        <chord>
          <notepname="d" oct="4" dur="8"/>
          <note pname="f" oct="4" dur="8"/>
        </chord>
        <chord>
          <note pname="c" oct="4" dur="8"/>
          <note pname="e" oct="4" dur="8"/>
        </chord>
        <chord>
          <note pname="a" oct="3" dur="8"/>
          <note pname="c" oct="4" dur="8"/>
        </chord>
      </beam>
    </layer>
  </staff>
</measure>
```
9. Rhythm

Now let’s encode the dotted rhythms by adding a @dots attribute to the <note> element. The value represents the number of augmentation dots accompanying the note and must be an integer less than or equal to 4. Note also that the number of beamed groups has changed. Insert the second beam and add a @dots attribute to the relevant notes.

```
<measure n="10">
  <staff>
    <layer>
      <rest dur="2"/>
      <beam>
        <chord>
          <note pname="e" oct="4" dur="8" dots="1"/>
          <note pname="g" oct="4" dur="8" dots="1"/>
        </chord>
        <chord>
          <note pname="d" oct="4" dur="16"/>
          <note pname="f" oct="4" dur="16"/>
        </chord>
      </beam>
    </layer>
  </staff>
  <layer>
    <beam>
      <chord>
        <note pname="c" oct="4" dur="8" dots="1"/>
        <note pname="e" oct="4" dur="8" dots="1"/>
      </chord>
      <chord>
        <note pname="a" oct="3" dur="16"/>
        <note pname="c" oct="4" dur="16"/>
      </chord>
    </beam>
  </layer>
</measure>
```
10. Accidentals

Finally, let's add the accidentals:

```
<beam>
  <chord>
    <note pname="e" oct="4" dur="8" dots="1" accid="f"/>
    <notepname="g" oct="4" dur="8" dots="1"/>
  </chord>
  <chord>
    <note pname="d" oct="4" dur="16"/>
    <note pname="f" oct="4" dur="16" accid="n"/>
  </chord>
</beam>
<beam>
  <chord>
    <note pname="c" oct="4" dur="8" dots="1"/>
    <note pname="e" oct="4" dur="8" dots="1" accid="n"/>
  </chord>
...
Additional Notation Encoding Practice

For the next example, we'll use the opening section of the famous chorale "Ein' feste Burg ist unser Gott", composed by Johann Sebastian Bach.

1. Score definition

Start your encoding with the creation of a score definition (<scoreDef>). As you've learned in the previous exercise, you need to encode a <scoreDef> element with its sub-elements and appropriate attributes within the <score> element. You might also want to indicate that the two staves are grouped by a brace. To do this, add a staff group (<staffGrp> element) as a child element to your score definition (<scoreDef>) and use the @symbol attribute with the value "brace" to encode this information. You can now insert two separate staff definitions (<staffDef> elements) into the staff group (<staffGrp>). Each <staffDef> should include specific staff information such as information on the shape (@clef.shape) and location (@clef.line) of its clef.

```xml
<scoreDef meter.count="4" meter.unit="4" meter.sym="common" key.sig="2s">
  <staffGrp symbol="brace">
    <staffDef n="1" lines="5" clef.shape="G" clef.line="2"/>
    <staffDef n="2" lines="5" clef.shape="F" clef.line="4"/>
  </staffGrp>
</scoreDef>
```

2. Staff and layer

After encoding the score definition (<scoreDef>), you can start to encode the first staff. Please ignore the upbeat for a moment (we will encode it a few steps later), and concentrate on just the first measure. As you can see in the image below, the first staff contains two individual streams of musical events, requiring the encoding of two layers here. Start the encoding of the first measure by putting two <layer> elements within the <staff> element. As it is the first staff of the chorale, remember to encode the number using the @n attribute. While the <layer> element is used to encode multiple "voices" within a single staff this element is always required to complete the structure, even if there is only one voice to encode.

...<measure n="1">
  <staff n="1"> <!-- Treble clef stave -->
    <layer n="1"> <!-- Soprano voice -->
       </layer>
    <layer n="2"> <!-- Alto voice -->
      </layer>
  </staff>
  <staff n="2"> <!-- Bass clef stave -->
    <layer n="1"> <!-- Tenor voice -->
      </layer>
    <layer n="2"> <!-- Bass voice -->
      </layer>
  </staff>
</measure>...

3. Notes

Next, add each of the notes with their respective durations, pitch names and octaves. Since you are encoding multiple voices on a single stave, you may wish to use the @stem.dir attribute of the <note> element to ensure that the voices can be differentiated.

...<measure n="1">
  <staff n="1">
    ...
  </staff>
</measure>
4. Individual lyric syllables and lyric verses

Using the `<syl>` element for the encoding of individual lyric syllables can be useful if, for instance, you want to provide additional details for the lyric syllables. The `<syl>` element has to be encoded as a child element of the `<note>` element.

If there are several lyric verses to encode, MEI also provides a `<verse>` element, which must also be encoded as a child element of the `<note>` element. It should be wrapped around the `<syl>` element. You can number the verses, if you like, using the @n attribute on `<verse>`.

The first section of the chorale has two verses, so you'll want to add `<verse>` and `<syl>` child elements to the relevant `<note>` elements.

The word "feste" contains a dash that acts as a syllable separator and "Burg" has a syllable extension. To encode these, you could add the appropriate @con attribute onto the `<syl>` element, choosing from the following list: s (space) = word separator, d (dash) = syllable separator, u (underscore) = syllable extension, t (tilde) = syllable
elision. You can also define whether a syllable marks the beginning, middle or end of a word by using the @wordpos attribute. Approved values include "i" (initial), "m" (medial) or "t" (terminal).

...<measure n="1">
  <staff n="1">
    <layer n="1">
      <note pname="d" oct="5" dur="4" stem.dir="up"/>
      <note pname="d" oct="5" dur="4" stem.dir="up"/>
      <beam>
        <note pname="a" oct="4" dur="8" stem.dir="up"/>
        <note pname="b" oct="4" dur="8" stem.dir="up"/>
      </beam>
      <note pname="c" oct="5" dur="4" stem.dir="up"/>
    </layer>
    <layer n="2">
      <note pname="d" oct="4" dur="4" stem.dir="down"/>
      <verse n="1">
        <syl con="d" wordpos="i">fe</syl>
      </verse>
      <verse n="2">
        <syl wordpos="i">hift</syl>
      </verse>
    </layer>
  </staff>
  <beam>
    <note pname="d" oct="4" dur="16" stem.dir="down"/>
    <verse n="1">
      <syl con="u" wordpos="t">ste</syl>
    </verse>
    <verse n="2">
      <syl wordpos="i">uns</syl>
    </verse>
  </note>
</measure>
5. Upbeat

We now need to encode an upbeat by adding the @metcon attribute to the <measure> element. This attribute indicates the relationship between the content of a staff or layer and the prevailing meter. A value of "true" for the @metcon attribute indicates conformance with the prevailing meter (i.e. a complete measure) while "false" means the opposite, an incomplete measure. Please encode the complete upbeat, using the appropriate @metcon attribute.

...
6. Fermatas
Now we're ready to deal with the fermatas by adding the @fermata attribute to the relevant <note> elements. Values for specifying its location include: "above", "below" or "within" the staff. Choose the appropriate value from the list to encode each fermata.

7. Slurs
The most common approach for encoding slurs is to use a combination of the @tstamp (timestamp) attribute and the @tstamp2 attribute. Note that slurs are encoded at the end of a measure, following notes, chords, and rests. The @tstamp attribute is used to encode the onset time in terms of musical time, i.e. beats. Since our chorale is in four-four time, the main timestamps of the measure are tstamp="1", tstamp="2", tstamp="3" and tstamp="4". As an example, we'll look at the slur in the second layer of the first staff, which begins on tstamp="1" and it ends on tstamp="2.5". The duration of a feature is encoded as a timestamp giving its endpoint, using the @tstamp2 attribute. In our example, you would enter a @tstamp2 attribute with the value "0m+2.5" (m stands for measure). You may choose to indicate the curve direction of the slurs ("above" or "below") and you can also specify the staff and the layer where they occur.
8. Repetition

Finally, you can encode the repetition on the last measure, using the @right attribute with the appropriate value from the following list: "dashed", "dotted", "dbl", "rptstart", "rptboth", "rptend". Please add a @right attribute to the <measure> element of measure 4 and insert the value "rptend".

... 
<measure n="4" right="rptend"> ...
More Advanced Notation Encoding

Now we can move ahead with some more advanced features of MEI, such as various types of articulation, ornamentation, cross-staff beaming and dynamics. You will also learn about the encoding of tuplets and XML identifiers.

Let's start by encoding the tuplets at the beginning of Schubert's "Erlköning":

![Image of Schubert's "Erlköning" sheet music]

1. Tuplets

There's a flurry of details to encode here! To simplify matters, we'll take it one step at a time. First, let's concentrate on the tuplets.

You'll have to decide whether you want to encode the tuplet as an element or as an attribute. In this encoding, we've chosen to use the `<tuplet>` element, which is wrapped around the notes of the tuplet. MEI offers several attributes for describing the details of the tuplet, among them: `@bracket.visible`, `@num`, `@num.visible` and `@num.place`. For a list of other possible attributes, take a look at chapter 4.2.4 of the Guidelines.

Since the dyads in the right-hand of the piano are chords, be sure to wrap each simultaneous pair in a `<chord>` element.

```xml
<measure n="1">
  <layer n="1">
```

...
<tuplet bracket.visible="false" num="3" num.visible="true" num.place="above">
  <beam>
    <chord stem.dir="up" dur="8">
      <note n="1" pname="g" oct="4"/>
      <note n="2" pname="g" oct="3"/>
    </chord>
    <chord stem.dir="up" dur="8">
      <note n="1" pname="g" oct="4"/>
      <note n="2" pname="g" oct="3"/>
    </chord>
    <chord stem.dir="up" dur="8">
      <note n="1" pname="g" oct="4"/>
      <note n="2" pname="g" oct="3"/>
    </chord>
  </beam>
</tuplet>

Note that this is only one of several possible solutions.

2. Using @copyof

As you’ve probably noticed, an encoding can be quite verbose when there’s a lot of repetition of content. When encoding the XML directly using a QWERTY keyboard, this verbosity can lead to encoding errors. It would be helpful to be able to encode something correctly once and simply copy the encoded feature wherever it’s needed. This can be accomplished through the use of the @copyof attribute.

Using the @copyof attribute, however, requires the use of another attribute, @xml:id. Placing this attribute on an element gives it a name by which it can be referred to later. Each @xml:id attribute must have a value that is unique within the current document. This allows you to unambiguously refer to the element bearing this value elsewhere in your document. The value of an @xml:id attribute must also be an XML name. An XML name must follow some basic rules:

● contain letters, numbers, and other characters, except spaces and colons
● cannot start with a number or punctuation character
- cannot start with the letters "xml" (or XML, or Xml, etc.)

In the current example, copying the tuplet will shorten your file and reduce the need for duplicate, and error-prone, encoding. First, you need to give the first tuplet an @xml:id attribute. Any tuplets that are exact copies of the first one can then be represented by an empty <tuplet> element whose @copyof attribute contains the name you gave to the first tuplet. Don't confuse the @copyof attribute with the @sameas attribute. For more information on relationships between elements, please have a look at chapter 7.1 of the Guidelines.

```xml
<measure n="1">
  <staff n="2">
    <layer n="1" xml:id="g-triplets">
      <tuplet bracket.visible="false" num="3"
        num.visible="true" num.place="above" xml:id="triplet1">
        <beam>
          <chord stem.dir="up" dur="8">
            <note n="1" pname="g" oct="4"/>
            <note n="2" pname="g" oct="3"/>
          </chord>
          <chord stem.dir="up" dur="8">
            <note n="1" pname="g" oct="4"/>
            <note n="2" pname="g" oct="3"/>
          </chord>
          <chord stem.dir="up" dur="8">
            <note n="1" pname="g" oct="4"/>
            <note n="2" pname="g" oct="3"/>
          </chord>
        </beam>
      </tuplet>
      <tuplet copyof="#triplet1"/>
      <tuplet copyof="#triplet1"/>
      <tuplet copyof="#triplet1"/>
    </layer>
  </staff>
</measure>
...
3. Instrument/Voice labels

Let’s return to the beginning of the song and go on to the next feature. You’ve already learned to encode score definitions (<scoreDef> ) and staff definitions (<staffDef>). Now we’ll talk about encoding the names of instruments and voices. You can use the attribute @label to encode information about instrumentation that appears at the beginning of the song. @label may occur as an attribute of the element <staffDef>. It can also appear on <staffGrp>, when an instrument, like the piano, is written on multiple staves.

```xml
...<score>
  <section>
    <scoreDef meter.unit="4" meter.sym="common">
      <staffGrp>
        <staffDef n="1" label="Singstimme." clef.shape="G" clef.line="2" key.sig="2f"/>
        <staffGrp label="Piano Forte." symbol="brace">
          <staffDef n="2" clef.shape="G" clef.line="2"
            key.sig="2f"/>
          <staffDef n="3" clef.shape="F" clef.line="4"
            key.sig="2f"/>
        </staffGrp>
      </staffGrp>
    </scoreDef>
  </section>
...</score>
```

4. Tempo instructions

You can encode the tempo instructions using the <tempo> element. <tempo> elements should be placed inside the <measure>, following the encoding of the staff content. Details of the placement of the tempo marking may be captured using @tstamp, @staff and @place attributes. The quarter note symbol that occurs within the tempo marking can be represented by the Unicode character reference ♩ (U+2669, see https://www.fileformat.info/info/unicode/char/2669/index.htm for more information).

```xml
...<layer>
You will also note that we encoded the line break in the tempo marking by using the `<lb>` element, which is the same in MEI as in TEI.

5. Dynamics

In the next step, you will learn how to encode some dynamic symbols, such as the one at the beginning of "Erlkönig". Dynamics are encoded using the `<dynam>` element. Like the `<tempo>` element, `<dynam>` should be placed within the measure, following the `<staff>` elements. Since each one makes reference to its related staff, the order in which the `<dynam>` and `<tempo>` elements occur is not important.

6. Note/Chord repetition

Congratulations! You’ve encoded the first measure of the "Erlkönig." Are you ready for the second measure?

In the next measure of the "Erlkönig", the tuplets in the right hand of the piano are replaced by shorthand notation that indicates repetition of a chord, called "bowed tremolo" in MEI.

MEI provides the `<bTrem>` element for this kind of repetition. Check chapter 4.2.5.3 of the Guidelines for information about its use.
Exploring the MEI Header - Part 1

The following sections on the MEI header aim to create metadata for an electronic transcription of Robert Schumann's song "Der Abendstern". If you were cataloging this work for a library database, you would capture the relevant bibliographic information for the work as metadata stored within the appropriate fields in the library database. Compiling metadata using MEI is not essentially different from that procedure. The MEI header also provides various places (called "fields" when working in a database, but "elements" in XML) where you can insert bibliographic information.

Working with the MEI header, you will learn that elements with the same name can be used in many different places, but that their precise meaning can change, depending on the context in which they are used. A <title> of a <work> is different than a <title> of a file. Therefore, you must always be aware of the current context when working on the header.

1. New MEI File

We'll explore the MEI header step by step, starting with the description of the electronic file itself. You learned how to create a new MEI document within the tutorial Creating a new MEI document. Take the file you created there or start a new one (ignoring the <music> part for the moment). The file should be completely empty but valid.
2. File Description
The first section of the header is the `<fileDesc>` element. As its name implies, this element contains a description of the file you're creating, not to be confused with the musical work that is the content of the file.

Obviously, it would be good to give the file a title and to indicate who is responsible for creating it. In addition, information about the ownership, publication, and distribution of the file would be helpful. In fact, these basic descriptive components are required by MEI. Looking at the structure of the empty MEI file just created, you'll notice a couple of mandatory elements. The `<meiHead>` element always requires a `<titleStmt>` (title statement) and a `<pubStmt>` (publication statement).

```
<meiHead>
  <fileDesc>
    <titleStmt>
      <title>Der Abendstern</title>
    </titleStmt>
    <pubStmt/>
  </fileDesc>
</meiHead>
```

3. File Title
Let's have a detailed look at the `<titleStmt>` element of your new MEI header. It contains a `<title>` element, which should be filled out with the title given to the
electronic work by its creator. Most often, this is the same title as the source of the encoding. So start the encoding of your MEI header by choosing an appropriate title.

When creating an electronic transcription of an existing source, it is highly recommended that the title be derived from the source while at the same time being clearly distinguishable from it. You might add a simple phrase, such as “an electronic transcription” or “a digital edition”, to distinguish the electronic work from the source in citations and in catalogs containing descriptions of both types of material.

For further information about the file description, please refer to the MEI Guidelines.

Now, add the distinguishing phrase of your choice to the title in the file description.

```xml
<meiHead>
  <fileDesc>
    <titleStmt>
      <title>Der Abendstern: an electronic transcription.</title>
    </titleStmt>
    <pubStmt/>
  </fileDesc>
</meiHead>
```

4. Responsibility Statement
The responsibility statement element `<respStmt>` is included within the title statement. This is the element within your file description where you'll encode one or more persons responsible for the creation of the electronic work (for example the encoder, editor, author or compiler) as well as persons who have been responsible for the creation of the existing source text, the composer(s).
The `<respStmt>` is optional. If used, it may contain a `<resp>` element (holding a phrase describing the nature of a person's intellectual responsibility). It may also have `<name>`, `<corpName>`, and `<persName>` elements indicating the responsible person or group.

Please add a `<respStmt>` element to your MEI header. Include information about the composer of the original work (Robert Schumann) and indicate who is responsible for the machine-readable transcription. (This should be you, as you are creating this file at the moment).

```
<meiHead>
  <fileDesc>
    <titleStmt>
      <title>Der Abendstern: an electronic transcription</title>
      <respStmt>
        <resp>Composed by:</resp>
        <persName>Robert Schumann</persName>
        <resp>Machine-readable transcription by:</resp>
        <persName>John Doe</persName>
      </respStmt>
    </titleStmt>
  </fileDesc>
</meiHead>
```

5. Attributes @role and @auth.uri

Because the order of elements in the MEI header is not predetermined, it can be somewhat complicated to programmatically extract the correct combinations of `<resp>` and `<persName>` elements. To avoid this problem, we recommend that you use the `@role` attribute on `<persName>` to specify a person's responsibility. The controlled vocabulary from the [MARC code list for relators](https://id.loc.gov/vocabulary/relators) is a good source for
values for this attribute. Using a controlled vocabulary makes your files easier to understand and thus facilitates data interchange.

It’s also highly recommended that you standardize the form of names in the various responsibility statements. For example, you could take the normalized form of a person’s name from an authority file. The @auth.uri attribute can be used to indicate the URI of the authority file you’ve consulted.

```xml
<meiHead>
    <fileDesc>
        <titleStmt>
            <title>Der Abendstern: an electronic transcription</title>
            <respStmt>
                <resp>Composed by:</resp>
                <persName role="composer" auth.uri="http://d-nb.info/gnd">Robert Schumann</persName>
                <resp>Machine-readable transcription by:</resp>
                <persName role="encoder">John Doe</persName>
            </respStmt>
        </titleStmt>
    </fileDesc>
</meiHead>
```

6. Publication Statement

Let’s go on to the second mandatory element of the file description: the publication statement.

The `<pubStmt>` element is a container for information regarding the publication or distribution of a bibliographic item. It includes the publisher’s name and address, the date of publication, and other relevant details. It may also contain a single `<unpub>` element, if the file has yet to be published.

As your file has not been published yet, please add the `<unpub>` child element to your file description. You might also add a short phrase indicating the nature of or the reason for the unpublished status as the element’s content, but this is optional.
7. Revision Description

For the last step in this tutorial let’s have a short look at another section of the MEI header: the revision description, which is represented by the `<revisionDesc>` element. The revision description is always encoded at the end of the MEI header. It may contain only `<change>` child elements.

Although it is not mandatory, it is a good practice to provide a `<revisionDesc>`. Its purpose is to record modifications to the file. Each modification is described in a separate `<change>` element, which may hold information about the modification date, affected content and responsibility. Major revisions of the header itself should also be documented in the `<revisionDesc>`.

What you could do right now is to create the beginning of a list of `<change>` elements. So fill in the `<revisionDesc>` element, along with the sub-element `<change>` and its sub-elements `<respStmt>`, `<changeDesc>` and `<date>`. Add an `@n` attribute to the `<change>` element and give it a value of "1", since this is the first change made to the MEI file. Please also enter the name of the person responsible
for the change (this would be you again), the date of change in ISO format (YYYY-MM-DD) and a description of the changes you made.

<meiHead>
  <fileDesc>
    <titleStmt>
      <title>Der Abendstern: an electronic transcription</title>
    </titleStmt>
    <respStmt>
      <resp>Composed by:</resp>
      <persName role="composer" auth.uri="http://d-nb.info/gnd">Robert Schumann</persName>
    </respStmt>
    <resp>Machine-readable transcription by:</resp>
    <persName role="encoder">John Doe</persName>
  </respStmt>
  <unpub>Incomplete!</unpub>
</fileStmt>
</fileDesc>
<revisionDesc>
  <change n="1">
    <respStmt>
      <persName>[Name of the person responsible for the change]</persName>
    </respStmt>
    <changeDesc>
      <p>[Description of the change made]</p>
    </changeDesc>
    <date isodate="YYYY-MM-DD"/>
  </change>
</revisionDesc>
</meiHead>
Exploring the MEI Header - Part 2

Now that we've covered how to encode a minimal header, we'll proceed to encoding some additional details for Robert Schumann's song “Der Abendstern”. We'll use the following sources:

- the reprint of the first Leipzig edition 1849, published by Breitkopf & Härtel:
  ![Reprint Image]

- and the entry describing this manifestation in the catalog of the German National Library:
Furthermore, you will learn how to indicate the relationship between this song and the song cycle of which it is a part.

Please use the file from Part 1 as the basis of your further encodings.

1. Source Description (sourceDesc)

The file description is the place to encode the sources used to create the electronic file, so insert a `<sourceDesc>` element into your file description. As the reprint of the first print by Breitkopf & Härtel (Leipzig 1849) is used as the exemplar in this case, you should encode its metadata there.

```
<meiHead>
  <fileDesc>
    <titlestmt>
      <title>Der Abendstern: an electronic transcription</title>
      <respstmt>
        <resp>Composed by:</resp>
      </respstmt>
    </titlestmt>
  </fileDesc>
```

Furthermore, you will learn how to indicate the relationship between this song and the song cycle of which it is a part.

Please use the file from Part 1 as the basis of your further encodings.

1. Source Description (sourceDesc)

The file description is the place to encode the sources used to create the electronic file, so insert a `<sourceDesc>` element into your file description. As the reprint of the first print by Breitkopf & Härtel (Leipzig 1849) is used as the exemplar in this case, you should encode its metadata there.

```
<meiHead>
  <fileDesc>
    <titlestmt>
      <title>Der Abendstern: an electronic transcription</title>
      <respstmt>
        <resp>Composed by:</resp>
      </respstmt>
    </titlestmt>
  </fileDesc>
```
2. Work description (workDesc)

As a next step, fill in the element for the work description. The work description is represented by the <workDesc> element. It follows the file description.

<meiHead>
  <fileDesc>
    ...
    <workDesc>
      <work/>
    </workDesc>
    ...
  </fileDesc>
</meiHead>

3. Title statements of the source description and the work description

In Part 1 you learned that the file description includes a title statement that contains the title and the persons responsible for the electronic file you’re creating. The <titleStmt> element is one of the elements that can occur in different places within a single MEI file. The source description and the work description have their own title statements. So you need to decide where to encode each one.

<meiHead>
4. Uniform titles

If you’d like to encode any uniform titles for the “Liederalbum” and the song “Der Abendstern”, you may add another <title> element and a @type attribute with the value of “uniform”.

```
<fileDesc>
  ...
  <sourceDesc>
    <source>
      <titleStmt>
        <title>Lieder-Album für die Jugend für Singstimme(n) und Klavier ; op. 79</title>
      </titleStmt>
    </source>
  </sourceDesc>
  <workDesc>
    <work>
      <titleStmt>
        <title>Der Abendstern</title>
      </titleStmt>
    </work>
  </workDesc>
  ...
</meiHead>

<fileDesc>
  ...
  <sourceDesc>
    <source>
      <titleStmt>
        <title>Lieder-Album für die Jugend für Singstimme(n) und Klavier ; op. 79</title>
        <title type="uniform">Lieder für die Jugend</title>
      </titleStmt>
    </source>
  </sourceDesc>
```
5. Persons responsible in sourceDesc and workDesc

Now encode the persons responsible for the source(s) used for the electronic transcription by adding a responsibility statement (<respStmt>) to the <titleStmt> within the <sourceDesc> element. Please include role information for everyone involved in the creation of the work.

Do the same for the work description (<workDesc>), adding the persons responsible for the song “Der Abendstern”, the first song of the song cycle.

<meiHead>
<fileDesc>
...<sourceDesc>
<source>
<titleStmt>
<title>Lieder-Album für die Jugend für Singstimme(n) und Klavier ; op. 79<title>
<title type="uniform">Lieder für die Jugend</title>
<respStmt>
<persName role="composer">Robert Schumann</persName>
<resp>Herausgegeben von:</resp>
<persName role="editor">Ulrich Mahler</persName>
</respStmt>
</source>
</sourceDesc>
</fileDesc>
</meiHead>
Der Abendstern
Lieder für die Jugend
Robert Schumann
August Heinrich Hoffmann von Fallersleben

6. @dbkey, @authority, @authURI, @role
We hope you're following the recommendations to use standardized forms of any names for the responsible parties. If so, add information about any authority file or controlled vocabulary which you've consulted or which provides further information.

Lieder-Album für die Jugend für Singstimme(n) und Klavier; op. 79
Lieder für die Jugend
7. Information on publication of the source

The next exercise deals with the edition statement (<editionStmt>) and the publication statement (<pubStmt>) of the source description (<sourceDesc>). This exercise encodes information about the publication of the reprint that can be found in the catalog entry illustrated above.

1. Enter an edition statement (<editionStmt>) after the <titleStmt> element.
2. Enter a publication statement (<pubStmt>) after the <editionStmt> element.

```xml
<meiHead>
  <fileDesc>
    ...
    <sourceDesc>
      <source>
        <titleStmt>
          ...
        </titleStmt>
        <editionStmt>
          <edition></edition>
        </editionStmt>
        <pubStmt></pubStmt>
      </source>
    </sourceDesc>
  </fileDesc>
  ...
</meiHead>
```

8. Contents of the edition statement of the source description

The edition statement (<editionStmt>) is a container for metadata pertaining to a particular edition of the material being described. Use the <edition> child element for capturing information about the reprint of the first 1849 printing from Leipzig. The <edition> element contains a word or text phrase that indicates a difference in either content or form between the item being described and a related item previously issued by the same publisher.

The title page of the reprint reads:

*Reprint der Erstausgabe Leipzig 1849*
*Reprint of the First Printing Leipzig 1849*

```xml
<meiHead>
  <fileDesc>
    ...
    <sourceDesc>
      <source>
```

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9. Contents of the publication statement of the source description

The title pages also display other information regarding the publication of the reprint. Have a look at the scans below:
ROBERT SCHUMANN
(1810–1856)

Lieder-Album für die Jugend
für Singstimme(n) und Klavier
for Voice(s) and Piano
op. 79

Reprint der Erstauflage Leipzig 1849
Reprint of the First Printing Leipzig 1849

herausgegeben von / edited by
Ulrich Mahler

BREITKOPF & HÄRTEL · WIESBADEN
Edition Breitkopf 8357
Hildesheim · Germany

Der Umschlag des Albums stammt von einem Exemplar des Lieder-Albums
aus der Sammlung Habsburg (Österreichische Nationalbibliothek, Wien).

© 1998 by Breitkopf & Härtel, Wiesbaden
Druck: PIRX, Nimenscheid, Minden
To encode information about publisher, the printer, the publisher’s address, the order number and the copyright notice, you can use several special child elements within the publication statement (<pubStmt>) of the source description:

1. Please add a <respStmt> element to the <pubStmt> element.
2. Now add a <corpName> element to the <respStmt> and enter the name of the publisher of the reprint.
3. The sample reads: “Druck: PIROL Notendruckerei, Minden”. Add a <resp> element and a second <corpName> element to the <respStmt> to encode this information on the printer.
4. You can also encode the address of the publisher, which is given on the title page of the reprint. You may use the <address> element, which requires one or more <addrLine> child elements to specify the place of publication.
5. For encoding the order number of the reprint, please add an <identifier> element to the publication statement. The @type attribute can be used to specify which kind of identifier you’re capturing.

There is also a copyright notice within the reprint. For encoding this, please add an <availability> element as well as an <useRestrict> child element to the publication statement of the source description.

```
<meiHead>
  <fileDesc>
    ...
    <sourceDesc>
      <source>
        <titleStmt>
          ...
        </titleStmt>
        <editionStmt>
          ...
        </editionStmt>
      </source>
      <pubStmt>
        <respStmt>
          <corpName auth.uri="http://d-nb.info/gnd/330001418">Breitkopf und Härtel</corpName>
          <resp>Druck: </resp>
          <corpName>PIROL Notendruckerei, Minden</corpName>
        </respStmt>
      </pubStmt>
    ...
  </sourceDesc>
</fileDesc>
```
10. Series statement of the source description

As shown on the title page, the "Lieder-Album für die Jugend" is published within the series "Breitkopf Archiv", which is edited by Joachim Draheim.

You can capture this information in the series statement by adding a `<seriesStmt>` after the publication statement (<pubStmt>) of the source description.

```xml
<seriesStmt>
  <title>Breitkopf-Archiv</title>
  <respStmt>
    <resp>Herausgegeben von:</resp>
    <persName role="editor" auth.uri="http://d-nb.info/gnd">Joachim Draheim</persName>
  </respStmt>
</seriesStmt>
```
11. Physical description of the source description

The catalog entry of the German National Library gives some information on physical descriptions of the reprint:

Create a physical description \(<physDesc>\) element within the source description and enter the child elements \(<dimensions>\), which encodes information about the physical size of a bibliographic source, and \(<extent>\), which is used to express size in terms other than physical dimensions, such as number of pages etc.

To encode the plate number of the reprint, found at the foot of page 3 of the source, enter a \(<plateNum>\) child element to the physical description.
12. Classification of the source description

Also within the source description, the `<classification>` element can be used to classify a musical text according to one or more of the following methods:

1. by reference to a recognized international classification scheme such as the DDC, the Universal Decimal Classification, the Library of Congress Classification, or any other system widely used in library and documentation work;
2. by providing a set of keywords, as provided, for example, by British Library or Library of Congress Cataloguing in Publication data.

The following elements are provided for this purpose: `<termList>` and `<classCode>`.

The `<termList>` element categorizes an individual text by supplying a set of terms that may describe its topic or subject matter, its physical or intellectual form, date, etc. Each term is represented by a `<term>` element. In some schemes, the order of items in the list is significant, for example, from major topic to minor; in others, the
list has an organized substructure of its own. Wherever possible, such terms should be taken from a recognized source.

Try to classify the song cycle and enter the data in the `<classification>` element.

```xml
<meiHead>
  <fileDesc>
    ...
    <sourceDesc>
      <source>
        ...
        <seriesStmt>
          ...
          </seriesStmt>
        <classification>
          <termList>
            <term classcode="#DNB_Sachgruppen">02a Werke für Einzelstimmen</term>
          </termList>
        </classification>
      </source>
    </sourceDesc>
  </fileDesc>
    ...
</meiHead>
```

Well done! Within this tutorial you learned to encode all required metadata for identifying the source of your electronic transcription. You also learned how to incorporate a work description in you header.

**Exploring the MEI Header - Part 3**

Although you created quite an extensive header in Part 2, we can step on and enhance your encoding a little bit more. Level 3 will deal with more special features of the MEI header. You will learn how to transcribe a title page and the table of contents of a source, how to encode non-bibliographic aspects of a text within the work description, how to link a facsimile or information on the performance of a work.
Please take the file you created in parts 1 and 2 as a basis for your further encodings.

1. Contents of a source

It is often useful to give information about works contained in a source. The reprint of the “Liederalbum” contains 29 songs. Each of these songs could be encoded with a separate <work> element within the work description.

![Table of Contents](image)
As a first exercise, please search an appropriate element within the source description where you could encode such information. Explore the given child elements and try to encode all the information on the page with the table of contents and including the headline.

```
<meiHead>
  <fileDesc>
    ...
  </fileDesc>
  <sourceDesc>
    <source>
      ...
    </source>
    <classification>
      ...
    </classification>
    <contents>
      <head>INHALT.</head>
      <label>Kinderlieder von Hoffmann von Fallersleben.</label>
      <contentItem n="1">1. Der Abendstern.</contentItem>
      <contentItem n="2">2. Schmetterling.</contentItem>
      <contentItem n="3">3. Frühlingsbotschaft.</contentItem>
      <contentItem n="4">4. Frühlingsgruss.</contentItem>
      <contentItem n="5">5. Vom Schlaraffenland.</contentItem>
      <contentItem n="6">6. Sonntag.</contentItem>
      <contentItem n="7">Zwei Zigeunerliedchen, aus dem Spanischen von E. Geibel.</contentItem>
      <contentItem n="8">Des Knaben Berglied, v. L. Uhland.</contentItem>
      <contentItem n="9">Mailied.</contentItem>
      <contentItem n="10">Käuzlein, aus des Knaben Wunderhorn.</contentItem>
      <contentItem n="11">Hinaus in's Freie, von Hoffmann von Fallersleben.</contentItem>
      <contentItem n="12">Der Sandmann, von H. Kletke.</contentItem>
      <contentItem n="13">Marienwürmchen, aus des Knaben Wunderhorn.</contentItem>
    </contents>
  </sourceDesc>
</meiHead>
```
2. titlePage element of the source description

Within the source description you can encode further details on the source of your electronic transcription. In addition to information on the provenance of a certain source, you could also add special information like inscriptions or a hand list to the physical description. You can also encode detailed information on the title page within the physical description. In the case of the reprint you could encode information on even two title pages, the title page of the reprint and the included original title page of the first print.

Please add a <titlePage> element to the physical description of the source, explore the allowed child elements and encode the information given in the scans above.
Breitkopf Archiv Frühdrucke und bibliophile Ausgaben von hohem Quellenwert

Early printings and bibliophiles' editions of a high documentary value

breitkopf & härtel, wiesbaden

edition breitkopf 8307

printed in germany

reprint der erstausgabe leipzig 1849

reprint of the first printing leipzig 1849

for voice(s) and piano

op. 79

for die jugend

nach den ursprünglichen ausgaben von 1849

by joachim draheim

by ulrich mahlert

by robert schumann (1810–1856)

by robert schumann

by c. hahn lith.
3. Encoding of key, tempo and meter elements within the work description

Now let's have a detailed look at the work description. In the work description, multiple `<work>` elements could be encoded. At the moment we just need one and you already encoded the title of it in the previous tutorial. This `<work>` element contains non-bibliographic information on the song “Der Abendstern”.

Information about key, tempo and meter could be encoded here. Using the `<key>` element you can describe the key, the `<tempo>` element is used to encode information about the tempo indication, and the `<meter>` element captures information on the time signature.

Add the three elements to the work description of your MEI file and fill them.

```
<meiHead>
  <fileDesc>
    ...
  </fileDesc>
  <workDesc>
    <work>
      <titleStmt>
        ...
      </titleStmt>
      <key pname="a" mode="major">A major</key>
      <tempo>Langsam.</tempo>
      <meter count="2" unit="4"/>
    </work>
  </workDesc>
  ...
</meiHead>
```
4. Performance medium of the work description

The next element you should pay attention to is `<perfMedium>`. The performance medium indicates the number and character of the performing forces used in a musical composition.

Please add a `<perfMedium>` element to the work description and encode the instrumental parts of the song "Der Abendstern".

```
<meiHead>
  <fileDesc>
    ...
  </fileDesc>
  <workDesc>
    <work>
      <titleStmt>
        ...
      </titleStmt>
      <key pname="a" mode="major">A major</key>
      <tempo>Langsam.</tempo>
      <meter count="2" unit="4"/>
      <perfMedium>
        <instrumentation>
          <instrVoice>Singstimme.</instrVoice>
          <instrVoice>Pianoforte.</instrVoice>
        </instrumentation>
      </perfMedium>
    </work>
  </workDesc>
  ...
</meiHead>
```
5. Encoding of incipit information - 1

Within a single <work> element you can encode information on the incipit of a musical composition. The beginning of a piece of music is often used for identification purposes, especially when the piece has only a generic title, such as „Sonata no. 3”. They appear in catalogs of music and in tables of contents of printed music that include multiple works. The following elements are provided for the inclusion of incipits: <incip>, <incipCode>, <incipText>, <score> and <graphic>. The elements <incipCode> and <incipText> are available for the inclusion of coded incipits and textual incipits, respectively. The <incipText> element should contain only the initial performed text of the work, while <incipCode> may contain both words and music, depending on the capabilities of the scheme used to encode it. When both music and text are provided in <incipCode>, it may be helpful to repeat the text in <incipText> in order to provide easier access to only the text, for example, for indexing of the text without having to extract it from the coded incipit.

Both <incipCode> and <incipText> allow reference to an external file location via the target attribute and specification of the internet media type of external file via the mimetype attribute.

Begin with the incipit text. Enter an <incip> element to your work description and encode the opening words of the song.

```xml
<meiHead>
  <fileDesc>
    ...
  </fileDesc>
  <workDesc>
    <work>
      <titleStmt>
        ...
      </titleStmt>
      <key name="a" mode="major">A major</key>
      <tempo>Langsam.</tempo>
      <meter count="2" unit="4"/>
    </work>
    <incip>
      <incipText>
```
6. Encoding of incipit information - II

Now encode the complete incipit of the song "Der Abendstern". Use the `<score>` element as a starting point. The encoding doesn’t differ from music being encoded within the `<music>` element. If you don’t know how to encode music yet, please have a look at the tutorials on the music first.
<incip>
  <incipText>
  <p>Du liebler Stern</p>
  </incipText>
</incip>
<score>
  <scoreDef>
    <staffGrp label="Singstimme" lines="5" meter.count="2" meter.unit="4" clef.shape="G" clef.line="2" key.sig="3s"/>
    <staffGrp label="Pianoforte" symbol="brace">
<staffDef n="2" lines="5" meter.count="2" meter.unit="4" clef.shape="G" clef.line="2" key.sig="3s"/>
<staffDef n="3" lines="5" meter.count="2" meter.unit="4" clef.shape="F" clef.line="4" key.sig="3s"/>
</staffGrp>
</scoreDef>
<section>
<measure n="0" metcon="false">
 <staff n="1">
  <layer>
   <note pname="a" oct="4" dur="8">
    <verse n="1">
     <syl>V.1. Du</syl>
    </verse>
    <verse n="2">
     <syl>V.2. Wie</syl>
    </verse>
    <verse n="3">
     <syl>V.3. So</syl>
    </verse>
    <verse n="4">
     <syl>V.4. Wie</syl>
    </verse>
   </note>
  </layer>
 </staff>
 <staff n="2">
  <layer>
   <note pname="a" oct="4" dur="8">
   </note>
  </layer>
 </staff>
 <staff n="3">
  <layer>
   <note pname="a" oct="3" dur="8">
   </note>
  </layer>
 </staff>
</measure>
<slur tstamp="0.5" curvedir="below" dur="1m+2.5" staff="2"/>
<dynam place="below" tstamp="0.5" staff="1">p</dynam>
<dir place="above" staff="1" layer="1"
tstamp="0">Langsam.</dir>
<dynam place="below" tstamp="0.5"
staff="2">p</dynam>
<measure>
<measure n="1">
<staff n="1">
<layer>
<note pname="c" oct="5" dur="4">
<verse n="1">
<syl con="d">lieb</syl>
</verse>
<verse n="2">
<syl>lieb '</syl>
</verse>
<verse n="3">
<syl>blick '</syl>
</verse>
<verse n="4">
<syl>nickst</syl>
</verse>
</note>
<note pname="a" oct="4" dur="8">
<verse n="1">
<syl>cher</syl>
</verse>
<verse n="2">
<syl>doch</syl>
</verse>
<verse n="3">
<syl>nach</syl>
</verse>
<verse n="4">
<syl>mir</syl>
</verse>
</note>
</layer>
</staff>
<staff n="2">
<layer>
<chord dur="4"/>
<note pname="c" oct="4"/>
<note pname="e" oct="4"/>
<notepname="a" oct="4"/>
<note pname="c" oct="5"/>
</chord>
<beam>
<chord dur="8">
  <note pname="d" oct="4"/>
  <note pname="e" oct="4"/>
  <note pname="g" oct="4"/>
  <note pname="b" oct="4"/>
</chord>
<chord dur="8">
  <note pname="e" oct="4"/>
  <note pname="a" oct="4"/>
</chord>
</beam>
</layer>
</staff>
<staff n="3">
<layer>
<chord dur="4">
  <note pname="a" oct="2"/>
  <note pname="e" oct="3"/>
  <note pname="a" oct="3"/>
</chord>
<beam>
<chord dur="8">
  <note pname="b" oct="2"/>
  <note pname="e" oct="3"/>
</chord>
<chord dur="8">
  <note pname="c" oct="3"/>
  <note pname="e" oct="3"/>
  <note pname="a" oct="3"/>
</chord>
</beam>
</layer>
</staff>
</measure>
<measure n="2"/>
<staff n="1">
  <layer>
    <note pname="f" oct="4" dur="4" dots="1">
      <verse n="1">
        <syl>Stern</syl>,
      </verse>
      <verse n="2">
        <syl>dich</syl>
      </verse>
      <verse n="3">
        <syl>dir</syl>,
      </verse>
      <verse n="4">
        <syl>zu</syl>
      </verse>
    </note>
  </layer>
</staff>

<staff n="2">
  <layer>
    <chord dur="2">
      <note pname="d" oct="4"/>
      <note pname="f" oct="4"/>
    </chord>
  </layer>
</staff>

<staff n="3">
  <layer>
    <chord dur="2">
      <note pname="d" oct="3"/>
      <note pname="a" oct="3"/>
    </chord>
  </layer>
</staff>
</measure>
</section>
</score>
</incip>
An extensive users guide for music21 is available for free online.

Commented [4]: cut
Important Links & Select Existing Projects

MEI Github page, https://github.com/music-encoding
MEI Guidelines, https://music-encoding.org/guidelines/v4/content/

Online catalogs and aggregators

Doing Reusable Musical Data (DoReMus), http://www.doremus.org/
Digital Image Archive of Medieval Music (DIAMM), https://www.diamm.ac.uk/
Music Scholarship Online (MuSO), http://muso.arts.gla.ac.uk/
Opera & Ballet Primary Sources (OBPS), https://sites.lib.byu.edu/obps/
Virtual Library Musicology (ViFaMusik), https://www.vifamusik.de/

Digital projects

Beethoven Werkstatt, http://beethovens-werkstatt.de (MEI)
Burns Antiphoner, http://burnsantiphoner.bc.edu/
CHARM, http://www.charm.rhul.ac.uk/index.html
Chopin First Editions Online, http://www.chopinonline.ac.uk/cfeo/
Documenting Teresa Carreno Project, https://documentingcarreno.org/
Du Chemin Lost Voices, http://digitalduchemin.org/ (MEI)
Early Modern Songscapes, http://songscapes.org (MEI + TEI)
English Broadside Ballad Archive, https://ebba.english.ucsb.edu/
Freischütz Digital, http://freischuetz-digital.de/ (MEI)
John Cage Unbound, http://exhibitions.nypl.org/johncage/
Linked Jazz, https://linkedjazz.org/
Suggested Readings

Readings are attached to this document in the following order.


Music Information Retrieval

John Ashley Burgoyne, Ichiho Fujinaga, and J. Stephen Downie

Music information retrieval (MIR) is "a multidisciplinary research endeavor that strives to develop innovative content-based searching schemes, novel interfaces, and evolving networked delivery mechanisms in an effort to make the world’s vast store of music accessible to all" (Downie, 2004). The methods of MIR research are almost invariably computational, but the particular techniques used vary as widely as music itself and the different roles it can play in one’s life. MIR is behind the technologies that make personalized recommendations for new music one might wish to purchase, software that estimates the key and tempo of tracks to help DJs mix smoothly, scanners that can convert printed music into digitally editable scores, and many other digital interfaces to musical information. As more and more consumers interact with music digitally, the importance of MIR will only continue to grow.

MIR research is applied research and strongly task-oriented. Because of its computational underpinnings, one can classify these tasks most naturally by examining the type of input data they entail and the type of data desired for output. The input data for MIR are always digital music data, which primarily take one of four forms: images of printed or handwritten music; so-called symbolic formats, such as the Musical Instrument Digital Interface (MIDI) standard, that seek to represent musical scores in a machine-interpretable form; digital audio; and metadata, either of traditional categories associated with library catalogs or of newer forms such as blogs, social-media posts, reviews, or other online texts about music. The space of possible outputs is much larger, but there are three fundamental categories: information retrieval tasks, which primarily seek to return a piece of music to a user based on some kind of query (e.g., recommending new music based on past music purchases); identification or attribution tasks, which seek to assign a single label or value to the input data (e.g., identifying the composer or
estimating the tempo, and sequence-labeling tasks, which rather than assigning a single label to the input data, seek to label the input data in multiple locations as it unfolds in real-time (e.g., providing a sequence of chord labels that correspond to an audio file). Although there are large overlaps and co-occurrence of representations at important conferences, the core concern of MIR is distinct from the goal of musicology, including computational musicology and music theory research; music composition, and sound engineering, including sound synthesis and compositional techniques. Musicological questions in general are more open-ended and descriptive than MIR questions — for example, a description of the stylistic characteristics of music by Jassmin (musicology) vs. an automated system for predicting whether a piece of music is by Jassmin or one of his contemporaries (MIR). Computational research in music cognition tends to focus on models of the human mind, whereas MIR prefers the best performing model for music cognition, regardless of their cognitive plausibility (compare Fujinaga’s study of timbre (1998), which takes an MIR approach, with McAdams’s (1999), which seeks a cognitive interpretation. MIR research on audio shares with sound engineering a focus on signal processing, research in sound synthesis, but MIR tasks tend to focus on labeling or retrieval rather than creation. Nonetheless, there is growing interest in filling the gaps between MIR and music cognition, as one can see from the list of keynote speakers (and the International Society for Music Information Retrieval (ISMIR) of keynotes at conferences) of the ISMIR 2006 and 2011; 2010; 2012; and 2013). Pachet from sound engineering and computational creativity (2013).

This chapter begins with a sketch of the history of MIR, including the development of the ISMIR conference and the annual Music Information Retrieval Evaluation eXchange (MIREX), wherein the newest techniques in MIR are shared and compared. A more detailed summary of the most important branches of MIR research follows. A more detailed summary of the most important branches of MIR research follows, organized by the four primary types of data that MIR researchers use: images, so-called digital materials, and metadata about music. The chapter concludes with a discussion of some of the open questions in MIR and likely directions for development over the next five to ten years.

A Brief History of MIR

In some ways, MIR with symbolic data has the longest history, a history that extends back much further than the modern music information retrieval itself. As modern statistical methods developed in the late nineteenth and early twentieth centuries, some scholars were already applying them to music. Without computers available to support their research, these early MIR scholars tabulated musical features by hand, directly from musical scores, and sought to specify stylistic characteristics based on these features. One of the earliest such studies, for example, demonstrated that larger melodic intervals occur less frequently in folk music than in smaller melodic intervals (Myers, 1907). Some early ethnomathological work used such tabulations of musical features to distinguish or describe the styles of non-Western musical cultures, such as Tunisian music (Homburg, 1996) or Native American music (Watt, 1924).

As computers became more widely available to researchers in the 1960s and 1970s, interest grew in computerized analysis of music. The terms computational musicology and music information retrieval were born: both first used in the titles of academic papers in the mid-1960s (Kassler, 1966; Logemann, 1964). Many early research efforts were concentrated solely on optimal representations for symbolic encoding of music for the computer (Lindell, 1972). Other scholarly concerns in this era were primarily stylistic and would be considered computational musicology today: horizontal and vertical musical intervals in the music of Josphin (Mendel, 1969), for example, or so-called tonal analysis of the relationships among various sources for Josquin’s Missa Pange Lingua (Hall, 1973). Pioneering work on analysis of musical audio data also began in these decades, including detailed analysis on musical instrument timbre (Slawson, 1968; Risset & Mathews, 1969; Grey, 1975) in pitch tracking, which started in the speech domain and was later applied to music (Moore, 1975; Ashenfelter, 1976; Pisarecki & Couler, 1977); and present work by Gehr et al. (1985), which discussed extracting pitches, keys, meter, and tempo.

Excepting a few bright spots, such as the launch of Computing in Musicology, a periodical compiling active research in computational musicology, and early work on recognition of rhythm and pitch (Ishii, 1985; Dussan & Houing, 1989), there was a relative lull in computational research on music during the 1980s. Music cognition, on the other hand, flourished, including the founding of Music Perception, still one of its leading journals today. One of the possible reasons computational musicology did not grow as quickly as expected during this time, especially as compared to computer-aided text analysis, was a lack of large datasets. Without optimal musical recognition technology to convert scanned images of printed music to a machine-readable encoding, all musical data had to be entered manually, which was (and still is) cumbersome, expensive, and error-prone (Pugui et al., 2007a).

In the 1990s, two things occurred that helped MIR to grow again. One was the increasing amount of music that was becoming easily available as digital audio, which solved the problem of encoding. The other was the surge in the computing power of desktop computers allowing researchers to analyze music easily. The earliest papers on MIR, introducing the ever-popular query-by-humming research, appeared in the first half of the decade (Kagiyama et al., 1993; Goh et al., 1995), followed by papers on searching through databases via audio content (Wold & Blum, 1996; McNab et al., 1996). In August 1999, an “Exploratory Workshop on Music Information Retrieval” was held within the ACM SIGIR (Association for Computing Machinery, Special Interest Group on Information Retrieval) conference in Berkeley, California. That September, another “Music Information Retrieval” workshop was held in London as part of the Digital Resources for the Humanities annual conference at King’s College.

These workshops inspired the first ever International Symposium for Music Information Retrieval, held in Plymouth, Massachusetts, in October 2000. This workshop grew into an annual conference, known as the International Society of Music Information Retrieval (ISMIR) Conference since the incorporation of the Society in 2001. To date, the ISMIR proceedings comprise nearly 1500 papers spanning the full range of MIR concerns, and the conference has become the pre-eminent venue for disseminating new research in the field. ISMIR is particularly important because there is no single academic journal that spans the breadth of MIR research.
MIREX

As ISMIR became more established, and in particular as certain core tasks became more defined, MIR researchers sought to ascertain the relative strengths and deficiencies of their algorithms under rigorous sets of test conditions. The Music Information Retrieval Evaluation & Exchange (MIREX) was developed to meet that need, and, like ISMIR itself, MIREX has contributed greatly to the growing success and impact of MIR research (Downie, 2008; Downie et al., 2010; Cunningham et al., 2012).

MIREX holds its first suite of evaluations in 2005 (Downie et al., 2005). It operates on an annual cycle wherein like-minded researchers gather together to tackle a specific MIR sub-problem such as pitch detection or score alignment. Once a group has come together, they create a MIREX “task” under which the participants will run their evaluations. They then need to construct the three principal components that make up each MIREX task: (1) a common set of data to be analyzed; (2) a common set of queries or procedures to be run against the data; and (3) a common set of metrics and evaluations to be used to evaluate the outputs of each algorithm. The application of one algorithm against one dataset that produces one set of results is called a “run” in MIREX parlance. Runs are usually completed in the late summer of each year, in time for the submitters to reflect upon their results in anticipation of their presenting posters at the special MIREX sessions held at each ISMIR conference. After the MIREX session at ISMIR, the cycle begins anew.

The MIREX model borrows shamelessly from the older Text Retrieval Conference (TREC) evaluation campaign. Unlike TREC, however, MIREX follows a nonconsumptive research paradigm wherein algorithms are brought to the data (stored at the University of Illinois) rather than having the datasets distributed to the MIR researchers. The nonconsumptive model helps MIREX to avoid costly and complicated intellectual property arrangements that plague those doing research on digital music materials. This nonconsumptive model is also now being deployed to allow for algorithmic access to the vast collection of copyright-restricted textual materials found in the Hart/Trust corpus (Kowalczyk et al., 2013).

In parallel with MIR research in general, MIREX has grown significantly over the years. MIREX 2005 used 10 datasets to generate 86 runs across nine tasks using algorithms submitted by 82 participants. MIREX 2013 saw the evaluation of more than 300 runs of algorithms submitted by over 100 individual researchers. Since 2005, MIREX has evaluated more than 2000 runs. Beyond simple growth, MIREX has played a role in moving MIR research forward. For example, in 2007, the top average precision score in the Audio Cover Song Identification (ACS) task was 52%. By MIREX 2009, the best average precision score had reached 75%.

The MIR Pipeline

MIR tasks, for MIREX or otherwise, tend to follow a fairly standard pipeline, illustrated in Figure 15.1: feature extraction to convert the input data into a useful intermediate representation, followed by inference to convert the features to the desired output. If the input data are particularly complex (e.g., full-quality audio files or high-resolution color images), the pipeline may sometimes include some kind of pre-processing to simplify the data prior to feature extraction, for example, converting stereo audio to mono or binarizing a color image to strictly black and white. MIR researchers may focus on any or all of these steps in the pipelines of tasks that interest them.

Machine learning, the use of data to tune the parameters of an algorithm automatically, is important throughout the MIR pipeline, and one important question for MIR researchers is how to best include machine learning in their pipelines.
researchers at each step of the pipeline is the appropriate balance to strike between machine learning and expert human knowledge. In general, the balance for feature extraction has been tipped in favor of expert knowledge and the balance for inference has been tipped in favor of machine learning. Researchers in automatic chord estimation from audio, for example, know in advance that a useful feature to extract might be how much sound energy is in each pitch class (C, C sharp, D, etc.), but when inferring actual chord labels from these so-called chroma vector features, they may prefer to let a machine decide precisely where the thresholds should be between particular chords. Cutting across this general trend is the fact that machine learning is only feasible when there are large amounts of data available. Thus, the earliest work in MIR tended to favor expert knowledge at all levels of the pipeline, whereas given the amount of data available today, there is a growing trend in MIR to prefer machine learning whenever possible (Humphrey et al., 2013).

Whether learned by a machine or tuned by a human expert, each step of the pipeline also must work within the natural constraints and possibilities of the input data. As a result, there are a number of canonical MIR tasks that have taken shape and are likely to remain stable for some time to come. Given a large collection of images of musical scores, for example, the natural task is to try to convert these images into faithful symbolic representations of the same score, a process known as optical music recognition (OMR). Extracting a symbolic score is likewise a natural task for audio data as well, although it remains one of the great open engineering challenges in the field; MIR with audio data tends to focus on intermediate representations such as key detection, chord estimation, beat tracking, or tempo estimation. Table 15.1 lists the classical MIR tasks, organized by the types of input and output. The remainder of this section discusses each block of the table in more detail.

**Table 15.1** Classical MIR tasks, by input and output type.

<table>
<thead>
<tr>
<th>Information retrieval</th>
<th>Classification &amp; estimation</th>
<th>Sequence labeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Images</td>
<td>Scribeprinter identification</td>
<td>Optical music recognition (OMR)</td>
</tr>
<tr>
<td>Symmetric data</td>
<td>Performer identification</td>
<td>Expressive timing</td>
</tr>
<tr>
<td>Melodic/harmonic</td>
<td>Composer identification</td>
<td>Voice separation</td>
</tr>
<tr>
<td>similarity measures</td>
<td>Genre classification</td>
<td>Automated harmonic analysis</td>
</tr>
<tr>
<td>Theme finding</td>
<td>Mood classification</td>
<td>Pitch spelling</td>
</tr>
<tr>
<td>(audio or score)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cover-song</td>
<td>Performer identification</td>
<td>Multiple ID</td>
</tr>
<tr>
<td>identification</td>
<td>Composer identification</td>
<td>estimation and tracking</td>
</tr>
<tr>
<td>Similarity measures/</td>
<td>Genre classification</td>
<td></td>
</tr>
<tr>
<td>recommendation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerprinting</td>
<td>Emotion/mood classification</td>
<td>Melody extraction</td>
</tr>
<tr>
<td>Playlist generation</td>
<td>Tag estimation</td>
<td>Score following</td>
</tr>
<tr>
<td>Music recommendation</td>
<td>Tempo estimation</td>
<td>Chord estimation</td>
</tr>
<tr>
<td>Database search and</td>
<td>Meter estimation</td>
<td>Onset detection</td>
</tr>
<tr>
<td>federation</td>
<td></td>
<td>Beat/bar tracking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structural segmentation</td>
</tr>
<tr>
<td>Playlist generation</td>
<td></td>
<td>Source separation</td>
</tr>
</tbody>
</table>

**Image Data**

There is relatively little variation possible in the MIR pipelines that stem from image input, in part because the space of conceivable outputs is so constrained. It is difficult to imagine a practical use case where images of musical scores would be the query rather than the response to an information retrieval system. Even classification or estimation tasks are conceivable only in niche applications at best, such as identifying the scribe who was responsible for a particular page of a manuscript (Baudet et al., 2003). The canonical MIR output for an image of a musical score is a symbolic representation of that same score, a process known as optical music recognition (OMR), by analogy to optical character recognition (OCR) in the text domain. OMR is of particular interest as an accompaniment to large music digitization projects at libraries and archival institutions, as it can create a machine-readable catalog of the digitized content in a symbolic form that lends itself easily to search and to computational musicology (Hankinson et al., 2012).

The OMR pipeline typically includes a substantial amount of pre-processing prior to feature extraction, including document image analysis to identify page regions containing music rather than text or decoration, binarizing the image to black-and-white, removing staff lines and identifying connected components of black pixels (Rebolo et al., 2012). Feature extraction and inference vary widely, depending on the source material. Much work is devoted to common music notation (as well as several commercial products), but other research groups focus explicitly on early printed music and music manuscripts, for which there is unlikely ever to be sufficient commercial interest to produce a viable product. Common output formats include MusicXML, the Music Encoding Initiative (MEE), and the formats of commercial music notation systems such as Finale or Sibelius.

Recent developments are encouraging more OMR to take place online. Audierws has launched an online OMR service for common music notation, and the SIMSSA project is strving toward a similar service for earlier music (Hankinson et al., 2012).

**Symbolic Data**

In contrast to image data, symbolic data lends itself naturally to a broader range of possible outputs. A large portion of computational as well as traditional musicological research is score-based, and many MIR tools for symbolic data can be seen as potential support tools for musicological researchers.

One of the canonical uses for symbolic data is as a query for information retrieval: identifying a piece of music based on a few notes of one of its most memorable themes. Long before the advent of computers, dictionaries of musical themes such as Barlow and Magrath's (1948) included indices based on melodic patterns. Themefinder is one of the earliest and perhaps still the best-known large-scale computerized search engine.
for musical themes (Sapp et al., 2004), and interfaces for melody-based searching are becoming an almost standard component of online music databases, for example, the Peachesoul corpus and the Global Client Database. MIREX also features tasks for related tasks like query-by-sampling, whereby users seek to retrieve a melody from a database by way of its rhythm, and attempts to mimic human judgment of melodic similarity, which can improve the quality of search results when users’ queries are imperfect.

Clustering and estimation tasks are also common for symbolic data. This category of output tends to correspond with the links to computational musicology. Style analysis, as mentioned earlier, has long been a concern of computational musicology, and the converse problem is identifying the composer of an unknown piece of music. MIREX has also included tasks for identifying the genre of pieces within symbolic MIREX has also included tasks for identifying the genre of pieces within symbolic music. McKay & Fujinaga (2005), and recently added a task for discovering repeated themes and sections (Gallis et al., 2013).

Labeled sequential outputs for symbolic data come in two kinds, one oriented toward musical performance and the other toward musical analysis. The musical performance stream comprises a large body of research in finding ways for computers to play back symbolic scores less mechanically, in particular, expressive timing (Kikic & Miranda, 2013). The other stream focuses on musicological tools, such as automated thematic analysis (Tempereley, 2001) or pitch spelling to handle ambiguities of enharmonic equivalences in formats like MIDI that do not record the distinction naturally (Chew, 2014).

Audio
Audio has dominated MIR research for the past two decades. In part, this is because there is no "natural" output or pipeline for audio, almost anything is possible. Digital audio is ubiquitous, and despite the legal challenges of working with copyrighted material, it is relatively easy for most research groups to acquire digital audio in great quantity.

Like image data, audio data tends to be too large and complex to use directly for feature extraction. Some kind of pre-processing is typical, including techniques such as collapsing stereo or multichannel recordings to mono, reducing the sampling rate, and breaking the audio down into short overlapping frames from which features can be extracted independently. The result is a collection of parallel sequences of different feature values, which are then used for inference.

The canonical audio information retrieval task is query-by-humming, whereby users hum a tune into a microphone and ask a computer to identify the piece of music that they are attempting to perform. Although perhaps less popular than it used to be, query-by-humming has been part of MIR research since the mid-1990s and has had some successful commercial implementations, including the SoundHound music service (Dammann et al., 2007). Query-by-humming is a specific case of audio fingerprinting, which seeks to mark audio fragments of any kind in such a way that they can work effectively for retrieving music from a database, with applications ranging from identifying music playing in one's surroundings to ensuring copyright compliance (Choudhurkar et al., 2011). There are also many applications for faster fingerprinting, identifying audio that is merely similar to a query rather than exactly the same. Predicting audio similarity has challenges both cognitive and computational.

but it also has many applications, including music recommendation systems, playlist generation systems, and cover-song identification (Pfeifer et al., 2012).

Audio lends itself to similar classification and estimation tasks to the symbolic domain, and a battery of MIREX tasks on artist, composer, genre, and mood classification has been standard for a number of years now. In addition to these tasks, there are a number of musicological support tasks that are relevant for audio because they seek to retrieve some of the most useful pieces of information that are apparent from a musical score but not from an audio file: key finding, tempo estimation (especially useful for DJs), and meter estimation. As social media surrounding music becomes more important, tag prediction has become an especially interesting classification task: trying to guess how users would label a piece of music themselves given a free choice of descriptions to use, such as the tags used for the Last.fm music service (Turnbull et al., 2008; Bertin-Mahieux et al., 2011).

Sequence labeling tasks are in many ways the holy grail of MIR tasks for audio data. The greatest challenge would be to render a direct transcription from audio to a symbolic score, but there are no systems (to date) that can accomplish this task completely successfully (Benedos et al., 2013). In many cases, however, a complete transcription is unnecessary, and somewhat simpler tasks are sufficient. In a performance environment, for example, score following, whereby a machine follows a symbolic score in time with a live performance, is often sufficient for synchronizing performance events, and several such systems have been deployed successfully (Cont, 2011). For other applications, only a specific aspect of the score is necessary, such as the melody (Salamon, 2013) or a chord transcription (McVicar et al., 2014). Performance for these types of tasks is increasing rapidly and may eventually blur the distinction between working with symbolic versus audio data.

Metadata
Image, symbolic, and audio data all pertain directly to the music itself, so-called content-based music information retrieval. It is also possible to work with metadata about music, such as titles, artists, lyrics, or music blogs and journalism, either exclusively or in tandem with content-based features. Sequence labeling is not possible from metadata alone, but several important information retrieval and classification tasks are. One of the most effective uses of metadata has been for music recommendation (Gelina, 2010), but these types of "cultural features" or "community metadata" have also proven helpful for genre classification (Whitman, 2005; McKay et al., 2010) and artist clustering (Scheib et al., 2011) among other tasks.

The Future of MIR
Relatively few of the classical MIR problems are truly solved, and we expect that considerable research energy will be devoted to improving the state of the art in the near future.
High-level Output

MIR was born of computational musicology, but as digital audio became more widely available in the 1990s, interest veered away from the symbolic data that had traditionally been of concern to musicologists and focused instead on audio. That bias continues to haunt the field today: approximately 95% of MIREX tasks involve audio signal processing, with only a handful uniquely dealing with symbolic data. Concomitant with this bias, MIR has also traditionally emphasized “low-level” tasks, those that are necessary to process audio but are not especially interesting musically. These tendencies have hindered collaboration between musicologists and MIR researchers (Cook, 2005). Not only are many low-level MIR tasks uninteresting musically, musicology has also insisted on a higher level of accuracy for the high-level tasks than early algorithms were able to provide (although see Pugin et al., 2007b, for an example of how it can be possible to bootstrap an otherwise weak MIR tool quite profitably in some contexts). Nonetheless, a strong interest in relating the gap between computational musicology and MIR remains (Volk & Hommigh, 2012), and as the performance of high-level audio tasks improves, we could be re-entering a golden age of computational musicology, in partnership with MIR.

The release of several new tools and datasets may also revive interest in MIR with symbolic data. The music21 toolkit, an effort to address some perceived shortcomings of the Humdrum toolkit, is seeing wider adoption (Carlhoff & Arias, 2010). The McGill Billboard project has released over 1,000 expert chord transcriptions of American popular music as well as tools for parsing these data (Burgoyne et al., 2011; de Hass & Burgoyne, 2012). The Electronic Locator of Vertical Interval Sequences (ELVIS) project has collected and released a large dataset of symbolic scores of early music, along with new tools for analyzing contrapuntal relationships with music21. Far from supplanting traditional musicology, these projects are opening rich veins of investigation that would have been unimaginable even 15 years ago.

Social Media and Crowdsourcing

By way of interest in metadata, MIR has embraced social media from the beginning, and given the constant need for more data and ubiquity of digital music, MIR was an early adopter of crowdsourcing for gathering data from the general public. We expect that these trends will continue and even accelerate in the near future. Research attention has recently turned toward mining microblogs such as Twitter (Schoff et al., 2011; Weerakamp et al., 2013), and the use of games as a tool to encourage crowdsourcing.

Music Information Retrieval

Perhaps surprisingly, given the strong influence of machine learning in MIR, few datasets used in MIR to date are truly "big." One notable exception is the Million Song Dataset, which expressly sought to challenge MIR to work on a commercial scale and has also been used to investigate musicological questions about the evolution of pop music (Bertin-Mahieux et al., 2011b). The Structural Analysis of Large Amounts of Music (SALAM) project sought to bootstrap human annotations with supercomputers to build a dataset on a similar scale (Smith et al., 2011). The Pachmarhi corpus has made an unprecedented number of scores available for symbolic analysis (Viro, 2011). Much social media data can also fall into the big-data category. Big data has implications both for MIR itself—more data makes it possible to rely more on machine learning for feature extraction (Humphrey et al., 2015)—and the types of questions it can answer. Much like Moretti’s (2005) case for big-data methods in literature, machines can consume more music than one person could do in a lifetime, and recent studies have started to trace changes in style that would have been impossible to examine even thoroughly using traditional methods (Senn et al., 2012; Burgoyne et al., 2013; Zivic et al., 2015). These recent studies also show the interpretative challenges of big-data research in MIR, especially in communicating such results across disciplines and using statistical techniques appropriately and responsibly (Huron, 2013). We expect the number of methodological and communicative techniques for big data in MIR to evolve rapidly over the next few years.

Multivalent User Interfaces

For the most part, researchers have studied each of the classical MIR tasks independently of other tasks. That is changing, though, in response to a growing concern within the MIR community over MIR’s relative inaccessibility to users and the user experience. Although the complaint is not new (Wiering, 2007), it has been increasing in urgency recently (Lee & Cunningham, 2013). One response has been to develop multivalent user interfaces that integrate multiple MIR technologies into a single interface. The SALAMI project, for example, combined multiple approaches to music similarity and structural analysis to devise a unique interface for browsing the output of many popular segmentation algorithms over a large database of 350,000 songs (more than two years of continuous audio) (Baierbridge et al., 2012). The SIMSSA project is attempting a similar feat for a broad range of DMIR technologies, and is seeking to integrate crowdsourcing to improve data quality and provide new training material for machine learning (Hankinson et al., 2012). The Songle project integrates crowdsourcing with a wide range of different audio MIR tasks: meter estimation, beat tracking, meter extraction, chord estimation, melody
extraction, and segmentation (Goto et al., 2015). All of these projects emphasize actual use by real persons, a trend that we expect to continue; MIREX itself is undergoing discussions at the time of writing to integrate user-interface evaluation as a permanent part of its battery.

Conclusion

As soon as computers became a part of the academic infrastructure, researchers became interested in using them to study music. Over a period of some decades, the computers have gotten better at answering research questions, and meeting demonstrated needs. The past two decades have seen a particularly strong growth in the field of music information retrieval (MIR). MIR researchers work on musical data in all its forms—images, symbolic data, audio, and metadata—and they answer many classes of questions from classic information retrieval to simple estimation or classification, to complex sequence labeling. Most digital music services now integrate some kind of MIR technology, and the ubiquity and importance of digital music through contemporary culture suggests that the field will only continue to grow.


MIREEK Wiki: http://music.inscor.org/miereek


16

Data Modeling

Julia Flanders and Fotis Jannidis

Nowadays computers can do many things: they anticipate how share prices will develop, they describe how rockets fly, they allow us to dig into thousands of books from many libraries to find common topics, or present us with maps and events from times long gone. For all these tasks computers need models: models of the share prices and the factors involved in their development, models of how a physical object like a rocket will behave in the atmosphere, models of books, and models of regions and events. The models provide formalized perspectives on their subjects, expressed in a way that makes it possible to gather specific information about the subject. In short, the formalized model determines which aspects of the subject will be computable and in what form.

Though it is obvious how central modeling is to computing, there is no disciplinary field concerned with modeling in the digital realm. What we do have is a group of different fields engaged in discussing digital modeling: for example, in computer science “data modeling” refers to the design of databases (Simson, 2007) and “object modeling” often refers to the design of entities in the context of software development; for example, with the help of the Unified Modeling Language (UML). Mathematical modeling covers areas like discrete dynamical systems or growth models (Mooney and Swift, 1999) and also statistical models (Freedman, 2009), and these have been applied not only to physics and biology but also to economy and sociology (Miller and Page, 2007). And data modeling, especially the digital modeling of text, has a long history of intense debate in the digital humanities, concerning issues such as how to model textual materiality, how to represent the semantics of data models, and whether models should be driven by function or by higher-level descriptive goals. Thus far, these discussions have only been partially informed by research on modeling in other fields: there is as yet no unifying theory. As the domain of digital humanities matures,
The Music Addressability API

A draft specification for addressing portions of music notation on the web

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ABSTRACT

This paper describes an Application Programming Interface (API) for addressing music notation on the web regardless of the format in which it is stored. The API was created as a method for addressing and extracting specific portions of music notation published in machine-readable formats on the web. Music notation, like text, can be “addressed” in new ways in a digital environment, allowing scholars to identify and name structures of various kinds, thus raising such questions as how can one virtually “circle” some music notation? How can a machine interpret this “circling” to select and retrieve the relevant music notation?

The API was evaluated by: 1) creating an implementation of the API for documents in the Music Encoding Initiative (MEI) format; and by 2) remodelling a dataset of music analysis statements from the Du Chemin: Lost Voices project (Haverford College) by using the API to connect the analytical statements with the portion of notation they refer to. Building this corpus has demonstrated that the Music Addressability API is capable of modelling complex analytical statements containing references to music notation.

CCS Concepts

• Applied computing → Sound and music computing; Annotation; • Information systems → Web services;

Keywords

Music on the web; Music citation; Digital Musicology

1. INTRODUCTION AND BACKGROUND

Enhancing Music Notation Addressability (EMA) was a research project funded with a Level 2 Digital Humanities start up grant from the National Endowment for the Humanities between June 1, 2014 and October 31, 2015.

Prompted by the fact that addressing such units of music notation as measures, notes, and phrases has long been a powerful instrument in musicological discourse.

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When talking about music in general, it is important to say that addressing written music notation is not the only instrument of the musicologist. Music exists in several domains besides the written or “graphemic” one, each addressable in its own way [1]. For the purpose of this paper, we focus on written Western music notation, because it plays a prominent role in musicological discourse.
Interoperability Framework (IIIF) [6] has recently created an API to generalize this behavior, so that it can be implemented across multiple image servers and digital libraries. IIIF was used as a model for the Music Addressability API created for EMA. While format independent, this API still only refers to one file of music notation as opposed to an instance of a music work or piece. That is, it provides a mechanism, but it does intent to define what the music it points to is or is an instance of.

At the early planning stage, EMA was focused on creating methods for addressing exclusively documents in the Music Encoding Initiative (MEI) format. This was because music notation requires substantial computational modeling even for the simplest musical text before any further operation is possible. There are many different ways of representing a single note; some aspects are common to all representation systems, such as information about pitch and duration, but some systems will prioritize certain aspects over others. Nonetheless, we have found that there are simple units that are typically represented by all music notation systems for common western music notation, such as measure, staff, and beat. Therefore it was decided to develop an API and a URI scheme to make it possible to target music notation resources on the web regardless of their format. Such a scheme may facilitate (and some cases enable) a number of activities around music notation documents published on the web. The following table gives a few basic examples of how an implementation of the URI scheme could be useful to musicological research:

- **Scholarly**
  - *Analysis:* being able to address components of music notation for analytical purposes. Example: precisely identify start and end of a pedal tone in Bach’s Prelude no. 6 in D Minor, BWV 851.
  - *Citation:* quote a passage from an encoded music notation file. For example the timpani in the opening bars of the Overture to Mozart’s Don Giovanni.

- **Visual**
  - *Rendering:* rendering music notation in an interactive environment such as a browser or a tablet requires the ability to cut up a large music document. For example to show only the number of measures that fit in a given space.
  - *Highlighting:* address a segment of music notation to highlight it in a visual context (e.g. with color).

- **Procedural**
  - *Processing:* extracted portions of music notation can be passed on to another process. For example, given the MEI encoding of the Overture to Mozart’s Don Giovanni, extract the string instrument parts and send them to another program that will return an harmonic analysis.

The full API is published on GitHub at this address under a Creative Common Attribution 2.0 license: https://github.com/umd-mith/ema/blob/master/docs/api.md. We give here a brief overview of how the URI scheme operates.

3. **AN IMPLEMENTATION FOR MEI**

Unlike the API itself, its implementation cannot be format-independent. At the very least, an implementation of the API needs to know how a specific format models measures, the measure of a selection: it allows for precise addressability of contiguous as well as non-contiguous areas. While this offers a sufficient level of granularity for most music notation, it has some limitations discussed in Conclusions and future work.

The API also includes a number of options to configure the “completeness” of the addressing act. These parameters help determine, for example, what to do when a beat only affects part of a note. We defer to the API specification for further detail, but we include here an overview of the URI scheme in Backus-Naur form as it is defined according to the version 1.0.0 of the API.

![Figure 1: J. S. Bach - Trio Sonata No. 4 in C minor, BWV 1079 (Musikalisches Opfer) - Largo. mm 5-8.](image)

The notation highlighted in red in Fig. 1 occurs between measures 6 and 8, on the second, first, and third staves respectively. All the selected measures are not considered in full, but only starting after the first sixteenth note. This selection can be expressed according to a URI syntax:

```
/{identifier}/{measures}/{staves}/{beats}

/trio.mei/6-8/2,1,3/01.25-end,01.25-end,01.25-end
```

The measure is expressed as a range (6-8), staves can be selected through a range or separately with a comma (2,1,3), and the beats are always relative to their measure, so @01.25-end indicates a selection from beat 1.25 to the end of the measure. In this specification the beat is the primary driver of the selection: it allows for precise addressability of contiguous as well as non-contiguous areas. While this offers a sufficient level of granularity for most music notation, it has some limitations discussed in Conclusions and future work.
Our example implementation targets the Music Encoding Initiative (MEI) format not only because the dataset from Du Chemin: Lost Voices project (henceforth Digital Du Chemin, for brevity) is encoded in MEI, but also because MEI maintains a standard for representing music notation that is inspired by the same text encoding principles that motivated the Text Encoding Initiative, the de facto standard for encoding text in scholarly archives and editions [2]. As such, MEI has proven to be useful in the academic community, particularly for its ability in dealing with ambiguity and variance; this is useful, for example, for optical music recognition applications as well as digital scholarly editions.

The implementation is structured as a web service and is called Open MEI Addressability Service, or Omas. The code is available on GitHub under an Apache 2.0 license: https://github.com/umd-mith/ema/tree/master/Omas. Omas interprets a conformant URI, retrieves the specified MEI resource, applies the selection, and returns it. An additional parameter on the URI can be used to determine how “complete” the retrieved selection should be (whether it should, for example, include time and key signatures, etc.).

A demo is published online for testing Omas: http://mith.us/ema/omas/. Any MEI file publicly accessible on the web can be addressed through this demo. A form is provided to enter the parameters for the URI scheme; after submission, Omas retrieves the MEI file and returns the addressed portion of music notation and the corresponding URL conformant to the Music Addressability API. It is also possible to attempt to read the music notation using Verovio, an MEI rendering engine [4]. Since both Omas and Verovio are experimental software, however, results will vary substantially.

4. EVALUATION

In order to evaluate both the API and Omas, we took music analysis statements from the Digital Du Chemin project. Each musical piece in the corpus is annotated with analytical statements concerning various aspects of the notation, such as voice role and type of cadence. All these statements address the notation at measure level and are stored in a relational database. We exported the data and re-structured it as Linked Open Data (LOD), using URLs conformant to the Music Addressability API to address the measures in the MEI files targeted by each analytical statement.

Each analytical statement was modelled as its own graph, according to the Nanopublication guidelines. This specification is currently being used in the sciences to publish datasets; each scientific assertion is modelled independently so that it can be cited with a unique identifier (a “trusted” URI). A nanopublication is structured in three parts: assertion, provenance, and publication information [7].

Each of these sub-graphs can be populated using any LOD vocabularies. We modelled the Assertion graph using the Open Annotation specification, which provided helpful building blocks for associating each analytical statement with a specific portion of the music notation documents [5]. Fundamentally, each Open Annotation is made of one or more targets and bodies. In our case, the body is the analysis, and the target is a URL formulated according to the Music Addressability API defined above.

The Digital Du Chemin analyses only target measures and staves, but the Music Addressability API can deal with a much greater level of granularity. In order to test this functionality, Richard Freedman (PI of Digital Du Chemin) has created a handfull of more complex analyses.

5. CONCLUSIONS AND FUTURE WORK

In conclusion, building this corpus has successfully demonstrated that the Music Addressability API is capable of modeling complex analytical statements containing references to music notation. It also shows that it can be used together with other LOD vocabularies, such as Nanopublication, to enable and facilitate citation, attribution of credit, and distribution.
The Music Addressability API provides a system for addressing specific portions of machine-readable music notation on the web. The API’s implementation for MEI (Omas) can provide a working example for future implementation of the API for MEI and other formats. The evaluation completed using Digital Du Chemin data has provided a practical demonstration of the applicability of the API to a musicological project. The API, however, has some known limitations.

- The API is fundamentally based on beat, therefore it is not possible to address music notation with relative or no beat. Cadenzas, for example, are ornamental passages of an improvisational nature that can be written out with notation that disregards a measure’s beat, making it impossible to address subsets of the cadenza with the syntax discussed above. This, however, can be resolved in a future iteration of the API, though it is likely to complicate the URL scheme syntax.

- The API will not work well with notation such as neume and mensural notation; while it would be possible to address such notation at beat level as if it were contained in one sole measure, this is not ideal for specialists working with these notation systems. The best solution for this problem may be creating a separate URL scheme that does not rely on measure indexes.

- The API may or may not work with non-western music notation. The project has focused exclusively on western music notation for the time being.

While the project is now concluded, there is certainly more work to be done to improve and stabilize the API with future releases. In particular the API could benefit from a large test suite for future implementations, documentation for edge and complex cases, and reference implementations for other formats beyond MEI.

The work around the Music Addressability API and its implementation is currently being continued within the project Citations: The Renaissance Imitation Mass (CRIM), a project funded by Mellon and the Fondation Maison des Sciences de l’Homme until 2018. For this project, we will develop a system for generating expressions conformant to the Music Addressability API by selecting portions of music notation from a human-readable rendering in the browser. The analysts will be identifying citations and other imitative cross-references across a corpus of Renaissance masses. These will be modelled as Linked Open Data with a dedicated ontology of relationships (currently being developed by CRIM participants), will be referring to MEI-encoded music documents with Music Addressability API expressions, and will be published as Nanopublications after the findings of the Enhancing Music Notation Addressability project.

6. ACKNOWLEDGMENTS

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7. REFERENCES
“What does the data tell us?: Representation, Canon, and Music Encoding”

*Keynote text delivered at the [Music Encoding Conference](https://encodingconference.com), University of Maryland, May 24, 2018.

I am thrilled to be here with you today. I would like to begin by thanking the organizers, Raffaele Viglianti and Stephen Henry, for inviting me to give this keynote. I would also like thank the students and staff at the University of Maryland Libraries, MITH, and the Clarice Smith Performing Arts Center who were involved in making this conference run smoothly. Thank you.

When Raff and Stephen invited me to give this keynote they told me that the theme of the conference was “encoding and performance.” My original inclination was to talk about the ways in which I have engaged with digital tools and methods to facilitate faculty research and pedagogical initiatives, discuss the affordances that digital editions and encoded music can bring to a music seminar, as well as, ways in which students might interact with these materials. I will talk a bit about these things, but what was really on my mind and the focus of this keynote, is the issue of representation and canon. My hope is that this talk will encourage discussion and reflection.

...  

**Introduction**

Between 2010–2015, I was working at the University of Connecticut (UConn) as the Music & Dramatic Arts Librarian and a digital humanities specialist. The music department offered degrees from the undergraduate through the doctoral level. One of my many responsibilities was to teach several sessions of a graduate music research and bibliography course, in which students would be
introduced to key resources (both analog and digital) in music bibliography and research. One of the goals of this course was to expose students to the research process and activities, such as finding and accessing resources of primary and secondary materials, creating a bibliography, or writing a literature review.

![Library scene](image)

*A reading room at the Finnish National Archives in Helsinki. Photo: The National Archives of Finland/Merk Ojala.*

Archival research was new to most of the graduate students enrolled in this course, therefore one of my goals was to not only discuss and show them the various thematic catalogues, indexes, or bibliographies that could lead them to manuscripts or early editions, but to also demonstrate the process of searching for digitized materials in the numerous digital open access collections that had come online in the 21st century, as well as how to locate interactive or analytical music resources.
Example of digitized manuscript in Bibliothèque nationale de France, Lili Boulanger, Esquisses et croissants pour Cléopâtre dans le ciel, 1914-19 (manuscrit autographe).

Digital music collections, such as Gallica (BnF), Polona (from the National Library of Poland), Early American Sheet Music (Library of Congress), Sheet Music Consortium, or the IMSLP Petrucci Music Library, have in the last 20 years or so, made music manuscripts and early editions widely accessible and discoverable to scholars, students, and music enthusiasts.
For students (performers or musicologists, alike), access to materials in a digital environment can facilitate their research and enable them to analyze and study compositional works previously only available through a visit to the archives, on microfilm, or in a facsimile edition. As a subject and digital humanities librarian, I not only introduced students to these materials, but also demonstrated ways in which they might wish to engage with digitized materials and encoded data, hoping that a few of them might show interest in digital humanities or digital musicology as a way to leverage the affordances of digital tools and methods. The digital collections mentioned above, amongst many others, are important resources, however, they primarily offer access to high quality images with minimal metadata and no underlying music data that can be extracted for further analysis and study. How do most students interact with these materials? In general, I found that students will view the images online, bookmark URLs, extract measures or selections for their papers (often screenshots), and download or print individual or full images for further study or annotation purposes.
Creating notes and saving items in Polona about Mieczysław Szymanowski, including Virgil Exercises et Préludes (Leipzig: Breitkopf & Härtel, [1907]), No. 43356756.

Some of the platforms, such as Polona, enable users to create notes or annotations about the material they are viewing and retrieve or view them all together, as well as add items to a collection for later review or study.

Over time, digital library collections, including those from the Internet Archive, Gallica, Polona, and the HathiTrust have applied OCR to textual materials, such as historical newspapers or journals, enabling users to search within the texts and in some cases to also make corrections of the text. Unfortunately, this is not yet a standard practice for music materials. As many of you are aware, optical music recognition (OMR) is a technology that is still under development and can not yet be applied at large scale to digitized music materials. When students create and save notes for digitized music materials, it is akin to writing on a paper sticky (post-it) note and putting it into their score or text. In general, projects which have attempted to facilitate user interaction between source materials in a single digital workspace have focused on digital music editions.

This includes the Online Chopin Variorum Edition (OCVE). The OCVE has aggregated Fryderyk Chopin’s manuscripts and printed editions from libraries in Europe into a single platform where users can compare and view sources, melodic examples, or create annotations and commentaries that they can save in their own collection. This and other more recent digital music editions (such as the Beethoven Werkstatt, Giuseppe Sarti Edition or Carl Maria von Weber Gesamtausgabe) have
focused on addressing issues around the “work concept,” especially for composers or repertoire that may not have a definitive textual and music source history.

These digital music editions are valuable contributions, however, there are some drawbacks, including that not all are open access editions and there is not yet a way to aggregate these editions and other music data through a single portal or search interface, which would facilitate access and discovery, especially for students who are new to the research process.

In addition to digital music editions, there are encoding projects and resources that enable analysis, manipulation, and comparison of musical patterns and repertoires via graphical user interfaces, such as ThemeFinder (Center for Computer Assisted Research in the Humanities, Stanford University), Medieval Music Database, The Josquin Research Project (Stanford), or CANTUS manuscript database (Waterloo U/international), which enable students and scholars to search across repertoire due to the underlying encoded music data. As with digitized manuscripts, however, many of these tools focus primarily on early music, (often liturgical) repertoire from Western Europe, and while they may occasionally include a small percentage of composers from other time periods, they generally exclude works by women, people of color, and non-western composers.

Computational musicology projects developed over the last several decades, such as Computerized Mensural Music Editing (CMME) (UC Davis/Utrecht), MuseData (CCARH, Stanford), or Scribe (now NeoScribe) music software, have also focused primarily on early music repertoire and although the music data is generally accessible online, doing anything with this data presents a high barrier to entry for the
graduate students who may have little or no familiarity with encoding, programming, or computational analysis. Newer initiatives focused on the application of open and interoperable schemas and standards, including the **music encoding initiative** (MEI), **music21 toolkit** (MIT, Cuthbert), and **musicXML**, with which scholars are creating music datasets and digital music editions that represent various repertoires, genres, and time periods, present a greater range of possibilities for the study and analysis of music. These initiatives along with efforts from the **IIIF** (International Image Interoperability Framework) and optical music recognition (OMR) communities continue to push the boundaries of what will be possible when digitized music sources across collections and platforms can be displayed and searched through a single interface, such as **Single Interface for Music Score Searching and Analysis (SIMSSA)** (under development). Ongoing efforts built upon the decades long work of scholars, students, library and archives professionals, technologists (and others) have brought us closer to the promise of what music encoding and OMR can offer to the music research and scholarly community. Yet, there are still a number of areas and challenges that need to be addressed, especially in areas of pedagogy & training, archival selection, recovery, and canonization.

. . .

**Acts of Recovery**

How has the musicological community participated in **acts of recovery** and how has this translated into the work of the music encoding community? I should first explain what I mean by acts of recovery: this refers to the uncovering or recovery of histories, narratives, and works by underrepresented or marginalized people. In academia, scholars, primarily engaged with second wave feminist thinking (1960s-80s) became increasingly interested in decentering historical (hegemonic) narratives. In musicology this took a number of forms, including acts of recovery, development of a feminist (and later queer) music criticism, rethinking the canon, examination of ideological and cultural constructions, and application of methods from outside the discipline (such as cultural studies, literary criticism, feminist theory, queer studies, philosophy, and anthropology). I will mention a handful of publications by scholars who aimed to decenter the canon through acts of recovering women musicians. These publications and scholars have a
place on my bookshelf and have shaped my approaches to and understanding of canon and gender in relation to musicology.

One such publication was a 1986 collection of essays, *Women Making Music: The Western Art Tradition, 1150–1950*, edited by Jane M. Bowers and Judith Tick, which focused on highlighting neglected women composers overlooked by historical musicology. This text was an important contribution to musicology and is often on the reading list for university music courses, often those relegated as “women in music.” In honor of the 25th anniversary of WMM at the 2012 Feminist Theory in Music Conference, Tick shared that, looking back, she and Bowers “did not confront the use and misuse of “greatness” in contemporary historical musicology. (At its most perverse, misuse implicitly promotes the notion that the least bit of trivia about a “great man” is more important than scholarship on “second-tier” musicians.) We did not destabilize the idea of a “canon.” Although the editors may not have explicitly stated that their aim was to destabilize the canon, their publication can be viewed as an implicit, yet profound, contribution to centering the canon. In 1993, Ruth A. Solie’s *Musicology and Difference*, pushed the boundaries by exploring or applying concepts central to disciplines outside of musicology, including critical theory, ethnography, or post-structural theory, in order to address issues of otherness, gender, sexuality, and ideology. Essays in Susan C. Cook and Judy S. Tsou’s *Cecilia Reclaimed* (1994) blurred the line between Western and non-Western music, and high and popular culture, thus demonstrating that “the West is to be understood as a specific culture among many others.”

Alongside scholarly writing, a number of publishing initiatives sprang forth focused on uncovering and preserving works by women composers from the medieval through contemporary period, these included music presses, ClarNan (est. 1984), Furore Press (est. 1986), and Hildegard Publishing Company (est. 1988). In an effort to resurrect compositions by women, and package them in a way so they could supplement content in university music courses, anthologies of music by women, such as James Briscoe’s *Historical anthology of music by women* (1986; later 2004 ed. New HAMW), which presented scores and recordings of vocal and instrumental music by composers from ancient Greece through the 20th centuries alongside biographical articles written by leading scholars, gained popularity.
On a personal note—Although these presses and anthologies were around as early as 1984, my own understanding of canon was first shaped and reinforced by my Polish piano teacher, trained in western music traditions, who encouraged my love of Chopin, but never assigned any repertoire by women composers. Perhaps it never crossed his mind to mention that there was a Clara Schumann or Maria Szymanowska. Or more likely, it is because this assignation of value and superiority to works within the canon has been passed down across generations by teachers to their students, whether they are performers, composers, or scholars. Students that I work with have expressed similar experiences of minimal exposure to works by women or marginalized figures during their undergraduate and even graduate studies. As Katherine Bergeron wrote in the prologue to Disciplining Music (1992), “The canon, always in view, promotes decorum, ensures proper conduct. The individual within a field learns, by internalizing such standards, how not to transgress.” It was not until I was an undergraduate performance major when I searched for and “discovered” women composers thanks to the encouragement of several musicologists and mentors.

In the essay “What Do We Want to Teach,” written 19 years ago in Rethinking Music, Ellen Koskoff observed that “Simply creating a canon is not a problem; nor is embodying it with one’s own meaningful values. The problem comes with canonization—the institutionalization of certain works over others through the imposition of hierarchies of self-invested value upon other people and their musics.” How does this apply to the work we do as music scholars, librarians or archivists? When we teach music history, theory, or repertoire, when we program or perform works, when we create data—we are privileging works by certain composers and excluding others. We know this of course, but it becomes glaringly apparent when we look at, for example, whose works are performed by major orchestras in the United States. Staff at the Baltimore Symphony Orchestra have analyzed data from 89 of the largest symphony orchestras in the United States with membership in the League of American Orchestras. For the 2015–2016 season, they found that in a total of 2978 concerts in which 504 composers were represented, 98.3% of the composers were male and 1.7% female.
And if you are curious which composer's works are most frequently performed, here is the breakdown.

In the Winter 2018 issue of Symphony, Jesse Rosen, President and CEO for the League of American Orchestras, interviewed several thought
leaders from academic or performance organizations to consider this question, “are orchestras culturally specific?” Cecilia Olusola Tribble, community and organizational development coordinator for the Metro Nashville Arts Commission, responded “If we think about how white art forms, white people, white icons, composers, have always been at the fore of writing history—that is the issue. The question of cultural specificity is raised in a way that doesn’t take responsibility for the fact that classical music, historically and presently, is a colonizing force, and is a tool of colonization. Not only here in the United States, but globally.” Her statement is reflected in the content taught in music history courses, the repertoire our students perform, and the music we encode.

This reality is also visible in the technology and algorithms we use on a daily basis, for example if you go to Google and type in “music composers” your results will display a bar of images that you can scroll through. Here are a few of them…
What do you notice? In order to find women composers, black composers, Asian composers, etc. you need to add an additional attribute term to your search, such as “women music composers” or “black music composers.”

The default according to this algorithm is that “music composer = white male.”

For decades, music encoding has largely been the domain of scholars interested in early music. Access to medieval and renaissance music sources coincided with the availability of textual or music manuscripts and early printed editions, on microfilm, and then online, as digital images (the latter since the late 1990s). The work of libraries and archives in creating accessible online content has benefited the early music community and enabled the development of music encoding projects. Digital library collections, such as DIAMM, a comprehensive site for a complete list of polyphonic music manuscripts up to c. 1600; or the British Library Catalogue of Illuminated Manuscripts, as well as many individual institutional digital library collections continue to make high-resolution digital images available.

With funding and interest in building interoperable platforms, such as Europeana, Polona, Gallica, and HathiTrust there has been an increase
in accessible, aggregated digital content and metadata from individual institutions. While there has been growth in the number of manuscripts or early editions by underrepresented or unknown composers that can be accessed and studied online, institutions still privilege composers who hold a prominent place in the western music canon. For example, while the British Library has made numerous music manuscripts and editions by well-known composers available as digital images, including those by Beethoven, Handel, Haydn, and Schubert, works by women composers, such as Ethel Smyth (1858–1944), Francesca Caccini (1587–1641), or Thea Musgrave (b.1928), have not yet been digitized.

And, these are the more notable women composers that have made it into our music history courses, whose works were firsts in their own right, such as Smyth’s opera Der Wald, which premiered in 1903 and remained the only opera by a woman to be staged at the Met until 2016; or Caccini’s opera La Liberazione di Ruggerio dall’Isola d’Alcina.
(1625), believed to be the first opera composed by a woman composer. Works by these and other women are missing from encoded datasets and digital music editions. Even when published scores or digital images are available these composers continue to be overlooked and excluded from projects, especially those receiving grant funding for the creation of large music datasets. **If we continue to exclude works by women, people of color, and non-canonical composers, then how useful will our data be and for whom?**

Decisions for selecting composers, repertoire, genres for encoding or digital music edition creation, are often linked to the practices and research interests of the scholars at a particular institution or even geographic location. They are also tied to the disciplinary traditions passed from faculty to student and are influenced by the particular holdings (analog or digital) of an archive or library collection, as well as by funding sources.

Libraries and archives digitize content to make it accessible for scholars to use in their research and often expose data or create datasets that can be used for encoding, computational analysis, digital edition creation, or tool building. Some scholars may be involved in acquisitions decisions, in particular when expensive manuscripts or rare materials are being considered, as well as in the selection or prioritization of content for digitization. One problem that has arisen is that universities often focus their efforts on large-scale digitization of hegemonic texts, such as literary corpora by white European male authors, liturgical manuscripts, or Western early music editions, which again reinforces canonization. The collections in libraries and archives, primarily those in first-world countries with access to digital imaging equipment and digital library infrastructure, as well as institutional or grant funding, perpetuate not only canonization, but also colonization.

While I can not fully address the issue of colonization in this talk, I will point out that there are scholars and projects who are challenging colonization in the archives and academia. A few recent examples include, Elizabeth Maddock Dillon’s (Northeastern) work on the Early Caribbean Digital Archive, which is working to uncover a literary history of the colonial Caribbean that is “written or related by black, enslaved, creole, and/or colonized people” and Tamara Levit’s (UCLA) 2017 talk at the Society for American Music (SAM), in which she called
for addressing “structures of inequality and white supremacy in” [SAM].

In regards to canonization, most librarians or archivists see this happen firsthand in the materials that are housed in their institutions or prioritized for digitization. At Boston College, I have thus far been involved with two music encoding projects.

One of these projects focused on a 14th century liturgical antiphoner (Burns Antiphoner) which we encoded, made available through a Diva.JS viewer in several formats, including JSON and MEI.XML, and contributed to the CANTUS database. The encoded data augments the digitized manuscript in a way that may contribute to scholarly research and greater understanding of this particular genre of music, (not to diminish our accomplishment) however, we have in a sense contributed a low-hanging fruit, rather than challenging the notion of canon.

Recently, there has been a noticeable increase in discourse around library, archives, faculty, and institutional engagement in de-centering and decolonizing collections. A number of scholars, among them, Elizabeth Maddock Dillon (Northeastern U), Tonia Sutherland (University of Alabama), Lael Hughes-Watkins (Kent State University), and Safya Noble (University of Southern California) have been leading conversations on erasure, colonization, and social justice in the archives, as well as algorithmic bias. Professional organizations, such as the Digital Library Federation (DLF), are providing support to
professionals engaged in these efforts through grants, initiatives, and resources, including bibliographies around topics, such as “Ethics and Social Justice” for advancing hidden collections or documenting culturally sensitive materials.

As more libraries and archives begin to thoughtfully evaluate their collections, as well as their selection and digitization processes, they will require allies and advocates in their faculty. In addition to the institutional mission or strategic goals, curricular and research needs drive priorities around acquisition and digitization and this necessitates close interaction between librarians/archivists and faculty. Often institutional and faculty priorities take precedence over library or archives-led projects, therefore it is critical that there is faculty buy-in for initiatives focused on recovering or de-centering collections, which may lead to fruitful collaborations.

Some of these collaborations make take the form of digital pedagogy projects, which may use archival materials that focus on recovering historical narratives and social justice issues, as demonstrated in
projects, such as the student developed Lansing Urban Renewal project from Michigan State University or the Women, Work, and Song in Nineteenth-Century France exhibit from the McGill University Libraries, which features musical collections by women through scholarly essays, digitized content, and exhibits.

My intention is not to criticize early music scholars or the music encoding community in their efforts to make data available for analysis and study or to create encoded editions. This is an important area of research and contribution to our understanding of music. Instead, I suggest that we examine and consider the digital canon that we are creating. A canon that does not challenge or decenter, which has largely excluded work by women, people of color, and other underrepresented groups. As we continue to seek materials and create larger datasets in order to develop our machine learning capabilities, optical music recognition functionality, tools for searching, aggregating, and analysis (IIIF, SIMMSA), we must keep in mind which composers and repertoire we are including and which we may be excluding.

Canonization, is of course not a new phenomenon and is not limited to musicology. This is a problem that can be found in other disciplinary areas, including literary studies and digital humanities. As Texas A&M literary scholar Amy Earhart writes in “Can Information be Unfettered?
Race and the New Digital Humanities Canon” (2012) “Without careful and systematic analysis of our digital canons, we not only reproduce antiquated understandings of the canon but also reify them through our technological imprimatur.” She continues… “In digital humanities, however, we have much theoretical work to do in the selection of materials and application of digital tools to them.”

In literary studies with access to digitized texts and the TEI, a number of digital edition projects were born in the 90s and early 2000s, largely focused on white male authors, such as the Walt Whitman Archive, Dante Gabriel Rossetti Archive, Algernon Charles Swinburne Project, or the Mark Twain Project Online. A few encoding projects centered around women authors or feminist literary history also came online and still continue to develop, specifically the Women Writers Project (WWP), Willa Cather Archive, and Orlando. The WWP, in particular, is engaged in recovery of texts by early modern women writers. The project team is creating an encoded dataset of these texts that can be analyzed, studied, and visualized by students and scholars. Also important to note, is that through training of students, scholars, and librarians in the TEI and in developing assignments and teaching materials from their collections, the WWP project team, has created a community of practitioners.

The musicology community is beginning to follow in the footsteps of its colleagues in literary studies and with the development of MEI and MusicXML (early 2000s), developers, scholars, archives and library professionals are applying the standards and schemas drawn from the TEI and XML communities to music sources in an effort to build digital editions.
Within the last decade or so a number of digital music editions have been under development or published that focus on music of composers or repertoire from the 16th, 18th, and 19th centuries. In terms of encoding projects, the musicology community does not yet have anything comparable to the Women Writers Project, Willa Cather Archive, or Orlando. What are we waiting for?

If we take a look at which projects have received grants, we will find that in the United States, there were a total of 15 projects (since 2005) funded by the National Endowment for the Humanities and Andrew W. Mellon Foundation. A query in the NEH grants database with the search terms: “digital music,” “music encoding,” “musicxml,” and “optical music recognition” retrieved ten proposals from 2008–2016, for a total of $1,001,056.
The music encoding initiative (MEI) benefited from funding through the Digital Humanities division’s joint NEH and DFG (German) program, receiving funding in both 2009 and 2010 to focus on developing the data model and standard. Four of the ten projects focused primarily on encoding early music, specifically renaissance repertoire, and the one project focused on musical style of western music from 1300 to 1900 that aimed to build “one of the largest online repositories of symbolic musical data” did not include a single woman composer or person of color in the public-facing dataset. In this chart, you will also see that the majority of the projects fall into the tool building category.

The Andrew W. Mellon Foundation has funded music encoding projects since the early 2000s. Querying their grants database with these search terms: “digital music,” “digital musicology,” and “music encoding”, retrieves 5 relevant projects, funded at a total of $1,621,000. Three of these projects focused on (blue) tool building and creation of digital music editions (UK institutions), while the other two (orange) focused on encoding a musical corpus (Indiana U).

This sampling of data from the NEH and Mellon grants also illustrates what Amy Earhart notes in her own observations of digital humanities projects, that “examination of funded projects reveals that the shift toward innovation has focused on technological innovation, not on innovative restructuring of the canon through recovery.” As scholars continue to pursue future grant projects there should be a conscious effort to be more inclusive and perhaps seek out partners across institutions (including libraries and archives) who may house or have access to materials that have been overlooked. Grant agencies should
also encourage applications for music encoding projects that explore or address issues of intersectionality, diversity, and recovery.

Digital music edition projects exist largely in institutions or centres located in Europe where there is a strong tradition of scholarly editing that has flourished, carries more value, and often receives greater resources and institutional support than in other parts of the world. This can be seen with a number of recent projects at institutions, such as the Danish Centre for Music Publication, Akademie der Wissenschaften und Literatur Mainz, Programme Ricercar at the Centre for Renaissance Studies in Tours (CESR/University of Tours), and Universität der Künste Berlin. Many of these institutions are also building tools for computational analysis or graphical user interfaces for non-programmers, which are meant to break down some of the barriers associated with music encoding. While one of the benefits of encoding music is that it enables scholars to encode all versions of a manuscript or printed edition, individuals or institutions engaged in compiling digital music editions are still stuck on the singular composer/creator model. In her essay on “Editing Early Modern Women’s Manuscripts“ Texas A&M English scholar Margaret Ezell makes the following observation, “editors do not please to select certain types of material and this is in part because perhaps we are not yet changing some of the basic assumptions about what an ‘edition’ does, or in [historian Michael] Hunter’s terms, what is ‘appropriate.’ If those of us, in positions of privilege and authority, in selecting music sources for digitization, encoding, or edition creation, are looking for items that represent a “complete” collection or meet the criteria of the “work concept,” then we will continue to overlook the sources that would otherwise contribute valuable data and content for a richer understanding of musical history and a more inclusive digital canon.

What can we gain when we recover, research, and analyze works, typically excluded from the canon? Aspects of musical style, compositional process, attribution, or musical stylometry across genres could be better analyzed and studied if we have a greater representation of musical works, especially in a dataset. Musicologists have analyzed (with traditional tools) stylistic features of composers, such as Fanny Mendelssohn Hensel (1805–1847), who collaborated closely with other musicians, and whose compositions were published under her brother, Felix’s, name. Creating data or encoded editions of works by Hensel and other women, would enable distant reading
across repertoire, identification of unique or similar features with musicians who may have been their contemporaries, relatives, or mentors. Through my research of underrepresented composers (and performers), including Maria Szymanowska (1789–1831) (a predecessor and influence on Chopin) and Teresa Carreño (1853–1917), I have found that close musical communities and mentors were very important to these and other women musicians. And as still continues today, the role of their music teachers had an impact on their compositional style and performance repertoire. What can we learn from the experiences of women composers if we had a dataset to explore? Would it be possible to more easily examine and identify connections between teachers and students, as well as influences on their compositional development? How might elements in the compositional process deviate from, or exemplify, the musical structures and experiences that we expect based on our understanding of the canon? How can we leverage music data and technology to investigate musical communities of practice across the centuries at close and distant levels of reading?

In the 2004 monograph, *Empirical Musicology*, Nicholas Cook wrote “recent developments in computational musicology present a significant opportunity for disciplinary renewal... there is potential for musicology to be pursued as a more data-rich discipline than has generally been the case up to now...” As more content becomes available in forms that can be used for optical music recognition or reformatted for encoding and data analysis, we can not continue to ignore works by women, people of color, and other marginalized figures nor exclude them from large data-driven projects in musicology. Doing so will result in a poorly developed dataset that will impede our understanding of musical development over time.

Post-Script: Promises & Suggestions

During the last thirteen years or so since digital humanities has become commonplace on university campuses, in conference presentations, and publications, music encoding and digital musicology have also gained more interest amongst scholars, students, library and archives professionals. Funding bodies, such as the NEH, Mellon foundation, Canadian Social Sciences and Humanities Research Council, UK Arts
and Humanities Research Council, and others, have supported digital music projects to encode musical corpora, build data models, create digital editions, and develop tools. Librarians, archivists, and other specialists have collaborated with scholars on many of these projects, have presented on the schemas, standards (musicXML, MEI) and encoding projects, and provided workshops or trainings at annual conferences, such as the Music Library Association or Digital Humanities.

As a community, we have invested much time, resources, and intellectual labor into music encoding. As we know, music encoding is resource intensive and also presents numerous barriers to those unfamiliar with the schemas, standards, programming, and tools. At the same time, it holds many promises for the future of music research and the music community. Applications of IIIF and OMR to a larger body of digitized content can make the underlying music data available to scholars and students through search interfaces, such as SIMSSA and other federated search engines. Libraries and archives can explore the use of OMR on their collections in order to extract music notation and incipits, as well as encode music according to MusicXML or MEI standards to meet the Library of Congress’ recommended formats specification for long-term preservation. Larger datasets that better represent diverse repertoires can provide a more accurate understanding of the development in music notation, melodic borrowing, methods of imitation and variation, authorship, and other musical features.

Although there is a growing community of music encoders who are willing to work with XML and develop programming expertise in order to contribute to building tools, analyzing datasets, and creating digital editions, there is still no standard curriculum or lesson plan in place in most musicology or library science and information graduate programs. Institutions and programs, such as the CCARH (Stanford), DDIMAL (McGill), or Indiana University, amongst others around the globe, offer students and professionals the opportunity to engage with current digital musicology technologies and standards, however, many of us are self-taught or become acquainted with the languages and tools after we earn our degrees and have already moved into our careers as faculty or information professionals. There has been a growing need for training in music encoding, as well as other areas of digital musicology. Efforts such as pre-conference workshops,
ThatCamps, or summer institutes, such as DHSI, have served to provide some training, yet too often music faculty who teach undergrad through graduate programs do not fully consider the affordances of digital pedagogy, which may include music encoding, and the ways in which it can enhance their students’ toolkit. Post-graduate opportunities related to music encoding or other areas of computational musicology are often available, but the pool of students who may be interested or have some expertise in this area is still limited.

Students learn to stick to the canon from faculty and institutional programs. Those of us in the music encoding community need to consider cultural constructions, just as much as our colleagues who teach music history classes. For starters, we should not only rely on the music examples provided in music history or theory textbooks, but look beyond to resources, such as Music Theory Examples by Women, which identifies concepts applied in early to modern music repertoire.

When we create encoded music examples we need to include works by women and underrepresented composers. There are a number of initiatives and online sites, including the Diversity Composer Database and the Women Composers Database where unfamiliar or non-canonical composers and works can be identified.

We have already begun to see students, faculty, and performance groups push back against the traditional canon—demanding that curriculum be re-written and concert programs revised to include more than a handful of women or marginalized composers.
Although many of us are working to create tools that may not require musicologists to be familiar with programming or markup languages and schemas in order to use them, there is value in knowing what happens in the “black box.” There is still a hesitancy from faculty to explore music encoding or the application of computational musicology unless they are already familiar with it and use it in their own research. And yes, there is still skepticism of using a computer to study musical works. I have been told a number of times by faculty that music encoding is not a scholarly act and that they do not have time for it.

Moving forward, initiatives such as Music Scholarship Online (MuSo), similar in concept to NINES, 18thC Connect, and the Advanced Research Consortium which have served as peer-review and aggregators of DH (primarily textual/TEI) projects, promises to be an equivalent for music-focused digital projects. While MuSO will not solve the issue of canonicity, it can be used as a tool to not only bring together these dispersed datasets, editions, and other projects, but also to promote transparency through peer review and as a means to critique our progress in addressing canonization. Peer review of digital musicology projects may also persuade scholars to venture into this
area, rather than to continue to pursue traditional publication methods often tied to promotion & tenure. If, as Earhart suggests, "standards and institution have become a core part of project success and sustainability, crucial to the canonization of digital work," then initiatives, such as MuSo and SIMSSA, may be able to shift us towards acts of recovery.

As Tim Crawford and Richard Lewis wrote in their review of the “Music Encoding Initiative” in JAMS 2016, “There may still be some musicologists who would maintain that, since the discipline has managed quite nicely for the best part of two centuries using traditional (non-digital) resources, approaches that require the use of a computer are, somehow, invalid or unnecessary. But for the rest of us—and certainly for most younger researchers—it is obvious that modern tools are needed to enable new modes of investigation that will produce genuinely useful insights into historical repertoires.” If we are to take Crawford and Lewis up to the challenge and use our “modern tools” to “enable new modes of investigation that will produce genuinely useful insights into historical repertoires,” then we must make sure that we, our students, and our collaborators, are mindful of whose works or repertoire we recover, and, consider the cultural constructions that have determined, up to this point, what we have selected and reproduced digitally.

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White Paper
Grant Number HD-228783-15

“MuSO: Aggregation and Peer Review in Music”

Timothy Duguid, Project Director
Texas A&M University
August 31, 2016
Narrative Description
“MuSO: Aggregation and Peer Review in Music” was a project that laid the foundation for a virtual research environment (VRE) dedicated to music. It explored ways in which such an environment could draw from and contribute to existing VREs in the fields of history and literature. The MuSO (Music Scholarship Online) project considered the descriptive metadata needed for digital projects in music to become interoperable with these existing resources and proposed a peer reviewing mechanism that would provide quality control for the projects that would be aggregated by the MuSO VRE.

Project Activities
At the end of September, the Project Director and Principal Investigator, Timothy Duguid, attended the Project Directors’ Meeting at the NEH Headquarters in Washington D.C. By this time preparations had already begun in organizing the primary output of the project: a meeting to discuss issues surrounding aggregation and peer review of digital projects in music.

Immediately following the awarding of the grant, the College of Liberal Arts published a story on the project (along with another NEH project) that was placed on the school’s website and sent to Texas A&M Former Students (see Appendix A). To promote the meeting and the activities of the project, a website was built, at http://muso.tamu.edu. In addition, the Project Director utilized Twitter and Facebook to promote the activities of the MuSO project, including the meeting and the conference presentations that followed.

The meeting gathered a group of leading music librarians, musicologists, and music encoders to discuss these issues at Texas A&M University on January 27 and 28. Discussions occurred both through an email discussion list and at the meeting, the latter of which was attended by the following individuals:

Maristella Feustle, University of North Texas
Richard Freedman, Haverford College
Giuseppe Gerbino, Columbia University
Francesca Giannetti, Rutgers University
Johannes Kepper, Detmold/Paderborn
Mark McKnight, University of North Texas
Laurent Pugin, Répertoire International des Sources Musicales
Perry Roland, University of Virginia
Craig Sapp, Stanford University
Carl Stahmer, University of California at Davis
Joanna Swafford, State University of New York, New Paltz
Raffaele Viglianti, University of Maryland

The following participants were unable to attend the meeting, but they participated in the email discussions:
Those unable to attend the meeting were also able to participate remotely using the BlueJeans meeting service to which Texas A&M has an ongoing subscription.

The meeting was divided into two parts: day one dealt with issues surrounding the minimum metadata that should be required of digital projects in music, and day two focused on issues of peer review for digital projects (see Appendix B). The meeting incorporated several paper presentations, focused small group discussions, and large group discussions. Participants were invited to make notes on a shared Google Doc, and those notes were used to compile the final meeting notes (see Appendix C).

In the weeks and months following the meeting in January and before the ARC spring meeting, discussions continued via the email discussion list. In the course of those discussions, we were able to confirm a set of six recommendations to the ARC community that would promote the aggregation of musical resources and content along with its existing historical and literary collections (see Appendix D).

The Project Director attended the spring ARC meeting held at Purdue University on May 5-7. At that meeting, he presented a proposal for MuSO to join the ARC community. MuSO was officially admitted to the community, and Director participated in the metadata discussions that followed, presenting MuSO’s recommendations for modifications to ARC’s metadata standards.

Due to the activities of MuSO, the Project Director was invited to participate in a question-and-answer panel at the Music Library Association in Cincinnati entitled “Bridging Emerging and Established Approaches to Music Research” during which he discussed the MuSO project and the need for a virtual research environment for music that draws together new and existing digital resources for music along with those being created by scholars in other humanistic fields.

To promote the findings of the MuSO meeting among musicologists and music encoders, the Project Director gave paper and poster presentations at relevant conferences. First, he presented a paper at the American Musical Society Southwest spring meeting in San Antonio, TX (see Appendix E). He also presented a poster at the Music Encoding Conference in Montreal. The poster was entitled “Music Scholarship Online: Aggregation and Peer Review for Music” (see Appendix F), and it garnered much interest from the encoding community as it seeks to ensure high-quality digital scholarship is accessible and discoverable to music performers and scholars alike.
Accomplishments

This project set out to accomplish two things: to establish a metadata framework for digital objects relating to music and to outline a method for peer reviewing digital content relating to music. The first objective was accomplished through the RDF recommendations that MuSO made to the ARC community. With these set, MuSO has a basic RDF schema on which to start aggregating objects that will make them interoperable with digital objects relating to other disciplines already aggregated by ARC.

The second objective was accomplished by outlining a bi-level peer review process. The MuSO community decided that the first level of peer review would be most appropriate for digital collections. At this level, the MuSO Advisory Board would determine the suitability of the content by asking each project the following questions:

1. To whom is this content interesting?
2. How does the project make its materials manifest, exposed, and documented?
3. What is the sustainability plan for the project?
4. Does the project achieve its own goals?

Should a project require a more rigorous academic review, the MuSO Peer Review Board would assign it to a discipline-specific reviewer who would consider the resource’s content and a technology reviewer who would ensure the material is stored and presented in ways that adhere to current standards.

Audiences

There were three major audiences for this project: music librarians, traditional and digital musicologists, and digital humanists. Participants in the MuSO meetings and email discussions were taken from these three groups, and specific actions were taken to reach out to each during and after the meeting in January.

The first major audience, music librarians, form perhaps one of the most important groups for the MuSO project, particularly in its early stages due to their expertise in descriptive metadata and the myriad of recent and ongoing digitization projects that could be aggregated into MuSO. As such, the project director has attended consecutive annual meetings of the Music Library Association. This has been invaluable as he has been able to raise awareness for the MuSO project. At the last meeting in Cincinnati this past March, the project director participated on a panel during which he outlined the MuSO project for an audience of 150 music librarians.

The second major audience, digital musicologists, is a significantly smaller group than music librarians. However, it is no less important. This second group will generate the born-digital projects that MuSO will review and aggregate. The project director gave a paper presentation at the April meeting of the Southwest American Musicological Association in San Antonio, which was attended by 50 musicologists from Texas and American Southwest. The paper was very well received and has sparked new collaborations with musicologists in the Southwest United States, as many of them are engaging in born-digital research projects and music digitization projects. In addition, the project director presented a poster in May at the Music Encoding Conference in Montreal.
The poster garnered significant interest from the conference’s 80 digital musicologists and students in attendance from around the world.

The final major audience, digital humanists, was also reached in a couple of significant ways. First, the MuSO project teamed up with the Digital Humanities Working Group at Texas A&M to present a public lunchtime presentation by MuSO participant Carl Stahmer on the final day of the MuSO meeting. The presentation, entitled “The Early Modern Ideology: the economics and politics of moveable and virtual type” built on the MuSO discussions by exploring the new developments in the English Short Title Catalogue, particularly as it builds and implements a linked data infrastructure for its database. The presentation was attended by 50 digital humanities scholars from Texas A&M. The project director has also had a snapshot presentation accepted at the upcoming Digital Library Federation Forum meeting in Milwaukee in November, which will serve to expand awareness of the MuSO project, particularly as it looks ahead towards implementation.

**Continuation of the Project**

With the RDF established and a peer reviewing process outlined, MuSO is ready to be implemented as a full-fledged Virtual Research Environment and member of the Advanced Research Consortium. The project director has taken a new position at Glasgow University starting in October of this year, and Glasgow is very interested in the development and implementation of MuSO and will support the director as he seeks implementation funding for the project from within the United Kingdom. In particular, the Mellon Foundation has historically funded projects similar to MuSO, and the Leverhulme Foundation and Arts and Humanities Research Council are other potential benefactors for an implementation project.

Thanks to the outreach efforts of the project, a number of partnerships have been strengthened that will be critical in the future implementation of MuSO. The Advanced Research Consortium has been a key partner in the MuSO project, and this relationship promises to continue into the implementation, particularly as MuSO has officially become an official member of the ARC community. In addition, the MuSO project has resulted in strengthened collaborations with the Music Encoding Initiative (MEI) out of the University of Virginia, and MuSO will look to establish MEI as the standard for encoding RDF-compliant metadata for participating projects. It will also continue to work with the Single Interface for Music Score Searching and Analysis (SIMSSA) project out of McGill University to develop a method of sharing data so that both can benefit from the content available through their aggregated digital resources.

A number of new partnerships have also been formed as a result of the outreach efforts of the MuSO project. Notably, MuSO will collaborate with *Digital Humanities Quarterly* and *DHCommons* to publish MuSO peer reviews. MuSO will also pursue formal partnerships with *Répertoire International des Sources Musicales* as well as the Opera and Ballet Primary Sources project out of Brigham Young University to help identify and provide content for aggregation into MuSO and in fine-tuning the RDF for MuSO.
**Long Term Impact**

Thanks to the recommendations of the MuSO community, a number of changes have been made to the ARC RDF standards that will allow it to aggregate and describe musical content in ways that will be meaningful to music scholars. This will broaden the scope and impact of ARC as it seeks to make digital scholarly content discoverable and accessible to students and researchers around the world.

**Grant Products**

The grant resulted in a number of products. First, Elizabeth Grumbach and Laura Mandell gave presentations on aggregation and digital peer review at the MuSO meeting in January, and the PowerPoint slides from these presentations are freely available through Texas A&M’s digital repository, the OakTrust at [https://oaktrust.library.tamu.edu/handle/1969.1/157173](https://oaktrust.library.tamu.edu/handle/1969.1/157173). In addition, the official notes from the meeting are stored and freely available from the OakTrust.

The project director’s panel presentation in “Bridging Emerging and Established Approaches to Music Research” from the Music Library Association meeting may be viewed through the MLA’s conference video archives at [http://www.musiclibraryassoc.org/mpage/mla_2016_media](http://www.musiclibraryassoc.org/mpage/mla_2016_media). The poster presented at the Music Encoding Conference is reproduced in Appendix F. Finally, the presentation that the project director made at the American Musicological Society is available in Appendix E and is being revised for submission to *Notes*, the Journal of the Music Library Association.

The MuSO website, available at [http://muso.tamu.edu](http://muso.tamu.edu), provides another set of links to many of these resources. It is hosted by the Initiative for Digital Humanities, Media, and Culture (IDHMC), where it will continue to reside for the next two years, until funding can be secured to implement MuSO, or until another host can be found.
Appendix A: Local Publicity

Major grants to preserve the arts
July 13, 2015 (taken from https://liberalarts.tamu.edu/blog/2015/07/13/major-grants-to-preserve-the-arts/)

By Tyler Webb
With two new grants from the National Endowment for the Humanities (NEH), one of the largest funders of humanities programs in the United States, the College of Liberal Arts at Texas A&M University will be able preserve historical culture and musical arts.

Daniel Schwartz, an assistant professor in the Department of History and grant recipient, is on the second round of funding of a $300,000 grant project, “Advanced Reference Resources for Middle Eastern History.”

The main focus of the project, which is co-authored by David Michelson of Vanderbilt and Jeanne-Nicole Mellon Saint-Laurent of Marquette, is the website Syriaca.org, which publishes online reference works regarding the culture, literature and history of Syriac communities during the late antiquity period to present. Syriac, a dialect of Aramaic that is still used liturgically in Christian churches throughout the Middle East, is a large part of their heritage and culture.

“The basic mission of this website is to create a cyber-infrastructure, which is basically a set of online tools for doing research but also for linking research projects,” Schwartz said. “So we collaborate with a handful of projects in the states working with manuscripts and texts.”

The prevalence of Syriac culture sprouted during the period commonly known as the Dark Age, or Late Antiquity, which refers to the moment when the Roman Imperial power in the western half of the Mediterranean fell apart and the development of barbaric kingdoms became prevalent.

While previously overlooked, scholars have recently shown interest in this period because this is when cultures outside of the Roman core began to produce their own languages and literature.

“They are considered barbarians by the Romans,” Schwartz said. “They’re outside the civilized world. It’s a great moment when we get the periphery talking back to the core.”

One of the key things being done through Syriaca.org is the creation of Unique Resource Identifiers, or URIs, that allow researchers to link their information together into one common system.
“My specific area of focus is working with people,” Schwartz said. “There are many different names that people use to refer to me, and as a human you understand that, but a computer has no way to comprehend that unless we tell it that. These URI’s create the opportunity to link between a variety of things. We’re creating these unique identifiers for people, texts, and manuscripts.”

With this next round of funding, Schwartz’s team is working on a handbook of Syriac texts, cataloging all the authors, sources and works, and putting all of them into one place.

The second NEH grant is for a project entitled “Aggregation and Peer Review in Music.” It is a $30,000 start-up fund with similar principles of preservation. Led by Timothy Duguid, a postdoctoral research associate in the Initiative for Digital Humanities, Media and Culture, the project aims to create MuSO, or Music Scholarship Online. This will serve as a library of musical projects available on the internet.

Ranging anywhere from Beethoven to Lady Gaga, Duguid says this site is for the preservation of all music styles.

“It’s sort of like a one-stop shop for finding things online,” Duguid said. “It fills a need right now in the music community. Music researchers are starting to produce resources online but don’t have a way to promote them. There’s single place where I, as a scholar, can go to find it. This will make it so that even if you don’t know it exists, you will still be able to find it.”

In addition to a significant publicity campaign for MuSO, the funding from the grant will be largely used to host a two-day workshop of 15 scholars at Texas A&M to discuss the project.

“We will be discussing two areas of focus,” Duguid said. “First is regarding aggregation: What data do we need to collect from projects in order to make this valuable to music scholars. The second is providing peer review for projects that we decide to ingest. We want to make sure that the resources we are gathering are high quality.”

The funding for the project began in June, so the workshop is expected to be held within the next year.
Appendix B: Meeting Schedule

**Thursday, January 28**
9:00-9:30 – **Welcome & Introductions [MSC 2505]** (Timothy Duguid)

9:30-10:30 – **Breakouts & Discussion [MSC 2505]**: What do music scholars need from a digital curator and search mechanism?

10:30-11:00 – Break

11:00-12:30 – **Presentation [MSC 2505]**: “A template for MuSO: The Advanced Research Consortium and its RDF Guidelines” (Laura Mandell & Elizabeth Grumbach)

12:30-13:30 – Lunch

13:30-14:30 – **Breakout session [MSC 2505]**: What can current music projects tell us about essential metadata for music scholars?

14:30-15:00 – Break

15:00-17:00 – **Discussion [MSC 2505]**: What RDF guidelines should be used by MuSO?

**Friday, January 29**
9:00-10:00 – **Presentation [MSC 2505]**: “Digital Peer Review within ARC” (Laura Mandell & Liz Grumbach)

10:00-10:30 – Break

10:30-11:30 – **Breakout Discussions [MSC 2505]**: What standards should be used to evaluate digital projects in music? What are some exemplars for digital projects in music?

11:30-13:30 – **Lunch and Public Presentation [Glasscock Center]**: “The Early Modern Ideology: the economics and politics of moveable and virtual type” (Carl Stahmer)

13:30-15:00 – **Discussion [LAAH 433]**: What should be the peer review process for digital projects in music?

15:00-15:30 – Break

15:30-17:00 – **Discussion [LAAH 433]**: Future plans and next steps
Appendix C: Meeting Notes

1. Breakout Session 1 – “What do music scholars need from a digital curator and search mechanism?”

Participants were asked to list some music aggregators and then to identify the critical characteristics of a music scholarship aggregator.

The group identified the following aggregators:
- ArchiveGrid (www.oclc.org/research/themes/research-collections/archivegrid.html)
- Digital Resources for Musicology (drm.ccarh.org)
- DoReMus (www.doremus.org)
- Europeana Sounds (www.europeanasounds.eu)
- Isidore (www.rechercheisidore.fr)
- Music Treasures Consortium (memory.loc.gov/diglib/ihas/html/treasures/treasures-home.html)
- Opera and Ballet Primary Sources (sites.lib.byu.edu/obps)
- Portal to Texas History (texashistory.unt.edu/)
- NINES (www.nines.org)

It was discussed that good aggregators should:
- Include short descriptions of the projects as a whole
- The descriptions should be uniform and use metadata
- They should be flexible to allow for some variability based on individual project needs
- Allow user submissions
- Allow easy searching
- Offer outreach and training for metadata standards
- Acquire a constant funding source

2. Breakout Session 2 – “What can current digital projects tell us about essential metadata for music scholars?”

Participants were asked to list some digital projects in music and to take a look at their descriptive metadata. They were then asked to compare this with ARC’s RDF.

The list of digital projects included:
- Augmented Notes (www.augmentednotes.com)
- Beethoven’s Werkstatt (beethovens-werkstatt.de)
- Centre for the History and Analysis of Recorded Music (www.charm.rhul.ac.uk/sound/sound.html)
- Chopin First Editions Online (www.chopinonline.ac.uk/cfeco)
- Documenting Teresa Carreño (documentingcarreno.org)
Projects identified generally used the following metadata categories:

- Creator
- Title
- Unique Identifier (URI)
- Scope and content statement
- Repository
- Form/Genre
- Notation types
- Tools/Capabilities
- Typology
- Technical specs for recordings, etc.
- Authorities

It was suggested that the MEI header could be a vehicle for metadata content.

One suggested modification to the ARC RDF was to change `<role...>` to something like `<Persname role="XXX" xml: id = “Jane Doe”>`. This would make the data more interoperable and compatible with linked data systems.

It was determined that some of the ARC RDF is not consistent and that the categorizations need to be brought to the same level. That is, apples and oranges should not be possibilities in the same metadata field.

For the `<dc:type>` field, the following should be added:

- Dataset
- Printed text
• Realia
• Notated music
• Encoded content

We also recommend that “full text” should be modified to “searchable content” or something to that effect to allow for searching of encoded media.

3. Breakout Session 3 – “What standards should be used to evaluate digital projects in music?”

Objects that can be reviewed:
• Encoded content
• Software tools
• Archives
• Digital editions

Things to consider in a review:
• Motivation of the project (audience, perceived use, goals)
• Documentation of the project
• Integrity of practices, research questions
• Clear and orderly site architecture
• Visibility and Accessibility (Usability)
• Sustainability (a plan must be in place, regardless of whether it is to last or become obsolete)
• Description of the intellectual property and materials that the site offers
• Accreditation of sources and contributors
• Importance and Relevance
• Innovation and Originality (either in presentation or content)
• Interoperability

We determined that MuSO should have two levels of peer review:
1. Aggregation Review – This is a basic review by the editorial board to determine whether a project merits inclusion in the MuSO catalog
2. Traditional Review – This is an academic review of the content and presentation of the resource

We recommend that ARC change its basic peer review questions to:
5. To whom is this content interesting?
6. How does the project make its materials manifest, exposed, and documented?
7. What is the sustainability plan for the project?
8. Does the project achieve its own goals?

Next Steps
It was agreed that MuSO should join the ARC community. A sub-node structure for MuSO could be envisaged that would parallel the current ARC structure. However, MuSO should start as a single node that could then subdivide as things develop in the future.
The initial governance structure of MuSO would consist of an appointed advisory board. After it is established, a more representative system will be established that will include representatives from relevant scholarly societies.

An application will be submitted that will help implement MuSO through an NEH Implementation Grant. That grant will fund:

- Software development
- Metadata creation
- Database curation
- Publicity and PR for metadata creation, aggregation, and digital peer review

Remaining Questions:

- What is MuSO going to aggregate?
- How do you deal with umbrella projects vs. smaller projects (i.e. SIMSSA vs. its components like Diva.js)?
- Should we aggregate software and how?
- How do we evaluate collaborative work?
- How should we modify <collex:genre>?
- How should we modify <dc:discipline>?
- Should we use Collex? What are our other options?
Appendix D: Official Recommendations to ARC

1. ARC should change its formatting for the role element to something like <Persname role="XXX" xml:id="Jane Doe"> Are there any other metadata elements that should be treated similarly? (see http://bit.ly/collexwiki)

2. The <collex:genre> element currently includes formats and genres, so it would be best to modify it as below while moving the deleted values over to the <dc:type> element (added values are in bold, deleted values are struck-through):

   Analysis, Bibliography, Catalog, Citation, Collection, Correspondence, Criticism, Drama, Ephemera, Edition, Fiction, Historiography, Law, Life Writing, Liturgy, Musical Work, Musical Analysis, Musical Recording, Musical Score, Nonfiction, Performance, Pretext, Poetry, Religion, Reference Works, Review, Scripture, Sermon, Translation, Travel Writing, Treatise

If this is not possible or acceptable to the ARC community, we would recommend retaining both the deleted and adding the new values.

3. We came up with a set of recommended new values for the <dc:type> element in January. However, given that the current <collex:genre> element includes a number of formats in addition to genres, I have modified our original suggestions so as to make a better distinction between type and genre. You will note that I added “Ephemera” instead of “Realia”. Is that acceptable? The following are the suggested values for <dc:type> (additions are in bold):

   Citation, Codex, Collection, Dataset, Drawing, Encoded Content, Ephemera, Illustration, Interactive Resource, Manuscript, Map, Moving Image, Notated Music, Periodical, Physical Object, Printed Text, Roll, Sheet, Sound, Still Image, Typescript

4. Regarding the <collex:discipline> element, most are happy with the broader term “music” to replace “musicology”, especially due to the confusion that could result from using the term musicology (what about music theory, composition, etc.). However, I agree with some that “Art History” should be similarly broadened to “Art” (allowing for art criticism, research, history, etc.). The recommended values for this element would therefore be (modified values are in bold):

   Anthropology, Archaeology, Architecture, Art, Book History, Classics and Ancient History, Ethnic Studies, Film Studies, Gender Studies, Geography, History, Law, Literature, Manuscript Studies, Math, Music, Philosophy, Religious Studies, Science, Theater Studies

5. ARC’s current model using <dcterms:hasPart>, <dcterms:ispartof>, and <dc:relation> are sufficient for now, but MuSO will require more complex descriptions of relationships and will be investigating a more FRBR-based model.
6. ARC should include a review date for peer-reviewed content by creating a new non-mandatory element called `<collex:reviewdate>`
Appendix E: Paper given at the American Musicological Society Southwest spring meeting

AMS Southwest Meeting
April 2, 2016

Music Scholarship Online: Problems for Digital Musicology and a Potential Solution
By Timothy Duguid

When I moved from Scotland to Texas in 2013, I traded-in castles and kilts for American football stadiums and cowboy boots. A historical musicologist whose idea of digital humanities consisted of HTML websites, PDFs, digital music recordings, and Excel spreadsheets, I also found myself in an English department (of all places) trying to navigate a strange new world of metadata schemas and data visualization along with a collection of acronyms and abbreviations that reminded me of Alphabits Soup. My first year was spent configuring a new visualization laboratory dedicated to humanities research, while also trying to catch-up with these new concepts. Throughout my time there, however, my work has revealed several ways in which musicological research is lagging behind other disciplines such as history and literature.

As Laurent Pugin recently observed, most digital work in the field of musicology to date has been focused on issues of access and scale. As we are all aware, more and more resources are being made available online as collections are being digitized. Some examples include the Digital Archive of the Beethoven-Haus, the Digital Image Archive of Medieval Music, and the Julliard Manuscript Collection. In fact, the 2014 AMS Conference in Milwaukee included an entire panel on “Digital Musicology”, and it focused almost exclusively on digitized collections and archives.

However, digital musicology and indeed the digital humanities as a whole reach well beyond simply taking a picture of a resource and cataloging it for a web-based interface (valuable as those efforts may be). They also relate to the ability to use, analyze, and manipulate the information contained in that picture. Computers do not natively know how to read what is on an image, so groups such as the Text Creation Partnership have set out to transcribe text-based resources to make them fully computer searchable. Similar efforts in music research would include the KernScores repository and the Josquin Research Project out of Stanford University. Along with the ELVIS project out of McGill University, these projects are focused on creating large collections of computer-readable music for the purposes of analysis.

Since hand transcription is so time intensive, however, corporations such as Google are investing significant capital in Optical Character Recognition technologies. These effectively program computers to be able to “read” what is on images. This is similar in music, which is
even more complicated for computers to “read”. Nevertheless, researchers at McGill are attempting to produce a reliable Optical Music Recognition tool that will allow them to quickly transcribe music that can then be searched and analyzed.

Despite these advances, the musicological community has shied away from implementing these along with other recent developments into research and dissemination workflows. Beyond making more music accessible and analyzable as computer-readable data, adaptive user interfaces for displaying and playing music and hold amazing promise for researchers. It is now possible to build and develop diverse, open digital resources to help people better understand and work with music-related data.

There are a number of reasons for the community’s reticence towards digital methodologies. Frans Wiering recently published the results of a survey of the ISMIR community that revealed that the lack of usable data was the most significant barrier to scholarship in digital musicology. Second to that were issues of usability and training. Since this survey was conducted among so-called “techies”, it is no wonder that they were most concerned with data availability. If I was to poll this room or music departments across the American Southwest, however, I would anticipate that the most significant hurdle would be unfamiliarity or discomfort with digital resources and computer programming. Indeed, there is presently a sharp learning curve for conducting digital research in musicology, and when we add to that the many demands that are made upon the schedules of early career faculty and researchers (the folks who are most likely to want to conduct that research), it is no wonder that digital musicology and its research methodologies remain relatively unexplored and underutilized.

Beyond issues of time constraints, the most significant barriers to born-digital projects in musicology center around the concepts of authority and discoverability. Information posted on the Internet, particularly outside of traditional reputable journals and publishers, carries the stigma of being academically suspect. Given the amount of time and labor required in generating digital resources, few are willing and able to invest a significant amount of time into something that will not advance their career. This then carries over into the music classroom, leaving students to assume that the latest technology in musicology research is limited to PDFs PowerPoints, and streaming audio.

Discoverability also remains a significant issue for all digital projects. Indeed, the challenge for anyone posting information on the internet – regardless of whether that information is open or proprietary, music-related or otherwise – is ensuring that the people who need it most are aware of its existence. Whether we like it or not, Google stands at the forefront of web crawling practices to help with the discoverability problem. Even so, the bias of Google’s search results, placing the most well-connected websites and the most popular websites at the top of its results pages, is well documented. The question for researchers on limited or nonexistent budgets is therefore how to ensure that their content can be discovered and disseminated.

While most researchers in the sciences and humanities therefore still turn to fixed formats for reporting their findings and for sharing their data, some are generating born-digital
resources for dissemination. For instance, Jerome McGann’s Rosetti Archive combines analysis of art, design, and literature into a single digital resource that includes digital editions of Rosetti’s writings and scholarly analysis of all of the site’s content.

It is with these types of projects in mind that McGann began the Networked Infrastructure for Nineteenth-Century Electronic Scholarship (NINES). He argued that there would be a brain-drain from digital studies if pre-tenure researchers could not get proper academic credit and wide recognition for their digital work. This virtual research environment (VRE) aggregates digital projects alongside content from archives and scholarly journals, providing a one-stop-shop for nineteenth-century studies. Since the development of NINES, other communities have come online using it as a model: the Medieval Electronic Scholarly Alliance (MESA), the Renaissance Knowledge Network (ReKN), 18th Connect, and Modernist Networks (ModNets). All of these resources form nodes in the Advanced Research Consortium (ARC), providing coverage of humanistic research in each of the major historical epochs of Western Culture. ARC has also begun to add subject-specific mini-nodes that are based on libraries’ special collections. These include Studies in Radicalism Online (SiRO) out of Michigan State University and the Great Lakes Aggregator out of the University of Michigan.

ARC stands as an answer to those who are concerned with both discoverability and career advancement in the digital humanities. Scholarly projects request peer review by the illustrious editorial boards that serve each period-specific scholarly community. For projects that pass this peer review, ARC then collects descriptive metadata about them so that they can be aggregated with other high quality resources in a faceted search interface. This is admittedly similar to the cataloging work already being done by libraries, with a significant difference. ARC is a grassroots organization built by scholars for scholars. It relies on its contributors (the experts) to describe their own projects.

ARC does not store anything other than descriptive metadata. Therefore, its user interfaces respond to search queries by presenting the relevant returns from each of its period-specific nodes and then they send users out to the actual resources themselves. This gives each project an amazing amount of flexibility to determine how much information it wants ARC to index, and this allows each project to determine the best methods for presenting its data and/or analyses.

ARC has been eminently successful in reviewing and aggregating digital projects in the fields of history and philology, as its database now lists nearly 100,000 peer-reviewed digital objects among over 1.7 million other cultural artifacts that can all be freely and openly searched through any one of ARC’s participating nodes.

This is great for researchers in literature and history, but what about music scholars? Indeed, a number of high-quality digital projects in music have begun to surface, and Beethoven’s Werkstatt is just one of those projects. This project is creating born-digital genetic editions of Beethoven’s music. How can scholars generating born-digital music scholarship such as this ensure that their hard work will be discoverable? Furthermore, how can users ensure that the information presented there is reliable?
Enter: Music Scholarship Online (MuSO). This NEH-funded project seeks to establish a virtual research environment dedicated to music studies that would join the ARC community and would therefore benefit from the interdisciplinary resources already contained therein. In its initial phase, MuSO is working with music scholars, librarians, and coders to modify ARC’s current metadata requirements, which are currently tailored to literary and historical scholarship.

We hosted a workshop at Texas A&M at the end of January to begin the revision process, and we came to some interesting conclusions. First, the descriptive metadata required by MuSO must be lean and simple. We are working with digital projects that have limited budgets. If these projects have given any thought to using metadata to describe their site and content, they probably cannot employ a metadata librarian to generate that metadata. Moreover, we are not interested in generating preservation metadata. We are rather interested in gathering metadata necessary for discovery. So, while we rely on the cataloging expertise of librarians, we must continually remind them and ourselves that we are only need the information that will allow scholars to find the digital resources.

Second, we realized that music projects need a more robust system for describing the relationships between objects than what exists for literary and historical scholarship. Perhaps more than any other discipline, music relies on hierarchies and sequences of smaller units to generate perspective and meaning. In the most basic sense, ARC presently allows literary scholars to identify that the “Return of the King” is part of Tolkien’s *Lord of the Rings*, so also music scholars can identify the fourth movement of Brahms’s *Symphony No. 4*. More than that, however, musicians need to be able to express and distinguish more complex relationships including (but not limited to) excerpts, arrangements, and medleys that are far less prevalent in literary objects.

Finally, we need a more standardized vocabulary for describing objects. ARC relies on authorities such as DublinCore and the Library of Congress for its vocabulary, but even so literary scholars have their own ideas of what constitute discipline, genre, and even the `<dc:type>` element from DublinCore. These do not necessarily align with how musicians understand these elements, nor do the existing vocabularies meet the needs of music projects. Once again, we are reliant on the community of music scholars and librarians in helping us to develop an ontology that provides meaningful descriptions to music scholars and that plays well across disciplines.

Having dealt with the discoverability issue, I return to the issue of authority. MuSO’s position as an aggregator of digital music scholarship can only be cemented among academic circles if it can develop a system of peer review that can ensure the quality of its contributions. Following the examples of ARC’s other communities, MuSO will develop a system of peer review. MuSO will gather an editorial board consisting of well-respected music scholars. This group will oversee two levels of peer review. In the first level, the board itself will evaluate projects and archives for inclusion in MuSO. At this level, the board will evaluate projects based on the following four questions:

1. To whom is this content interesting?
2. How are this project's materials manifested, exposed, and documented?
3. What is the sustainability plan for the project?
4. Does the project achieve its stated goals?

Should a project desire a more rigorous academic review, it can apply to the editorial board for the level two review. In these instances, the editorial board would turn to two groups of experts in relevant fields to examine the resource's content and presentation of data.

With these set, MuSO will be poised to be a leading resource for music researchers to conduct high-quality scholarship, both digital and analog. It will allow scholars to discover content from archives, journals, and digital projects; furthermore, it will promote new digital scholarship. Beyond musical studies, however, scholars will be presented with multidisciplinary relationships and therefore avenues for new and innovative enquiries.
Music Scholarship Online (MuSO) is a proposed finding aid and peer review platform for digital scholarship in music. It will gather a community of music scholars dedicated to high-quality digital scholarship that will work together to promote the work of their colleagues by conducting outreach to the music community and by building a research environment for students and researchers to harness the power of technology to conduct and disseminate new and innovative research in music.

MuSO has joined the Advanced Research Consortium, which is a hub of humanities research nodes containing scholarly resources spanning the history of Western culture from the medieval to the modern periods. This strategic partnership will promote high-quality multidisciplinary digital research.

So, you have a digital project....

How can you ensure that people can discover the content of your project?

How can you make your project interoperable with other projects and digital resources?

How can you receive professional credit for your project?
Appendix G: Letter of commitment to host the MuSO website
Laurent Pugin

Interaction with Music Encoding

A significant proportion of Western music is part of a written tradition and its history is closely linked to that of music notation. Over the centuries, written music notation has served as a medium for composers that allows them to interact with musicians, conductors, singers or instrument performers. One key characteristic of music notation is that it is an open system that was constantly evolving, and continues to evolve, according to the needs and original ideas of composers. This is true for the introduction of the most fundamental components of music notation, such as staff lines or notes, but also for the most atypical and peculiar additions, as seen in particular for twentieth and twenty-first century repertoires. New symbols, but principally new ways of arranging and assembling them, are constantly added and established. In this regard, music notation is quite different from text, whose evolution consists mostly of changes in the vocabulary and grammar of the language not requiring significant changes in the components used to write it. These are more or less limited to the letters of the alphabet, and this has not significantly changed for centuries.

The medium used for writing music notation has also evolved over the centuries. As for text, printing followed on from handwritten parchment and paper manuscripts. Music was initially printed with a multiple impression technique, and later with a single impression typographic technique that was particularly well suited to vocal music. During the eighteenth century, engraving gradually superseded the typographic printing technique that the evolution of music notation was making less and less appropriate. This was due in part to the many changes to notation brought on by the development of idiomatic instrumental music, with shorter note durations, larger ambitus, and the development of dynamics and articulation signs, for example. The introduction of a new technique does not automatically make previous ones obsolete. Handwritten manuscripts are still used today, and the typographic printing technique remained in use for decades after engraving became the norm. The successful introduction of a new technique is often determined by economic factors and its profitability. The single impression technique made music printing much simpler and more profitable than before, which was decisive for developing a new marking.
Conversely, early attempts at music engraving in the sixteenth century remained largely unexploited for a long time even though the technique was clearly much more appropriate than typography for music. Later, at the end of the eighteenth century, lithography rapidly became a widely used printing technique, being four times cheaper than engraving.\(^1\)

Repeatedly throughout history we see attempts to make one technique resemble another, usually in imitation of a more prestigious or more established one. For example, the first music incunabula were made to look very similar to manuscripts, as were early engraved prints. Likewise, in eighteenth century typography, square note heads from sixteenth and seventeenth century prints were replaced by round ones, undoubtedly to imitate the appearance of engraved prints.

Imitation is just as much a driving force in computer music engraving. Since the beginning of the development of music notation software applications in the Sixties, the goal has been primarily to generate a result that mirrors plate engraving. Music engraving has a long tradition, with its own rules, and can be seen as an art in itself.\(^2\) Creating a music engraving software application requires both this tradition and the rules of engraving to be understood and formalized. The numerous writings on music engraving have served as guidelines for the development of music notation software applications.\(^3\) However, the inherent complexity of music notation, when combined with the desire to imitate engraving which is of a non-written tradition, makes computer engraving a complex endeavour. It remains barely conceivable that perfect digital engraving can be obtained without human intervention.\(^4\)

Music engraving software applications have also tried to imitate plate engraving in terms of output media by targeting printed editions. The available output of music notation software applications is traditionally PostScript or PDF, two printing formats developed by Adobe. This situation is not surprising since most of the major tools that are currently used, such as Score, Finale or Sibelius, to mention only a few, were designed before the appearance or the growth of the internet.\(^5\) At the other end of the chain, paper is undoubtedly still the most widely used support for musicians to

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2. For an overview of music engraving (and music printing in general) as a visual art, see Kate van Orden (Ed.), *Music and the Cultures of Print*, New York 2000 (Critical and cultural musicology 1).
read music, making printed output fully appropriate. However, only twenty or thirty years after the initial development of music notation software applications, the digital domain has significantly changed with the advent of the online world. For music notation, this translates into new possibilities but also new challenges to be faced. While PDF can easily be published online, either as is or converted to images, it is not a very flexible format and remains seriously limited in terms of interaction.

Behind the scenes

A great number of codes for music have been developed over the years. We can group them into three categories, along the lines of Selfridge-Field’s survey: codes for sound applications, codes for music notation applications, and codes for analytical and more abstract applications.\(^6\) For notation, many of the codes were designed as a storage facility for software applications. This is certainly the case for the proprietary binary formats, which are not human readable and, for the most part, not openly documented. This makes data exchange extremely difficult, if not impossible. A file generated by one software application cannot be read by another, nor even sometimes by later versions of itself when backward compatibility is not supported. A first attempt at providing an exchange data format for music notation software applications was made in the mid-Nineties with the Notation Interchange File Format (NIFF). For various reasons, however, NIFF was eventually abandoned and the currently most widely used interchange format for music notation remains MusicXML.\(^7\)

MusicXML started as an XML representation of MuseData. It was developed by Michael Good and is now owned by MakeMusic, the company that develops Finale. One advantage of MusicXML over NIFF was not being binary, making it human readable. Because it uses XML as the underlying data structure, it also has the advantage of being processable with XML-related technologies, such as XSL transforms, even though in practice this does not seem to be a widely used approach.

Another important plain text format for music notation is LilyPond.\(^8\) More than a code, LilyPond is in fact a compiler for typesetting music notation. The code used by the LilyPond compiler is very similar to the one used by the LaTeX typesetting system, with a markup based on escaped commands and bracketed parameters. LilyPond

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\(^7\) [http://www.musicxml.com](http://www.musicxml.com) [last accessed: 30 Nov. 2015].

\(^8\) Han Wen Nienhuys and Jan Nieuwenhuizen, *LilyPond, a system for automated music engraving*, in: *Colloquium on Musical Informatics (XIV CIM 2003)*, May 2003. See also [http://www.lilypond.org](http://www.lilypond.org) [last accessed: 30 Nov. 2015].
is a quite powerful system that can typeset complex scores. Among its strengths is
the fact that it has a modular design and that it is extendable. One key concept with
LilyPond is that the score is defined with text markup that is eventually processed and
transformed into music notation. This differs from so-called WYSIWYG (‘what you see
is what you get’) approaches adopted by most of the notation software applications,
where the score is created through a user-interface that directly shows what the final
output of the score looks like.

The MusicXML and LilyPond codes are taken here as counter examples for illustrating
the objective pursued by the Music Encoding Initiative (MEI). The overall goal of MEI
is to define a structure for encoding musical documents. It focuses on formalizing
the interpreted content of music documents in a declarative way (as opposed to a
procedural way). As a result, one of the principal goals of MEI is not how to encode
the music notation for it to be processable by existing computer software applications,
or for it to be typesetted, but instead how to model the music notation and how to
represent it digitally in a structured and meaningful way. This fundamental difference
in the approach can be corroborated by the fact that for many years, MEI remained
designed away from software application support, keeping it abstract and un-biased
by any software application requirement. For MEI, however, this resulted in a low
rate of adoption for several years since it was present primarily at a theoretical level.
Furthermore, community-based developments require in-depth discussions, which
can sometimes slow down the development process. This was certainly the case with
MEI, but undoubtedly in a beneficial way. The situation has changed radically over
the last few years and MEI is now widely used in research projects throughout the
world.

The aforementioned codes, and many others, share similar basic concepts (e. g., staff,
notes, rests, etc.). This means that, in practice, converting from one of these formats
to another is possible, but only to some extent. It is in fact quite difficult to go beyond
the basic similar concepts, and this is where the fundamental differences between the
encoding approaches have an impact. LilyPond is notoriously difficult to parse outside
the LilyPond compiler when it comes to complex scores. One reason is that it uses its
own markup syntax (not XML) and a parser that is embedded in the LilyPond compiler,
which makes converting a LilyPond file extremely difficult. But the main reason is that
the structure of a LilyPond file is always organized according to the desired typeset
output, with a strong focus on layout. Consequently, even though LilyPond uses an
architecture that separates the data from the desired output, the latter fundamentally

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9 The project was started about 15 years ago by Perry Roland and is now developed by a community of
scholars with a variety of backgrounds, expertise areas and interests. See http://www.music-encoding.
org [last accessed: 30 Nov. 2015].
drives the structure of the data. Furthermore, because the structure is not constrained
by any schema, it can be of unpredictable complexity. With MusicXML, even though
like MEI it uses XML and is defined by a schema, the stumbling block is structural,
too. Some parts of MusicXML clearly do not model music notation but are instead
structured based on how a software application processes the data. In other words,
it is highly procedural, and the structure of the notation is not given explicitly but
can be extracted only by sequentially processing the data. This is true for chords or
multiple voice writing (where the processing ‘cursor’ goes backward or forward), all
common components of music notation for which the representation in MusicXML is
clearly problematic, beyond its interchange role.

Nonetheless, converting MEI to other codes for rendering the notation has been an
acceptable solution for the MEI community for several years and in many projects.
For this the community has developed various conversion stylesheets, allowing the
MEI to be converted directly to a typesetting format, or to be imported into other
software applications via MusicXML.10 Such a situation was not fully satisfactory,
however, for two main reasons. The first is that converting for rendering quickly
becomes problematic with the rich and complex MEI markup that is precisely its
unique attribute. With a conversion step, it is likely that not all the information will
be preserved in the rendering, or at least only in cumbersome ways. The second
reason, which is directly related to the first, is that converting for rendering seriously
limits the potential for interaction, because some features might be inappropriately
rendered. Furthermore, having a chain of tools makes it difficult to go back from the
notation to the encoding.

Interaction

Music notation interaction is already quite prevalent in music performance and music
composition environments.11 In many cases, notation is mixed with various types of
digital objects, creating so-called augmented multi-media scores. In such approaches,
the score is treated as a graphic object allowing a temporal object to be represented and
extended. One example of such an environment is InScore, a framework for designing
interactive and augmented live music scores.12 It reads common Western music

11 Jason Freeman and Andrew Colella, Tools for Real-Time Music Notation, in: Contemporary Music
Review 29 (2010), Special Issue: Virtual Scores and Real-Time Playing, p. 101–113, DOI: 10.1080/
07494467.2010.509599.
12 Dominique Fober, Yann Orlarey and Stéphane Letz, InScore – An environment for the design of live
notation (e.g., MusicXML) and can be extended with arbitrary digital material, such as images, vector graphics, or videos, for example. It is highly performance focused, with an interface to the Open Sound Control (OSC) format. In such environments, real-time processing is often a key requirement. In Lee, the music notation is displayed in real time, which makes it possible for acoustic musicians to be integrated into laptop ensembles.\textsuperscript{13} Other projects have proposed solutions for integrating uncommon dynamic music notations in Max/MSP environments.\textsuperscript{14} LilyPond, too, has been used for real-time generation of music notation.\textsuperscript{15}

Applications that involve interactions and that are widely used by musicologists are music notation editors. They are mostly desktop applications, with their own music notation rendering engine directly embedded in them. A few online music notation editors exist, however. One of them is Scorio, which uses LilyPond running as a server backend.\textsuperscript{16} Noteflight is an additional example of such an application.\textsuperscript{17} Originally written in Adobe Flash it now also offers an HTML5 version. Interaction with music notation is frequent in music information retrieval (MIR) applications, as well. For example, basic interaction can be necessary for highlighting search results, or in score-following applications. In these, the rendering of the music notation is usually achieved through rendering libraries and the interaction is most of the time unidirectional.

In 2013, the Swiss RISM Office launched the development of an open source software library for rendering music incipits, named Verovio.\textsuperscript{18} The main idea was to develop a tool that could render MEI natively. That is, without having MEI converted to another format, either explicitly or internally in the software application used for rendering. With Verovio, the MEI markup is parsed and rendered as notation with a single tool and in one step. Verovio has been developed as a software library and not as a full software application. This means that it is not a desktop music notation application but instead a software component that can be integrated into a wide range of application environments.

\textsuperscript{16} \url{http://www.scorio.com} [last accessed: 30 Nov. 2015].
\textsuperscript{17} \url{http://www.noteflight.com} [last accessed: 30 Nov. 2015].
The decision was made to develop Verovio from scratch in order to be able to operate on an in-memory representation of MEI. Verovio directly implements the MEI structure internally, with the exception of a top-level page-based organization that is required for the organization of the rendering. The reason for choosing to implement a library from scratch rather than modifying an existing library such as GuidoLib, for example, is that in the long run it will make it significantly easier to render complex MEI features. Previous experience has indeed shown that modifying an existing solution can be very quick to develop at the beginning, but that the development curve eventually reaches a plateau.

Verovio is designed to be light and fast and has no external dependencies, making it very flexible and easy to embed. This opens up a whole range of different possible uses. The JavaScript version of Verovio is particularly promising because it provides a fast in-browser music MEI typesetting engine that can easily be integrated into web-based applications. This setup makes it possible to design groundbreaking web applications where the MEI encoding is rendered on the fly. In such designs we can rethink the interface and avoid mimicking page output. We can instead adjust the layout dynamically to the screen of the device used by the user. The layout can be calculated to fill the size of the screen, or interactively changed according to a zoom level adjusted by the user.

However innovative the dynamic layout of music notation may be, it remains a very basic interaction. Verovio aims to go further and to produce a graphic output that can then be the foundation for more complex interaction. The output in Verovio is designed in an abstract way. This means different output formats can easily be implemented. The default format chosen is the Scalable Vector Graphics (SVG) format. SVG is an XML vector graphic format developed by the W3C. It is supported natively by all modern browsers, including on mobile devices. One interesting feature of SVG is that its XML tree can be constructed as desired. Since Verovio implements the MEI structure internally, this key feature of SVG makes it possible to preserve the MEI structure in the output. Each element in the MEI document has a corresponding SVG element in the SVG tree with the relevant @xml:id and @class attributes. For example, a <note> element with an @xml:id attribute in the MEI file will have a corresponding <g> element in the SVG with a @class attribute equal to “note” and an @id attribute corresponding to the @xml:id of the MEI note.

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19 Pugin et al., Verovio (see note 18).
21 http://www.w3.org/Graphics/SVG/ [last accessed: 30 Nov. 2015].
Preserving the MEI structure in the SVG output is a considerable overhead in the rendering process, since the order in which elements can be drawn does not always correspond to the encoding structure. Nonetheless, Verovio not only establishes a mapping between each MEI element and the corresponding SVG `<g>` element, it also preserves the hierarchy of the MEI elements in its output. For example, in MEI, a `<beam>` can be the child element of a `<tuplet>`, but the opposite is also possible. The hierarchy is fully preserved in the SVG as shown in Figure 1.

Other music rendering tools can also produce SVG, and using this format for music notation is not new. It is also available as an output in LilyPond and VexFlow, or used in the HTML5 version of Noteflight. However, to our knowledge, generating an SVG XML tree that reflects the music encoding is completely new. In other tools, the generated SVG is an unstructured, or very loosely structured, set of vector graphic

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For example, drawing the duration bars of a beam is possible only once its notes have been drawn, or in cross-staff notation, drawing a note on a lower staff is possible only when this lower staff has been drawn.
primitives. In LilyPond, for example, SVG is an alternative to Postscript, and the structure of the SVG is a flat list of graphic primitives corresponding to the sequence in which the corresponding PostScript file is normally written.

The setup provided by Verovio makes interaction with the music notation in web-browsers extremely simple. Interaction is possible with specific MEI elements by accessing them by @id. MEI elements can also be accessed by type. For example, it is straightforward to interact with all slur elements rendered in the SVG since each slur in the MEI will have a corresponding <g> SVG element with the “slur” @class attribute. Furthermore, since the element hierarchy is preserved in the MEI-SVG element mapping, interacting with an element provides access to all its children as structured in the MEI. Accessing a beam in the SVG provides access to all its notes, for example. This would not be the case with an SVG organized as a flat list of graphics. In terms of interaction, all the default interaction possibilities provided by SVG are available out of the box. They include selecting, highlighting via CSS, dragging, hiding, etc.

As a result, Verovio’s output in SVG is not the end of an unidirectional rendering process. Quite on the contrary, it should instead be seen as an intermediate layer standing between the MEI encoding and its rendering that can act as the cornerstone for a bi-directional interaction: from the encoding to the notation, but also from the notation to the encoding through the user interface (Figure 2).
Interaction with the invisible

A major field of application of MEI is that of digital critical editions. In this context, variants between the different sources need to be identified and represented. Variants in music critical editing are a topic in themselves. What to expect varies significantly from one historical period to another, from one repertoire to another, and from one type of source to another, and ultimately each editorial project is unique. Framing variant definitions and variants needs constantly to be re-evaluated on a case-by-case basis, although some common patterns and categories can be established. Recurrent problems in treating variants include defining the scope of a variant, and deciding when a difference between two sources constitutes a variant (or not).

MEI does not answer these questions, which are beyond our discussion. However, MEI includes a whole set of features for encoding variants, which is one of its strengths. It works in a similar way to TEI (Text Encoding Initiative), using a parallel segmentation method for the encoding of the variants. With parallel segmentation, the encoding stream is divided into several branches whenever the different sources have divergent content, each branch representing one version. The segmentation is represented with an \(<app>\) element that contains all variants, each of them being encoded within an \(<rdg>\) element (or a \(<lem>\) element for a lemma, or base text, if any).

This way of representing variants directly in the text is a radical change from the traditional critical apparatus paradigm and it raises interesting challenges in terms of visualization. Experimental work in the MEI community has been done on this. The MEISE editor is one such. Its development focused from the beginning on MEI features, such as editorial markup, that are not supported by existing music notation software applications. In MEISE, the variants can be selected directly from the XML tree. Another project is the meiView web application, which is an experimental project for displaying variants in 15th and 16th century music. It uses VexFlow as a

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25 For more information about this, see the chapters "Critical Apparatus" and "Editorial Markup" of the MEI guidelines at http://music-encoding.org/documentation/2.1.1/chapters/ [last accessed: 30 Nov. 2015].
27 This works well for non-overlapping variants. For overlapping variants, or variants overlapping with other elements in the MEI tree, alternative solutions are being developed.
rendering engine and provides a solution for the user to interact with the variants. Wherever a variant occurs in the score, a green dot is displayed and clicking on it shows a pop-up with all the variants listed. A variant can then be selected from the list.

In terms of design, it seems difficult to conceive a solution that would be appropriate for the visualization of any type of variant, in particular because of the high variability in terms of variant scope. Visualizing note pitch variants will quite likely require a different solution from variants in articulation. Variants where the difference is the insertion or deletion of measures will require completely different approaches, and so will variants that are permutations of entire sections. In some cases, it may make sense to be able to select a specific variant reading, but not always. Selecting one variant reading may sometimes yield results that are musically nonsense. The appropriate solution will be different from one edition case to another.

Verovio does not provide any ready-to-use solution for variant visualization. In that regard, it follows the MEI philosophy and remains application agnostic. Just as MEI aims to provide a general framework for encoding music documents, so the goal of Verovio is to provide a generic solution for rendering MEI without making strong assumptions on the visualization setting or the interface design. Verovio is a rendering engine developed as a software component and not an end-user application. The interface design is left to the application development.

Not providing a ready-to-use solution does not mean not providing anything, quite on the contrary. In fact, there is no need to provide a ready-to-use interface for variant visualization and interaction in Verovio because it already provides *de facto* a generic foundation for this: its SVG output.

With a printed edition, it is not possible to display everything in the score. Variants have to be presented separately in a critical apparatus. Similarly, variants encoded directly in the text in parallel can rarely be displayed all together (unless for very basic variants with limited scope). Consequently, Verovio is designed to render only one reading at a time.30 There may appear to be nothing in the notation rendered by Verovio that indicates the existence of a variant, but in fact this is not the case. Thanks to the preserved MEI structure and the MEI-SVG element mapping, the SVG tree includes a graphic XML element `<g>` for both the corresponding `<app>` and `<rdg>` MEI elements. This feature is available for variants, but also potentially for any editorial markup of MEI. By editorial markup we mean `<corr>`, `<sic>`, `<unclear>` for encoding corrections, apparently incorrect or unclear content, or markup for

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30 The variant selection is performed by passing an XPath expression matching the desired reading. Otherwise, the first reading (or the lemma if any) will be displayed.
Laurent Pugin

Figure 3: Verovio can be embedded in web applications and CSS manipulations can be used for highlighting desired elements in the notation

encoding the writing process such as <add> or <del> for insertions and deletions, for example. Having the editorial markup preserved in the output tree makes it very easy to develop interactive applications on top of it. Only to give one example, a very basic CSS operation on the SVG can highlight all the <corr> elements in the rendering.

The fact that Verovio renders only one variant at a time is no limitation. Indeed, even if not displayed, all variant readings exist in the SVG output. The output of Verovio includes in the SVG tree a graphic XML element <g> for each variant, including those that are not displayed. This means that the foundation Verovio provides for editorial markup interaction is invisible but exhaustive and fully accessible at any time. This is not only valid for the content of an <app> element, but with any segmentation appearing in the encoding, for example when encoding alternative content with a <choice> element.

The variant or alternative content that is currently not rendered is represented in the output and is accessible. It can be highlighted via CSS, or made clickable, for example. This is the true unrevealed interactive power of Verovio and it opens up completely new possibilities of interacting with the encoding.
Interaction with Music Encoding

Outlook

The basis for interactivity offered by MEI coupled with Verovio follows some important design principles. First for all, the principle of availability and discoverability. That is, all the content (e.g., all the variants) is available. Alternative text can be made discoverable, for example with CSS highlighting. It also follows the design principle of scalability. Verovio is light and fast. It can run on small devices, but it also supports large files in higher resource environments.

In addition, the approach proposed by MEI and Verovio fulfills several design principles specific to digital edition environments. They include the need to have good hyper-textual functionalities, which in the case of Verovio is closely linked to the discoverability principle. Alternative content can be accessed through links, for example for switching variants.

There are also some technical principles that are followed as far as possible. They include reusability and durability. By providing only the interaction foundation and not making any assumption in interface design, especially with a software library that has no dependencies, reusability is undeniably maximized. So is the durability, although durability is hard to predict in software development, particularly for digital humanities projects which have slow development cycles in comparison with the development of the technology itself. Reducing dependencies as much as possible is

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32 Typically viewing a MEI file corresponding to the equivalent of couple of hundred pages of music.
one way to increase durability. In the case of MEI rendering, keeping the rendering engine separate from larger applications that will use it is another way.

In terms of editions and interface design, there is much still to invent. This will need to be done hand in hand with the development of MEI. It is obvious that merely imitating printed output in a digital environment will not be satisfactory. Most effort should be spent on developing the added value that digital environments can offer. In parallel with the development of the online world is the appearance of new devices, such as tablets with wireless network access. They offer new possibilities in terms of digital access and change the manner and location in which digital content can be read. Developing these possibilities will not preclude the co-existence of printed editions, which have and will continue to retain their own added value. The challenge now is neither to replicate nor to supplant existing media or applications, but to expand horizons by exploring new ways of conceiving the information to which we have access, and MEI and Verovio are a decisive and exciting step in this direction.
MEI (Music Encoding Initiative) as a Basis for Thematic Catalogues: Thoughts, Experiences, and Preliminary Results

Niels Krabbe & Axel Teich Geertinger
(Danish Centre for Music Publication)

Abstract
The Danish Centre for Music Publication (DCM) was founded in the spring of 2009, building on the philological expertise of The Carl Nielsen Edition, which had published its 33rd and final volume in March 2009. The purpose of the DCM was, by nature, broader than that of The Carl Nielsen Edition, standing so to speak on two legs: one is the edition of unknown music kept in the library to be used by scholars and musicians and based on a philological approach, the other is the development of ways to disseminate the results of the Centre’s work via the internet. The latter aim has resulted in developing a system for storing and presenting data, especially related to thematic catalogs, based on MEI (Music Encoding Initiative) XML. At present, the software developed at the DCM, called MerMEId (Metadata Editor and Repository for MEI Data), is used for catalogs-in-progress for the works of Carl Nielsen, Johan Svendsen, J. P. E. Hartmann, Niels W. Gade, and J. A. Scheibe. In a further perspective, MEI enables the integration of detailed metadata with the full music text, including variants and emendations within the same file in a format that is interchangeable with other software such as a graphical note editor. In our presentation, we will outline the ideas and principles behind the MerMEId software and briefly demonstrate its use, from the point of view of both the editor and the user.

[***]

[Niels Krabbe:]

The following presentation will concentrate on one of the main functions of the Danish Centre for Music Publication: namely the developing of tools for expanding the traditional concept of a well-grounded “institution” in musicology of the previous centuries, namely the thematic catalogue with its host of static information and its strong anchoring in the state of research on the composer in question at the time of its publication – with its host of esoteric abbreviations and hundreds of library sigla – all of which makes it very useful for the dedicated nerd but not very user-friendly.

The presentation is divided into two sections. First I will give a general introduction to the aims and visions of DCM, thereby so to speak showing the intellectual journey from the work of the Carl Nielsen Edition to the concentration by DCM on this special topic; and after that my colleague, Dr. Axel Teich Geertinger will give a more technical presentation of DCM’s use of the
Music Encoding Initiative (MEI) as a basis for thematic catalogues in the broader sense of the word, and the role of DCM in housing and disseminating the tools via open source.

From CNU to DCM

As in many instances in Danish musical life you cannot navigate without including our towering national icon, Carl Nielsen. This also holds true in connection with our topic today: without Carl Nielsen we would obviously not have had a Carl Nielsen Edition. Without the edition we would not have had the Danish Centre for Music Publication, and without the Centre we would not have had the opportunity to get funding for development of the Music Encoding Initiative.

*The Carl Nielsen Edition* was housed at the Royal Library during the period 1993-2009, with the explicit aim to publish a scholarly edition of all the composer’s works.

It was established on the direct order of the Minister of Culture in 1993 because of a high-profile press polemic in connection with very critical remarks from the musicians and the conductor who were to perform Nielsen’s opera *Maskarade* in Germany and Austria. The musical score and the parts sent abroad for this performance, it was claimed, were “a scandal and a mess”, as the leading Copenhagen newspapers wrote on its front page.
In the wake of this serious criticism of Denmark’s handling of an important part of its cultural heritage, the government funded 5 full-time editors over a period of 15 years on the two explicit requirements that the schedule was kept and the budget was not exceeded. So under these working conditions the CNU project came to an end 15 years later with, by presenting 33 volumes in stiff blue bindings, the last volume being published on 31 March 2009, on the very day when the funding stopped.

The success of the Carl Nielsen Edition (mainly as to time schedule and budget) made it possible that the public funding behind the CNU could smoothly be transferred to a new five-year project in the Royal Library, namely the Danish Centre for Music Publication. One of the important considerations was to preserve the music philological expertise that had been built up during the 15 years with the work on Nielsen; no doubt the Nielsen edition was the most comprehensive music philological project having ever been set up in Denmark, and it was important not to lose the acquired experiences within this very restricted area of musicology. Another – and in connection with our talk today important – consideration, was that after all the detailed philological work with Nielsen’s manuscripts, prints, letters and other documents, the lack of a thematic catalogue of his works became pronounced, but also that much information from the edition could comparatively easily be included as an important part of such a thematic catalogue. I need not stress the fact that any composer of a certain stature approximately one hundred years after his birth would be blessed by any one of three standard tools: a collected edition, a standard monograph on life and work, and a thematic catalogue. In 1993 Nielsen had none of these three tools, in 2009 he had one (namely a collected edition) and when DCM was founded a second tool (namely a thematic catalogue) was on the agenda. So, in short the CNU in 2009 became the battering ram for the establishing of DCM.
Aim and vision

Immediately after its start in 2009, DCM formulated the following vision, which is still to be seen on its website and which is meant to govern the work of the centre during its first five-year period (up and until September 2014):

_The primary aim of the Danish Centre for Music Publication (DCM) is to make musical works and musical sources related to Danish music history available for music scholars and musicians; it is also the aim to develop and to expand philological competences and to develop methods and tools for digital editions of music._

As you will understand, the last part of this vision paves the way for expanding the understanding of a thematic catalogue and for considering the potentials of MEI in such a context.

Before Axel Teich Geertinger goes on to discuss technical details, I want to stress certain strategic considerations which we have had to make. When DCM was launched in 2009, part of the grant was tied to producing a thematic catalogue of Carl Nielsen’s works (CNW), and as the grant was given by the rather conservative Carl Nielsen Foundation, who until 2001 had all the performance rights to Nielsen’s music, it was obvious that a publication in traditional book form was expected, and that the funding was to further a Nielsen thematic catalogue ad modum Köchel, Hoboken, Kinsky, Schmieder etc. etc., that was to become a future standard reference tool for Nielsen scholars, musicians, concert managers and others.

A close study of three of the more recent printed thematic catalogues of composers which one could compare with Nielsen – namely Sibelius, Grieg, and Schumann – made us doubt the rationality in producing yet another volume along these lines, or rather the rationality in producing only a Nielsen catalogue as a book. Instead we decided on a more flexible solution, aiming at a combination of a traditional – but rather “small” – book to be available for quick reference on the shelves of libraries and elsewhere, and an ambitious site on the internet combining a traditional thematic catalogue with a modern dynamic Carl Nielsen site. In fact this ambition would mean an abolition of the distinction between thematic catalogue and documentary site in general, including the philologically edited music, tagged in a way which makes possible further manipulation like parallel readings, sources, emendations etc. The latter ambition, namely the inclusion of the full scores with editorial comments and alternative sources still belong to the future.

This is not the place to go into a more exhaustive analysis of the problems behind printed thematic catalogues like the ones mentioned on Sibelius, Grieg and Schumann. They all represent an impressive piece of scholarly thinking and work and are indispensable tools in any scholar’s work with these composers, but already the banal observation that by nature, they represent one and only one state of research, namely the state at the time of their publication, gives food for thought along different lines. To which of course should be added the very limited possibilities of making, for example:

- concordances
- chronological lists
- sorting out of people with different tasks in connection with the composer’s oeuvre like copyists, conductors, soloists
- venues of first performances
- number of movements in the works
- list of various types of sources
- “hands” in the manuscripts
- list of publishers
- dedications

– not to mention: the full score, marked up and tagged with a view to computer-aided analysis of the music. All such questions can be answered by one or two clicks via a site as the one we are aiming at.

Another aim of our use of the MEI standard in this connection is to make a metadata editor to be used for composers other than Carl Nielsen. In practice this aim has had two results so far.

One is that parallel to the Nielsen site, the MEI-based editor is at present being used in-house for thematic catalogues by two other Danish composers, N.W. Gade and J.P.E. Hartmann, and one German composer who worked in Denmark at a certain stage of his life, namely J.A. Scheibe. Furthermore we have made the editor, for which the acronym is the well-known Danish statue “MerMEId”, available as open source, and at present it is also used and developed by our Norwegian colleagues in connection with their planned Johan Svendsen edition and catalogue. Furthermore we have current contacts with colleagues in other places, not least in Detmold.

One final experience – which again may not come as a surprise to you, but which came as a surprise to us: A few months after the start of Danish Centre for Music publications, and after the project sketched above had been planned, we realized that such a project could not materialize unless the staff included very strong and very specialized IT expertise, far beyond what one could reasonably expect from music scholars. In the beginning we had to rely on ad hoc support from the large IT department of the library, but during that last 6 months and for the rest of the first five-year period we have now had a professional computer programmer as a member of staff without whom we would not be able to approach our ambitious goals in the future.

I will now give the floor to my colleague, Dr. Geertinger, for a technical report on MerMEId.

[Axel Teich Geertinger:]

As Prof. Krabbe has already pointed out, we decided from the start that the primary output of CNW (Carl Nielsen Works/Werke) should be an online catalogue, but we were also very well aware that digital solutions have their limitations as well. Not least databases are problematic in terms of preservation, software dependency, and the difficulty of data interchange with other applications.

These technical concerns made us try to re-think thematic catalogues in a broader context and to describe a generic concept for the production of such catalogues rather than providing a composer-specific solution.

When we started in 2009, our considerations happened to coincide with efforts of the Music Encoding Initiative (MEI), aiming at defining an XML-based standard for the encoding of critical editions of music. The first MEI schema defining this standard was released two years ago.
Naturally, this had our interest in terms of future digital editions, since no other encoding system known to us is capable of handling e.g. variant readings. But it was equally interesting for us to learn that MEI was also designed to support quite comprehensive metadata. This gave us the idea that the Nielsen thematic catalogue could be based on a set of MEI documents, which eventually would also be able to hold the entire score – both in the same document.

All these considerations finally made us opt for a solution based on XML documents – one document for each work – rather than a relational database, which otherwise would have been the most obvious choice and, I believe, the one used in nearly all comparable projects until now.

This is not the place to go into detail with the pros and cons of the two concepts, but especially the simple and largely software-independent nature of XML, and, as a consequence, the better long-term prospects were strong arguments for us to choose MEI XML rather than a database.
To illustrate the versatility of the XML-based concept, many different types of software can act on the same document. For instance, we can edit an MEI document with almost any text editor. The main body of the document – the section containing the actual score – could be edited with a graphic score editor. And finally, metadata can be edited with a special metadata editor – this is the project we are focusing on here. As you will see, catalogue data created in this way are by no means dependent on the metadata editor. It is merely an interface for convenient editing and handling, but you can just as well work with your data using other software, if you like.
Likewise, on the output side, many different applications may draw on the same set of data to produce e.g. a catalogue – whether online or in print –, a score, or to provide data for various kinds of music information retrieval applications or computer-assisted analysis. Thus, with the data clearly separated from any mode of presentation, the process of creating the data is independent of the intended output medium (printed or digital).

Our metadata editor has been given the name MerMEId – short for Metadata Editor and Repository for MEI Data. The MEI documents are stored on a web server. The editor itself is basically a large HTML/Javascript form running in a web browser against some server-side software. The MerMEId-specific code as well as any third-party software needed on the web server is all open source and available for free.

Before we take a closer look at the metadata editor, let us see an example of what we can produce with the pre-release version we have running already.

[HTML preview: Carl Nielsen’s Symphony No. 5]
II. Allegro. Presto. Andante tranquillo. Allegro (Tempo I)
Metre: 3/4

Performances

8.3.1922 Göteborg Orkesterförening, Göteborg (conductor: Carl Nielsen).
1.12.1922 Beethoven-Saal, Berlin (Philharmonisches Orchester conducted by Carl Nielsen).
9.6.1923 Tivoli, Copenhagen (conductor: Frederik Schnedler-Petersen).
20.1.1924 Stockholm (Koncertföreningens Orkester conducted by Georg Lennart Schnéevoigt).
9.6.1925 Tivoli, København (conductor: Carl Nielsen).
4.11.1926 Filharmonisk Selskab, Oslo (conductor: Carl Nielsen).
15.12.1927 Amsterdam (Concertgebouw conducted by Pierre Monteux).
27.10.1927 Leipzig (Gewandhausorchester conducted by Wilhelm Furtwängler).

Sources

Score, autograph, printer's copy
[Source classification: music; manuscript; autograph; score; printer's copy]
DK-Kk, CNS 66a [CNU Source B]. Library record
Provenance: 1937: Carl Johan Michaelsen. 34.5x27 cm. 127 pages.
Written in ink (Carl Nielsen). Additions in red crayon (Emil Telmányi) and pencil (Engraver).
Title page: Symfonii No 5 / for / Orkester / af / Carl Nielsen. / Op 50
Library binding. The score was used as a conducting score by CN and presumably also by other conductors, which is reflected in corrections and additions in the score.

Score, draft
[Source classification: music; manuscript; autograph; score; draft]
DK-Kk, CNS 66b [CNU Source C].
34.5x27 cm. 115 pages.
Written in pencil (Carl Nielsen). Additions in blue crayon (Carl Nielsen) and ink (Carl Nielsen).
Title page: Cover: Carl Nielsen / Symfoni nr 2den Del/Title page (library addition): [Carl Nielsen: Symfoni nr 5 / Op 50]
The cover originally only contained the second movement. Later, the first movement has been added. Added on back cover in CN's hand: "De [crossed out] Dunkle, hvilende Kræfter / De [crossed out] Vaagne Kræfter" (Dark resting forces / awakened forces).

Sketch (first movement)
[Source classification: music; manuscript; autograph; short_score; sketch]
DK-Kk, CNS 66c [CNU Source E]. Library record
Provenance: 1958: Irmelin Eggert Møller. 26x34.5 cm. 1 folio.
Written in pencil (Carl Nielsen).
Title page: Added in unknown hand: Carl Nielsen. 5te symfoni (Adagio)
Sketch for the 16 bar Adagio theme, first movement bb.268-283.

**Sketches (first movement)**

[Source classification: music; manuscript; autograph; short_score; sketch]

DK-Kk, CNS 16b [CNU Source F].
Provenance: 1935 (?): Margrethe Rosenberg.
34x26.5 cm. 7 folios.
Written in pencil (Carl Nielsen).
Title page: Suite for Klaver, op. 45
Three sketches for the first movement, contained in the autograph of piano suite opus 45; manuscript dated "Damgaard 20 August 19" and "Damgaard August 19".

**Sketch (first movement)**

[Source classification: music; manuscript; autograph; short_score; sketch]

DK-Kk, CNS 345l [CNU Source G].
34.5x26 cm. 1 folio.
Written in pencil (Carl Nielsen).
Title page: Grammofon-Vals
Rhythmic reworking of two bars of the Adagio theme of the first movement, contained in manuscript with music for the play Moderen.

**Parts, partly autograph**

[Source classification: music; manuscript; partly autograph; parts]

DK-Kk, C II, 10 [CNU Source D].
34.5x26 cm. 170 parts.
Written in ink (Johannes Andersen), ink (Fred.V. Zenders (?)) and ink (NN). Additions in pencil (Carl Nielsen).
Title page: Printed title label: UNVERKAUFLICHES LEIHMATERIAL :: EIGENTUM DES VERLEGENS / CARL NIELSEN / SYMPHONIE NR. 5 OP. 50 / [...] / SKANDINAVISK OG BORUPS MUSIKFORSLAG / AKTIEELSKB. / BREDG. A 19 KØBENHAVN K
Set of parts, some of which were used for the first edition and later, in 1926, as printing copies for the publication by Borups Musikforlag. In 1933 further copies were added to the set. The set was used as rental material until 1951, when it was given to The Royal Library.

**Parts, manuscript copy/phototype**

[Source classification: music; manuscript; copy; parts; complete]

DK-Kk, C II, 10 [CNU Source D*].

**Printed score, first edition**

[Source classification: music; print; score; first edition]

[CNU Source A].
Borups Musikforlag, København 1926. Plate no. MN. 2668.
23x16 cm. 184 pages.

**Printed pocket score, posthumous edition**

[Source classification: music; print; score; later edition]

[CNU Source H].
Skandinavisk Musikforlag, Copenhagen 1950.
19x14 cm. 172 pages.
Title page: Front page: CARL NIELSEN / SYMFONI no 5 / PARTITUR / SKANDINAVISCH MUSIKFORSLAG / KØBENHAVN / IIITitle page: Til mine venner / Vera og Carl Michaelsen / CARL NIELSEN / SYMFONI no 5 / OP. 50 / PARTITUR / SKANDINAVISCH MUSIKFORSLAG / KØBENHAVN
First printed edition, containing a preface by Emil Telmaányi and Erik Tuxen dated August 1950.

**Printed score, posthumous edition**

[Source classification: music; print; score; later edition]

[CNU Source I].
Skandinavisk Musikforlag, Copenhagen 1952.
29.5x23 cm. 172+6 pages.
Title page: CARL NIELSEN / SYMFONI no. 5 / SYMPHONY no. V / OP. 50 / PARTITUR / FULL SCORE / SKANDINAVISK MUSIKFORLAG / KØBENHAVN / III

Preface by Erik Tuxen dated August 1950. Including six pages of editorial notes.

### Printed parts, posthumous edition

[Source classification: music; print; parts; later edition]

[CNU Source I].

Skandinavisk Musikforlag, Copenhagen 1952.

#### Primary texts

**Letters:**

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<td>Carl Nielsen to Johannes Nielsen, DK-Kk CNA IAc</td>
<td>(CNB VI/1959, M &amp; M 193)</td>
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<td>Carl Nielsen to Helge Rode,</td>
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<td>9.10.1920</td>
<td>Carl Nielsen to Vera Michaelaen, DK-Kk CNA IAc</td>
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<td>15.2.1921</td>
<td>Carl Nielsen to Rudolph Simonsen, DK-Kk CNA IAc</td>
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<td>17.2.1921</td>
<td>Carl Nielsen to Emil og Anne Marie Telmányi, DK-Kk MTA CNS</td>
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<td>24.2.1921</td>
<td>Carl Nielsen to Frants Buhl,</td>
<td>DK-Kk NKS 4962 4^e</td>
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<td>4.3.1921</td>
<td>Carl Nielsen to Marie Carl-Nielsen, DK-Kk CNA IIIAa2</td>
<td>(CNB VII/30, T Sch 440)</td>
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<td>5.3.1921</td>
<td>from Anne Marie Carl-Nielsen to Irmelin Eggert Møller,</td>
<td>DK-Kk CNA IIIAa2</td>
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<td>12.3.1921</td>
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<td>from Carl Nielsen to Marie Carl-Nielsen, DK-Kk CNA IIAa</td>
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<td>from Carl Nielsen to Dagmar Borup, DK-Kk CNA IAc</td>
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<td>from Carl Nielsen to Vera Michaelaen, DK-Kk CNA IAc</td>
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<td>from Carl Nielsen to Victor Bendix, DK-Kk NKS 2040 2^e</td>
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<td>27.1.1922</td>
<td>from Carl Nielsen to Wilhelm Stenhammar, DK-Kk CNA IAc</td>
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<td>7.2.1922</td>
<td>from Carl Nielsen to Charlotte Trap de Thygeson, DK-Kk CNA IAc</td>
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<td>2.3.1922</td>
<td>from Alfred Nielsen to Carl Nielsen, Statens musikbibliotek, Stockholm</td>
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<td>3.3.1922</td>
<td>from Carl Nielsen to Cai Wendelboe Jensen, DK-Kk nbd 2. rk.,</td>
<td>acc. 1984/67</td>
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<td>8.3.1922</td>
<td>from Carl Nielsen og Henricke Magnus to Lisa Mannheimer, Privateje</td>
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<td>from Carl Nielsen to Rudolph Simonsen, DK-Kk CNA IAc</td>
<td>(CNB VII/255, M &amp; M 217)</td>
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<td>from Carl Nielsen to Anne Marie Carl-Nielsen, DK-Kk CNA IIAa</td>
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<td>24.7.1923</td>
<td>from Adolf Riis-Magnussen to Carl Nielsen, DK-Kk CNA IAb</td>
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<td>from Wilhelm Hansen to Carl Nielsen, DK-Kk WHA</td>
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<td>7.6.1925</td>
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<td>9.6.1925</td>
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<td>11.8.1925</td>
<td>from Carl Nielsen to Emil Telmányi, DK-Kk CNA</td>
<td>(CNB VIII/408)</td>
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Morten Kristensen: The "Nielsen Symphonic Allegro": Thematic Integration and Musical Cohesion (= Honors Paper, Mary Washington College). Mary Washington College 1992


A. Peter Brown: *The European Symphony from ca. 1800 to ca. 1930: Germany and the Nordic Countries (= The Symphonic Repertoire, Vol.III(A)),* p. 556-568


David Fanning: *The Symphonies of Carl Nielsen*. Manchester University, United Kingdom, Manchester 1977.


*Last changed 2012-05-09*
Some screenshots may give you an idea of what the metadata editor interface looks like so far:
To do

Some of the things we are working on right now:

As the amount of our data grew, we realized that the editor needed to be split up into smaller parts in order to reduce the amount of information to be handled by the browser. With large documents, the system is becoming slow, as it is. We will take each of these tabs and make them a separate editor.

This problem becomes even more apparent with the release of a new MEI schema later this year. The range of metadata supported by the next release is even greater, and there are some structural changes, requiring substantial re-coding the editor interface.

On the other hand, the extended metadata features of MEI 2012 will enable us to handle quite complex situations such as composite sources and different versions of the same work.

Another issue is the handling of formatted text. Both the encoding and the editing facilities for longer texts need improving.

We hope to be able to publish a full version of MerMEId for download this fall. If you would like to see the prototype in action, please contact me and I will show it to you on my laptop. Of course, we would also be pleased to hear from anyone who might be interested in using it.

The Royal Library, Copenhagen
nk@kb.dk / atge@kb.dk
www.kb.dk/dcm
Words appear in music scores with a variety of roles; they can be used as music notation themselves, or spell text to be sung, or be part of paratexts such as forewords and critical commentaries in printed score publications. This article explores the relationships between music and words in the context of digital editing, particularly with a focus on operatic libretti, which carry the spoken and sung words of operas. How can the hypertextual nature of the digital medium be exploited to model and publish these complex and important relationships? To contextualize and answer this question, this essay gives a brief description of these uses of words in scores and their relevance to historical investigation and editorial work. Operatic libretti are analysed more in depth because of their dual ontological status of standalone literary works and parts of operatic works. Carl Maria von Weber’s Der Freischütz, together with the editorial endeavours of the Weber-Gesamtausgabe and the digital edition project Freischütz Digital will serve as an example case study.1

Typically, words are most commonly found in scores for vocal music. Sung syllables are usually written under notes, but verses can also be grouped at the end of a section to indicate new words for repeated music. Across both vocal and non-vocal repertoires, words are also used to clarify and support music notation. Some recurring terms have become symbols themselves, like "piano" and "forte", Italian for "quietly" and "loudly". Often words are used to give directions to the performer and are picked from a well established vocabulary, such as the words and sentences indicating the speed and character of a performance. Composers have been notating music

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1 In the context of critical editing, the word "text" is often used interchangeably to indicate textual information carried by a source document, whether musical or literary, or to indicate reconstructed and edited text of a work. Because this essay focuses on the coexistence of music notation and written language it becomes occasionally necessary to use the word "text" to simply mean written language as distinguished from music notation. Nonetheless, whenever possible, "words" will be preferred for the sake of clarity. This is in line with The New Grove Dictionary of Music and The New Grove Dictionary of Opera, where "words" is used to indicate written language in entries such as Notation, §II and Libretto (i) and (ii).
with varying degrees of detail, though it is evident from written sources that at the
turn of the 19th century music notation was becoming increasingly detailed.\(^2\) It is
especially from this period onwards that it becomes not uncommon to find in the
score more words providing more detailed explanations on how to perform a passage
(notwithstanding the fact that unambiguous precision is unachievable),\(^3\) or even lines
from literary works, guiding the performer towards a certain mood and character
that the music should have. A well-known example is in the third movement of
Beethoven’s string quartet No. 15, Op. 132. The composer defines the movement as
a song of thanksgiving with the words “Heiliger Dankgesang eines Genesenen an
die Gottheit, in der lydischen Tonart” (a convalescent’s holy song of thanksgiving
to the divinity, in the Lydian mode). He later writes “Neue Kraft fühlend” (feeling
new strength), which indicates a narrative shift in the piece. Even though it is not
a prescriptive indication \textit{per se}, the performers are made aware of a mood shift that
they ought to consider when playing the music. This language becomes part of the
music notation and an integral component of the score, thus blurring the boundaries
between music notation and words.

Words are not in scores only as part of the music notation, however. Particularly in
printed publications, it is common to find, before and after the score, words about
the composer, the work, or about the production of the edition. If one looks at scores
as historical objects, these words may constitute an important source of contextual
information to the music work as well as to its performers, students and listeners. This
richness of information is the focus of the \textit{What’s the Score}\(^4\) project at the Bodleian
Library at Oxford University, which seeks to crowdsource transcriptions of text and
descriptions of cover images of several hundred piano scores coming mainly from
the Victorian era. The goal is to see emerging a taxonomy of popular genres, topics
and composers from the paratextual information, which may be more telling than the
music content in these publications.\(^5\)

\(^2\) A need for more detailed notation also reduced the use of too-generic words, for example those
indicating tempo – established during the Baroque period (Notation, §II – Grove Dictionary) – which
were being replaced with metronome markings after the invention of the machine. See Richard Taruskin,
\(^3\) To quote a recent example, Esa-Pekka Salonen’s Violin Concerto (2009) includes a cadenza between
the second and third movements. The written instructions restrain the improvisational and virtuosic
character of a typical cadenza: “This cadenza to be played as written/The pitches must significantly
overlap so that harmonies are heard. The \textit{gesture} of the harmonies is more important than the actual
pitches.”

\(^4\) Available at \url{http://www.whats-the-score.org/} [last accessed: 30 Nov. 2015].
\(^5\) In the Victorian era playing piano at home was a popular pastime of educated classes and formed the
basis of a popular music canon (E. David Gregory, \textit{Victorian Songhunters. The Recovery and Editing of
English Vernacular Ballads and Folk Lyrics, 1820–1883}, Lanham 2006, p. 14–16 and Ruth A. Solie, \textit{Music in
These few examples show how words are used for a variety of reasons in music notation. In the preparation of a scholarly edition, words, like any other sign on the page, may be helpful for the investigation of provenance of a source and to establish relationships with other sources. Words may need specific editorial criteria depending on their function in the score. Those that are part of the music notation are often regularized to the closed vocabulary expected in modern practice. For example, in older sources the words *piano* and *forte* may be spelled in full, or abbreviated in a variety of ways, but are regularized to the corresponding symbols in modern printed editions. Other, more descriptive words are usually left unchanged in editions, such as the words in Beethoven’s 15th string quartet mentioned before.

In the same way as editing words in scores requires dedicated editorial criteria in printed editions, so they do in a digital context. Abbreviations are a particularly telling example: expanding “All:ò” into “Allegro” is a different exercise compared to resolving a figured bass figure or ornament symbol; a different form of encoding is therefore necessary for the machine to tell the difference. Vocal music introduces a further complication; when sung text occurs in the musical score, textual linearity is jeopardized in favour of music notation. Those poetic structures such as verse form and lineation typically made evident by layout and formatting are inevitably lost. In a digital context, encoding can be used to indicate structures even when verses are set to music. This can be particularly useful in the editing of operatic works, where music and textual (as in written language) sources are particularly intertwined, and the libretto and the score are both different and inescapably related works. The following section will analyze this textual condition and reflect on the implications for digital editions of operatic works.

**Libretto and operatic score editions in a digital context**

Although typically associated with their composers, operas are the result of the work of many people that shape the music, words, setting and organization of these complex works. Libretti in particular are usually written by someone other than the composer, and their importance for and influence on the work as a whole has changed considerably through the history of opera. While this article does not intend to trace a history of the libretto, it is useful to discuss a few examples that show that libretti

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*Other Words. Victorian Conversations*, Berkeley 2004, chapter 3). The artistic value of the music itself is not comparable with more sophisticated music of the same time; this music was mainly composed with the idea of being entertaining and not too hard to play. However, this subject is not as well researched as others and an analysis of these publications may contribute considerably to research about the popular culture of their times.
often have an independent genesis from the operatic score and may, therefore, require dedicated editorial effort.

As publications, libretti originated as aids for the opera goers; they would be printed before each performance and were meant as ephemeral objects. These publications would usually include information about the performance such as date, orchestra composition, singers, and other participants. The presence of these facts make the few documents that survived important sources for the study of operatic history and reception. Gradually, the libretto as a publication became a more independent object, meant to last longer and be read away from the music and the theatre. Reinhard Strohm observes:


This evolution of libretto as a publication corresponded to a gradual standardization of the operatic repertory. These more durable libretti enabled the formation of a fairly specialized audience that likely used their copy to re-experience the spectacle of an opera they already knew or wished to know, especially before the existence of recordings. Particularly given the hypothesis of such an audience, it seems worthwhile to consider libretti under the lens of literary criticism. Nonetheless, Brian Trowell warns of a general lack of literary quality and originality of libretti: “of repertory operas before recent times, there is virtually none that has an entirely original plot. The use of a well-known story, whether from history or from fiction, offers great advantage to a librettist.” ⁸ Trowell argues that the requirements of being set to music cause libretti to appear less artistically valuable when compared to other dramatic literature. It is only when music and words are considered together that one can appreciate the “mysterious new compound that results from the fusion of words with

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⁷ “The fact that hundreds of thousands of opera libretti from the 18th and 19th centuries have been preserved, some in huge private collections, should remind us that libretti were read at home just as other theatrical and non-theatrical literature.” Reinhard Strohm, Partitur und Libretto. Zur Edition von Opernlibretten, in: Opernrevision. Bericht über das Symposium zum 60. Geburtstag von Sieghart Dohring, ed. by Helga Lühning and Reinhard Wiesend, Mainz 2005 (Schriften zur Musikwissenschaft 12), p. 37–56, here p. 45.

⁸ Brian Trowell, Libretto (ii), in: The New Grove Dictionary of Opera, ed. by Stanley Sadie, London 1992, vol. 2, p. 1191–1252, here p. 1198. This trend continues well into the 20th century, though the post-modern operatic world started portraying recent events and figures more factually, as it is evident from the enduring trend of “docu-opera”. 
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music." Strohm also discusses the dependence of the libretto on other components of the operatic work, but argues that this very dependency often makes room for genre-defining literary description of the action on the stage, or of episodes in the music.9 An uncommon yet significant example of this is Luigi Illica’s libretto for the opera Iris, music by Pietro Mascagni. In the edition printed by Ricordi in 1898, one can find “stage directions” such as the following:

Ecco la scena: la allegra casetta di Iris; – il suo giardino colla piccola siepe di biancospine in fiore; – nettamente ora spiccano i pallidi e sottili bambou nel risalto del villaggio; – il ruscello canta gaio ed azzurro il ritornello che gli viene dalla canzone serena ed azzurra del cielo; – e laggiù, là, nell’estremo fondo, il Fousiyama, alto come la brama degli umani anelanti alla gran pace del silenzio!10

Illica’s language in this passage is not functional in relation to the setting on stage of the opera; rather it is shaped to evoke an image in the reader’s mind. In other words, the author writes so that Iris’s story can be appreciated away from, and regardless of, the theatre and the music.

The librettist’s freedom of literary description is limited to the context of the libretto as a standalone publication and to those words that are not set to music. Words meant to be sung or acted, instead, often need to follow requirements of length and structure determined by the music. The music, likewise, is in turn shaped by the narrative pace that the words set. In this interdependence, the “upper hand” has been shifting between poet and composer over the centuries. Trowell summarizes this by remarking on the fact that while in the earliest forms of opera there was a formal division between writing the libretto and composing the music, since the 1760s such a division becomes more blurred and the “composer and poet begin to plan as more equal partners.” For example, recent studies on the libretti of Giacomo Puccini’s operas Tosca and La bohème and the composer’s correspondence show frequent and often heated discussions between Puccini, the two librettists Giuseppe Giacosa and Luigi Illica, and the publisher Giulio Ricordi. By studying the letters, one can find

9 Strohm, Partitur und Libretto (see note 7), p. 43. Strohm shows a few examples that show the variety of functions and audiences of libretto sources; for example, he explains how in the first print of the libretto of Iphigenia in Tauride (music by Tommaso Traetta and words by Marco Coltellini) there are substantial differences in use of punctuation from the score, as well as references to the music, such as “Si sente da lontano un preludio flebile” (a faint prelude is heard from afar).

10 “This is the scene: Iris’s merry little house; – its garden with a small flowered hawthorn hedge; – now the pale and thin bamboos neatly stand out against the village; – the river sings gaily and blue the refrain inspired by the sky’s calm and cerulean song; – and over there, in the utmost distance, the Fujiyama, tall like the longing of humans, gasping for the great peace of silence!”
evidence of text being set to music, as well as examples of music being prepared beforehand.

From an editorial perspective, any interrelation between the genesis of libretto and score must be considered; however, there are challenges to coordinating editorial approaches of these two outputs, namely because of the differences between music notation and words. Alan Tyson offers an example of how score and libretto sources are both revealing about the history of an operatic piece.\(^\text{11}\) The libretto published after the first production of Mozart’s *Le nozze di Figaro* has a recitativo and aria ("Dove sono i bei momenti") in the second act that appear in an odd position, both from a narrative perspective and a musical perspective (sequence of keys). Since this order is reflected in subsequent libretto and score sources, the *Neue Mozart Ausgabe* (NMA) published the operatic score in 1973 following this sequence. A later resurfacing of Mozart’s autograph manuscript, however, shows a more linear sequence. This confirmed an earlier study\(^\text{12}\) that suggested that the characters of Bartolo and Antonio were doubled by the same singer in the first production and since there was no time for him to change clothes, the scenes had been reordered without many modifications.\(^\text{13}\) If one were to prepare a critical edition of the libretto of *Le Nozze*, Mozart’s autograph score would have to account as an essential source, at least in order to justify a reordering of the scenes in the second act.

There is seemingly strong evidence that sources of libretto and score, as well as ancillary material such as letters, are to be considered in the preparation of a scholarly edition of an opera.\(^\text{14}\) However, most editorial projects focus on either the score or the libretto and editions of the score are the most common. The NMA, for example, addresses libretti in a dedicated section of the critical reports, listing variants for sung text and stage directions. This secondary location, together with the fact that the sung text is organized by measures (as opposed to verses), promotes the score as the main “text” for an operatic work (Figure 1).\(^\text{15}\)


\(^\text{14}\) The body of ancillary material is called "indirect tradition" in textual criticism. Indirect tradition may also include translations; for vocal music, and opera in particular, translations can be important sources. Some detailed examples can be found in Philip Gossett, *Divas and Scholars. Performing Italian Opera*, Chicago 2006, p. 280–406.

\(^\text{15}\) Printed libretti often apply a dramatic structure to the text based on scenes and verse lines, whereas the same libretto in the score would follow the score’s numbers, which often differ from or even contradict scene numbering (see Strohm, *Partitur und Libretto* (see note 7) and Andreas Münzmay and Daniel Röwenstrunk, *Editing Opera. Challenges of an Integrated Digital Presentation of Music and Text based on*
### Table: NMA Libretto of Don Giovanni

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<th>P</th>
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<td>wie W1</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>120</td>
<td>7</td>
<td>D. G.</td>
<td>mi Klammern</td>
<td>wie W1</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>123</td>
<td>14</td>
<td>D. A.</td>
<td>Signore, Amico</td>
<td>wie W1</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>125</td>
<td>32</td>
<td>D. G.</td>
<td>[ ]</td>
<td>E paure non badeate</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>125 f.</td>
<td>37 f.</td>
<td>D. E.</td>
<td>spavento</td>
<td>wie W1</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>126 f.</td>
<td>37 f.</td>
<td>D. E.</td>
<td>di quel traditore</td>
<td>wie W1</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>127</td>
<td>41 f.</td>
<td>D. E.</td>
<td>di quel traditore</td>
<td>wie W1</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>129</td>
<td>54</td>
<td>D. A.</td>
<td>volto, stato</td>
<td>wie W1</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>140</td>
<td>46 f.</td>
<td>D. A.</td>
<td>-</td>
<td>Alte erst</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>144</td>
<td>81</td>
<td>D. A.</td>
<td>[ ]</td>
<td>Di spavento</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>152[xy]</td>
<td>5</td>
<td>L.</td>
<td>-</td>
<td>Di torcermi, ricercami,</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
<tr>
<td>153</td>
<td>12</td>
<td>L.</td>
<td>chiacchiere</td>
<td>wie W1</td>
<td>wie W1</td>
<td>wie W1</td>
</tr>
</tbody>
</table>

Recently, however, libretti have begun receiving dedicated editorial efforts; the Carl-Maria-von-Weber-Gesamtausgabe, for example, has published a critical edition of Kind’s libretto for Der Freischütz independently from the score edition. The edition of the libretto and the forthcoming edition of the score for Der Freischütz will refer to common sources, carrying either words or music, but will exist in print as distinct scholarly endeavours.

In a digital-centric editorial workflow, the formalization of connections between literary and musical sources can be reduced to a more approachable engineering problem to be used in the context of digital publication. The project OPERA – Spektrum des europäischen Musiktheaters at Universität Bayreuth has been the first to experiment in this direction with a hybrid publication of Antonio Salieri’s Prima la musica e poi le parole. The score edition is published in print, while a dedicated digital edition includes interactive critical reports and a Text Encoding Initiative (TEI)-based digital edition of Giovanni Battista Casti’s libretto (Figure 2).

Figure 1: A page from the NMA libretto of Don Giovanni; the variants are organized by measure (Takt).

The digital model is not particularly sophisticated: it is not a digital critical edition in the sense that variants amongst sources are not modelled. The TEI encoding, in fact, models the texts already edited and includes editorial commentaries by way of annotations. Interestingly, and so far uniquely, however, this comparative view can be reorganized according to either the score’s or the libretto’s structures; the image above show the text organized by libretto scenes and line numbers, but those can be re-numbered according to arias and measures. Likewise, text can be searched and extrapolated according to either structure. This makes for a more powerful study tool than reports like those in the printed NMA and functionally demonstrates the relationships and idiosyncrasies of the two different typologies of document.\textsuperscript{17}

A digital model for the libretto of \textit{Der Freischütz}

OPERA’s approach to libretto and operatic score in the digital medium is an important proof-of-concept; however, their model has limitations, particularly because it does not

\textsuperscript{17} The "score version" also keeps repetition of verses introduced by setting the words to music; this also is an unprecedented practice.
include enough structured information about the editorial work. The *Freischütz Digital* (FreiDi) project is bringing this paradigm forward. As a consultant to this project, and as part of my doctoral research, I designed a TEI model for the libretto edition part of FreiDi.18 The model has two key aims: 1) since all sources are transcribed and encoded independently, they should be coordinated through an apparatus; 2) the apparatus should be able to refer to musical sources as well as literary ones.

Every libretto source identified by the editors is encoded in a separate TEI file, with a focus on the dramatic and lyrical structure of the text: the content is organized by scenes and verses; prose texts are distinguished and attributed to each actor; and stage directions and other descriptive text are identified as such. The transcriptions preserve original spelling and emphasis such as italicized and underlined text.19 Revised, deleted, and added passages are identified and marked up. These independent transcriptions are coordinated through a separate apparatus file that encodes textual variance with `<rdg>` elements containing pointers to markup in the encoding of the sources. In general, this approach produces a file similar to those generated after an alignment step in modern collation software such as Juxta and CollateX;20 however, it is designed to operate at more than one level of tokenization, so that statements about variation can be attached to any element in the TEI-encoded sources.

The TEI Guidelines describe a few methods to encode critical apparatus,21 the most common of which is the “parallel segmentation”. According to this method, textual variants are encoded directly in the text at phrase level and a “lemma” (or the text that the editor chooses against other variants) can be specified. More complex situations, common in large traditions, are often handled with the “double-end-point-attachment” method. Variants can be encoded away from the base text by specifying the start and end point of the lemma they are a variant of. This allows encoders to refer to overlapping areas on the base text.

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18 This work has been completed in coordination with editors Solveig Schreiter and Janette Seuffert. Benjamin Bohl has acted as project manager. See also Raffaele Viglianti, Solveig Schreiter and Benjamin Bohl, *A Stand-off Critical Apparatus for the Libretto of Der Freischütz*, in: *Proceedings of the annual Conference and Members’ Meeting of the TEI Consortium*, 2013.

19 According to text encoding principles, text is first encoded for the information that it carries, then for the way it looks. For example if the name of the character Max at the beginning of an aria is underlined, the encoding first records that the text is a “speaker”, then that this information is expressed in source document by underlining the text: `<speaker rend="underline">Max</speaker>`. 


Both of these methods make two important assumptions: 1) the existence of a base text, in terms of which the editor records variants from other sources; and 2) variants occur only at phrase level (for example the same system could not be used to record the lack of a full paragraph or stanza in one source). These methods are also less ideal when editors want to preserve textual aspects of the various sources such as spelling, abbreviations, or emphasis. These aspects constitute “accidental” variants, as opposed to “substantive” variants such as different words. For example, if the character name Agathe were underlined in a source and not in another, one would have to create a new apparatus entry to record such a difference (Figure 3):

![Figure 3: Example of accidental variant encoded with parallel segmentation](image)

Similarly to the “double-end-point-attachment” method, the FreiDi apparatus file allows the addressing of variants that would cause overlapping issues when encoded with the parallel segmentation method; yet it differs from it by keeping <app> statements independent from each other and from the text. This approach is motivated by the fact that not every difference between sources will be marked as a variant, such as different uses of the Eszett or differences due to document structure such as patches and paste-overs. Using the apparatus file to only identify what are considered “substantive” variants allows the transcription to keep a higher level of detail; although the transcriptions focus substantially on the encoding of the dramatic structure, the editors can include more diplomatic aspects in their transcription because variation

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22 This distinction between accidental and substantive variants was first introduced by Walter W. Greg, *The Rationale of Copy-text*, in: *Studies in Bibliography* 3 (1950), p. 19–36. Greg considered orthography and punctuation accidental and, since they often depend on personal taste and habit, he suggested following them closely from a selected copy-text, which is either an autograph or a document otherwise connected to the author. Substantive differences, instead, require collation and further investigation across sources.


24 As such, this model shares the approach of not mixing encoded sources and editorial statements to avoid overlapping hierarchies with Desmond Schmidt and Robert Colomb, *A Data Structure for Representing Multi-version Texts Online*, in: *International Journal of Human-Computer Studies* 67 (2009), p. 497–514. Schmidt’s method, however, applies a number of hierarchies to a plain text document, which is arguably not any source’s text and certainly not devoid of markup as Schmidt implies.
statements are kept separately. To briefly illustrate this model, let us consider the following verses from sources KA-tx15 and A-pt (Figure 4) and the corresponding apparatus file entry (Figure 5).25

| l xml:id="KA-tx15_11">Sie erzicke</l> | l xml:id="KA-tx15_12">Und bestricke</l> | l xml:id="KA-tx15_13">Und beglücke</l> |
| l xml:id="A-1t_l1">Sie erzicke</l> | l xml:id="A-1t_l2">und beglücke</l> | l xml:id="A-1t_l3">und bestricke</l> |

Figure 4: Example set of verse lines from two sources

```xml
<app>
  <rdg wit="KA-tx15">
    <ptr target="KA-tx15.xml#KA-tx15_12"/>
    <ptr target="KA-tx15.xml#KA-tx15_13"/>
  </rdg>
  <rdg wit="A-pt">
    <ptr target="A-pt.xml#A-pt_l2"/>
    <ptr target="A-pt.xml#A-pt_l3"/>
  </rdg>
</app>
```

Figure 5: Apparatus file

In this example, the apparatus file records as a variant the inversion of verses and the <app> statement is limited to a verse-level domain. The apparatus is made of independent <app> statements, so that differences in capitalization, punctuation and spelling that are not included at this point are encoded as separate statements instead. To record this, the granularity of encoding needs to be greater, for example by first singling out a word within a verse line and then addressing it in the apparatus (Figure 6 and Figure 7).

The encoding strategy illustrated by these examples makes use of a stand-off markup technique that allows encoders to make concurrent statements about a portion of text by linking one or more elements. The use of stand-off techniques in TEI is well documented and encouraged, though it is not widely adopted, except in its simplest forms. Linguistic corpora in TEI, however, are particularly dependent on these techniques, as they help with tokenization according to more than one principle (e.g., morphological, orthographic, syntactic).26 Incidentally, music encoding also

25 A-pt and KA-tx15 are names given to the sources by the editors of the *Weber Gesamtausgabe*, where A-pt identifies Friedrich Kind’s autograph manuscript and KA-tx15 a copy made under Kind’s supervision.

substantially relies on these techniques, to the point of being unavoidable even when encoding simple music notation; in text encoding, however, it only becomes necessary when recording complex textual phenomena. Often TEI projects shy away from stand-off techniques because they introduce considerable managerial overhead; the linking between elements happens through string identifiers, so encoders need to make sure that the references are correctly entered. If the encoding is done by hand (which is by far the most common way of creating TEI), it is a challenge to track and update changes to identifiers and avoid misspellings.

Good authoring tools can help producing solid stand-off markup, particularly if the elements linked are part of the same XML document. Efficient project management remains essential to deal with links across different documents (what Bański calls “remote stand-off”) and with project-specific requirements. In the case of the libretto of Der Freischütz, encoders have first manually encoded each source while introducing identifiers and supporting markup (such as <w>, <seg>, etc.), while the apparatus file is prepared at a later stage, once the transcriptions and encoding are considered relatively stable. In order to better understand the dynamics of dealing with stand-off markup, I developed a tool (the coreBuilder) to support the encoders in creating apparatus
entries in a visual environment. Encoders can select elements that form a variant from various sources and generate an apparatus entry like the ones shown above, which can be further revised or removed by the encoders. The tool automatically creates the links using the identifiers from the sources, thus reducing human error. Encoders have found the coreBuilder useful not only to minimize error, but also to speed up the creation and management of the external apparatus. The tool has been used when each transcription was nearly finalized, but enhancement and corrections were still undergoing. While it is trivial to add a new entry in the apparatus at a later stage, there is currently no way to automatically track changes in the sources that would invalidate information already entered in the apparatus. For example, if there is a substantial change in the transcription of one encoding that removes or alters identifiers, entries in the apparatus referring to those identifiers would remain unchanged and potentially erroneous. Practically speaking, it is not entirely possible to escape all the inconveniences of stand-off, though there is much to gain in the expressiveness that the technique brings to text encoding and using subsidiary tools such as the coreBuilder to reduce error and encoding time (Figure 8).

Figure 8: A screenshot of the coreBuilder tool. The user can create apparatus entries by opening files and clicking on elements that are part of readings. The system uses their IDs for building the stand-off apparatus automatically.

All the code for the coreBuilder is available at this address under an MIT license: https://github.com/raffazizzi/coreBuilder [last accessed: 30 Nov. 2015]. The tool is currently being generalized to deal with other kinds of stand-off markup besides critical apparatus.
The apparatus file, and the tool that helps to build it, can only record links between elements with identifiers; as shown above, this means that in order to address smaller portions of text (e.g., a word or a single letter in a verse) the encoders must introduce elements such as <seg> (segment), <w> (word), <c> (character) and <pc> (punctuation). These elements are being used with weak semantics; that is, although a <w> element may mark up a specific word, the only reason for doing so is to allow the apparatus to refer to the text at the right point. If the TEI of a single source were taken out of context (say for inclusion in a linguistic corpus of early 19th century German), the new adopters would be left to deal with the inconsistency introduced by certain words being marked up, while others were left alone. It would be more efficient to be able to refer to portions of text without needing further XML elements. The TEI XPointer schemes may be useful in this case (Figure 9).28

In this alternative apparatus example, the elements forming a variant are first selected through their identifier with the nested functions xpath() and id(). Then, string-range() is used to identify a textual range (e.g., a word) within the selected element, for example starting from position 4 and including the following 9 positions. This approach would not require the introduction of extra elements in the sources, though unfortunately the implementation of TEI’s scheme for XPointer is not very consistent or reliable at the time of writing. In practice, it would be more difficult to computationally parse and understand the apparatus to produce a usable interface for the digital edition. Moreover, the current definition of string-range() operates within a “fragment”, or a well-formed XML context. This would make it difficult to select ranges that include an opening or closing tag. Hugh Cayless has recently suggested that TEI XPointer ought to be more sophisticated, and he has proposed an extension of the schemes together with a working implementation.29 Using XPointer and string ranges

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avoids cluttering TEI transcriptions with unnecessary markup, though it requires an even greater stability of the TEI documents. For example, consider the case where a transcriber corrects her transcription from "beglükke" to "begluekke"; consider also that this text is marked up with a <w> element and that the apparatus refers to the element as part of an apparatus entry. This change would not require an update of the file because all the apparatus needs to know is where to locate the <w> element. However, if the apparatus were using string ranges, the introduction of an extra "e" would cause a shift in the character count within a fragment, thus introducing an error in the file, which would require updating. Whether this method for stand-off markup will be widely adopted remains to be seen: even with more flexibility and sophistication, the managerial overhead of stand-off techniques is likely to remain a challenge for smaller-scale TEI projects. For the digital edition of the libretto for Der Freischütz, it only remains a matter of speculation.

Coordinating libretto and score sources

Carl Maria von Weber and Friedrich Kind developed the concept for Der Freischütz collaboratively, though Weber waited for Kind to prepare a first full draft of the libretto before beginning to compose for more than three years, as is evident from his diaries of 1817–1821. Weber made substantial adjustments to his copy of the libretto, which is included in the sources for the libretto’s digital edition. Being very much rooted in the tradition of Singspiel, Freischütz includes scenes that are not sung, but acted out. Occasionally, Weber makes changes to these parts too; for example the famous Wolf’s Glen scene (act II, scene 5) was not planned to be sung, but Weber changes Kind’s prose into verse and sets it to music. He also makes the setting of the previous scene (still in the Wolf’s Glen) much more eerie by changing a stage direction to feature invisible spirit voices instead of ravens and forest birds.

Weber’s surviving autograph manuscript of the score (a fair copy) includes the revised words of the libretto set to music, which occasionally differ from the adjustments that he had already made on his own copy of the libretto. An interesting example can be found in Agathe’s Cavatina (Act III, Scene 2):

Weber deleted part of the last line of the second stanza, “aller seiner Kinder”, and the entire following stanza; then he added “meiner auch mit Liebe” above the line, but he eventually struck that out. Finally, he restored the text by writing a series of dots

beneath the line (it is unclear if the line underneath them in red ink is also an addition in Weber’s hand). By looking at this source only, one may think that Weber restored the text written by the copyist on the main line. However, the words set to music in the autograph score are closer to the ones added above the line by Weber: “meiner liebend”, which are then copied over to all further score copies. This is an example of how both libretto and score sources need to play a role in the preparation of the edition of the libretto. The encoding model, particularly the external apparatus, must be able to deal with both kind of sources. As part of the FreiDi project, each music source has been encoded with the Music Encoding Initiative (MEI) format; it is possible, therefore, to link readings from either kind of source together as a variant. Pointing to words in MEI documents often requires reference to more than one element, as words in MEI are separated into “syllables” written under each note (Figure 11).

Weber’s autograph manuscript and most of the copies made from it often also include stage directions and dialogue from scenes. The autograph manuscript contains a particularly interesting example before and after Ännchen’s Romanza ed Aria. This piece was composed by Weber as an extra number for the singer Johanna Eunicke after the completion of the opera between March and May 1821; it is stitched to the autograph score in a separate, smaller quire. Weber extends Agathe’s spoken text after the preceding piece (the Cavatina discussed above) and introduces a reply by

Figure 11: An example of how the apparatus file for the libretto will refer to score sources
Ännchen before her new piece. These words and the *Romanza ed Aria* do not appear in any libretto sources before 1821, though later they are included in copies sent to theaters in Vienna and Hamburg for their first performances.\(^3\)

The *Volkslied* (No. 14) sung by Agathe’s bridesmaids follows Ännchen’s piece. The lied, however, is also interesting from the point of view of the libretto: a sizable part of a spoken scene is included in Weber’s score manuscript, right in the middle of the piece. Typically for the genre, the *Volkslied* is structured in verse and chorus, with the melody repeated a few times. In the manuscript Weber writes the music once and then writes the words of the verses (without music notation) for three further repetitions, but Weber also writes down scene five from Kind’s libretto, where Agathe discovers she has been given a funeral wreath instead of a wedding one. At the right place in the scene, Weber rewrites the music notation of the first part of the chorus until the maids abruptly stop when Agathe gasps (Sample Notation 1).

The text of the scene contained in the score constitutes an additional witness to the libretto. The interplay between music and the action on stage creates an atypical situation where libretto and score are alternated and mixed on the page. It would be possible to encode words and textual structures in MEI, but the set of elements

\(^3\) Schreiter, *Der Freischütz* (see note 31), p. 67.
available is deliberately limited and concerned mostly with presentational rather than descriptive markup. Instead, the scene fragment within the score is encoded in TEI according to the same model used for the libretto edition, and embedded within the MEI encoding of the music. Most of the time, larger groups of words are clearly separated from the score by sections closed with double barlines. The MEI element `<div>` is used to wrap and embed the TEI encoding. The apparatus file for the libretto is then able to refer to verses and other components here in the same way as it does with other textual sources. The following encoding shows this in practice by transcribing part of the previous example: it encodes part of the last measure, followed by an MEI `<div>` element containing the beginning of the text of the second scene (Figure 12).

![Figure 12: Example of MEI file with embedded TEI encoding](image)

The encoding strategies described here are achievable in the context of the FreiDi project because libretto and music sources are being encoded as part of the same endeavour. This makes it possible to create the libretto apparatus described in

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34 Presentational markup encodes the way in which text is formatted, descriptive markup encodes what the text “is”.
this article that coordinates both types of sources. This is a unique situation at the moment, made possible not just by a uniquely skilled group of researchers, but also by a generous grant from a national funding agency; access to this kind of resource is not the standard for most Digital Humanities projects. The innovative OPERA project, which was discussed earlier, for example, is not encoding music sources (they will publish score editions only in print), though the digital project encodes a transcription of the words from score sources. Moreover, references to fragments of facsimile images are provided together with the transcription. This gives access to more context about the music to which the words are set and allows, for example, the building of an application that can show an image of the music notation to help contextualize the variant. However, while the words encoded in TEI can be processed further, in this case the music notation data cannot easily be parsed by the machine because it is an image. Including even a partial encoding of the music notation would make such information machine readable as the way in which syllables are mapped to notes in rhythm and pitch, which can be particularly telling and helpful for explaining connections between sources and the collaborative work between composers and librettists. Nonetheless, both OPERA and FreiDi are demonstrations of the opportunity offered by the digital medium to coordinate libretto and score editions in a way that would not be possible on paper. Ultimately, this allows for independent editions of libretti as literary texts, while facilitating the modelling of connections between libretto and score sources of the music edition.
DYNAMIC SEMANTIC NOTATION: JAMMING TOGETHER MUSIC ENCODING AND LINKED DATA

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ABSTRACT

The Music Encoding Initiative (MEI) [1] provides a framework for expressing musical notation that enables the identification (via XML identifiers), and thus addressing, of score elements at various levels of granularity (e.g. individual systems, measures, or notes) [2]. Verovio [3], an open-source MEI renderer that produces beautiful SVG renditions of the score, retains the MEI identifiers and element hierarchy in the produced output, enabling dynamic interactivity with score elements through a web browser. We present a demonstrator that combines these capabilities with semantic technologies including RDF, JSON-LD, SPARQL, and the Open Annotation data model, anchoring into the musical notation by using the MEI XML IDs as fragment identifiers to enable the fine-grained incorporation of musical notation within a web of Linked Data. This fusing of music and semantics affords the creation of rich Digital Music Objects supporting contemporary music consumption and performance.

1. MOTIVATION

In March 2015 the all-hands meeting of the FAST project (Fusing Audio and Semantic Technologies for Intelligent Music Production and Consumption) was supplemented with a late-night “jam session”, where an eclectic line up of participants performed on guitars, bass, keyboard, violin, and percussion. During the jam, a participant would signal to the other players a new piece that he or she wished the group to transition to; or reference a particular prior recording or artist they wished the group to emulate in style or interpretation; or call out direction to shape the structural elements of the performance, such as to repeat a chorus or verse, or move to a bridge section.

Each of these call-outs invokes concepts transcending the symbolic representation of the music being played (be that full parts or chord sequences), and reference significant context that can be captured or supplemented by meta-data from related material (e.g. about the artist, or a particular style, or the music structure). But, once identified and retrieved, all these contexts imply modifications to the musical notation that could be dynamically rendered to the individual performers, e.g. to modify articulation in a passage; or to jump to a different section, or queue up the next song to transition to. The tool presented here provides an initial implementation of this idea, using semantic technologies to reference external contextual information and dynamically generate Linked Data to both drive the interactions with the score and between the performers, and capture provenance information providing insight into the temporal evolution of the performance in terms of these interactions.

2. DATA MODEL

By treating the XML IDs of elements within the MEI resource as fragment identifiers, URIs can be straightforwardly generated for each notation element of interest. We employ the Open Annotation data model [4], using these URIs as annotation targets of annotations representing each requested action (call-out). Corresponding annotation bodies are associated with semantic tags defined to encode the different supported call-out types, e.g., meldterm:Jump requesting performers to jump from one section of the score to another. Each call-out is itself an annotation body of a top-level annotation targeting the URI of the MEI file that is currently being performed.

3. IMPLEMENTATION

We have developed a dynamic semantic notation client using HTML/CSS and JavaScript, served by a simple web service implemented with Python Flask. The procedure driving the rendering and multi-user interaction is illustrated in Figure 1. The client processes a framed JSON-LD representation of the RDF graph instantiating the data model. It then performs an HTTP GET call to acquire the MEI resource targeted by the top-level annotation, and renders the corresponding musical score to SVG using Verovio. Capture of user interactions and visual indication of call-out results is handled using HTML divs drawn as bounding boxes over portions of the SVG corresponding to MEI elements of interest; this is simplified...
by Verovio’s retention of MEI identifiers in the produced SVG output. Consequences of user call-outs are pushed to the server (HTTP POST), where they are incorporated into the RDF graph. The client then repeats this sequence in an iterative polling procedure, enabling multiple users (i.e., performers in the jam session) to interact dynamically with a shared representation of the score, presenting call-out outcomes to each user in near-real-time.

A screenshot of the system in action is provided in Figure 2. The client is capable of filtering multi-voiced MEI files to only show portions of the score relevant to the respective performer, via a simple XML transform using XPath; the MEI file displayed in the screenshot encodes a score for a string quartet, filtered to show only the viola part. Within the MEI hierarchy, voice-specific layers are situated underneath the level of measures. Thus, annotations targeting individual measures remain visible to each performer, even if those measures are located on different pages of the score according to the layout requirements of the respective voices being rendered.

![Figure 2. Screenshot illustrating a call-out requesting performers to jump from the end of the 13th measure back to the introduction. In jumps across pages, users can click on the jump source (red highlight) to switch pages appropriately in order to land at the jump target (green highlight).](image)

### 4. FUTURE WORK

Future work will focus on extending the supported actions and semantic capabilities of the system; handling the inter-face constraints of real-time user interaction within a live performance context; and expanding upon the applicability of our implementation and data model to scholarly, musicological use cases by enabling matching and linking of notation examples as they are described in scholarly text, via semantic hyperlinks, to and from the score, including exact matches and variants, illustrating interpretations, and situating the examples back in context.

### 5. ACKNOWLEDGEMENTS

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### 6. REFERENCES


Chapter 3
Digital Critical Editions of Music:
A Multidimensional Model
Frans Wiering

1. Introduction

The aim of this chapter is to think through some implications that ICT may have for critical editing and scholarly editions of music. These implications are likely to go far beyond currently accepted practices such as the use of music notation software for the preparation of scores, the online distribution of music in PDF format or even the interchange of score data in some encoded format. Yet there is an almost complete silence as to the more radical possibilities for innovation. This is rather surprising, perhaps even worrying, since the 'critical edition in the digital age' has been an issue of debate for at least ten years in literary studies and musicologists are generally well aware of developments in that area. So why this silence? Are musicologists disappointed by ICT after so many failed promises? Is current technology not mature enough for digital critical editions of music? Or is there no perceived use for these?

1.1 Outline

It is mainly the last question that will be addressed in this chapter. To prepare the ground, I will examine editorial methods in literary studies and musicology. Then I will present a generic, multidimensional model for digital critical editions of music, which is illustrated by means of four case studies. The chapter finishes with a critical evaluation of the model and a discussion of some obstacles that must be overcome before digital critical editions of music will be routinely created and used by musicologists.

1.2 What this chapter is not about

This chapter describes an abstract model for multidimensional editions of music as finished, relatively stable applications. Two issues are specifically not addressed: the implementation of such editions, and the process whereby editors might create

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them. As part of the former, a solution for the encoding of text-critical features was proposed by Wiering et al.; the latter was briefly discussed by Wiering et al. It is also important to note that the case studies in this chapter are conceptual and do not describe current initiatives for creating digital critical editions, with the exception of the Electronic Corpus of Lute Music (ECOLM).

2. Literary studies

By tradition, the object of a scholarly edition is to establish a well-reasoned text of a document. Methods for doing so have been around for centuries. The most influential of these is the stemmatic method developed by Karl Lachmann in the early nineteenth century. Its aim is to reconstruct, by comparing the surviving sources of a text and by evaluating their differences, the archetypal document from which these sources descend. Since Lachmann’s days, many alternative approaches have been proposed; all of these combine one or more reconstructed texts with an account of the source network. An important part of the latter is the critical apparatus, a list of corrected errors and variant readings that have not made it to the final text.

Three technological developments – structured markup, hypertext and mass digitization – have fundamentally affected critical editing. Structured markup became virtually identical with SGML after 1986, when it was released as an ISO standard; it is now superseded by the closely related XML recommendation. Document encoding using structured markup has two important characteristics that distinguish it from desktop publishing formats (and flat text representation). First, it separates the logical structure of a document from its visual presentation. As a consequence, multiple ‘views’ can be generated from one encoded document. For example, one view of a book is its full-text content, another the table of contents. Second, it allows the document to be enriched with additional information. An example is the encoding of both source errors and their correction, so that an apparatus can be automatically created. Both features of structured markup are exploited in the TEI markup scheme, which is used successfully in many


digital editions projects that focus on the information contained in the edited documents.\footnote{An example in musicology is \textit{Thesaurus musicarum italicarum}, which contains nearly 30 Italian music treatises edited with TEI markup (<http://www.euromusicology.org>), accessed 21 April 2009.)

Hypertext, which first reached the general public through Apple’s HyperCard (released in 1987) and later through the World Wide Web, allows documents to be structured in a non-linear way. A hypertext edition therefore may present more than one reading of a text, presenting alternative continuations of a text where the sources differ, or coordinate a number of completely encoded sources of a single document. McGann’s notion of HyperEditing, briefly discussed below, provides a theoretical justification for such an approach.

Mass digitization arose in the 1990s, stimulated by the ever-decreasing prices of storage space and by the availability of standard technology for creating and processing digital audio, images and video. A large number of digital libraries, archives and museums have emerged over the last decade, giving scholars access to documents with unprecedented ease. Even though metadata are routinely attached to digitised sources, their content is still undigested: therefore they provide no alternative to critical editions. However, models for digital editions do often include digital facsimiles as a way of presenting the raw materials on which the edition is based.

\subsection*{2.1 HyperEditing}

From the many scholars who have examined the consequences of these developments for critical editing, I have singled out Jerome McGann\footnote{J. McGann, ‘The Rationale of HyperText’ (1995). Available online from <http://www.iath.virginia.edu/public/jjm2/rationale.html>, accessed 21 April 2009.} for particular discussion because he draws the attention to the limitations of the book format itself: a book cannot contain and coordinate all source materials that an edition is based on. The analytical tools an edition in book format contains, notably the critical apparatus, are shaped by this fact: these abbreviate and restructure information from many different sources in such a way that it fits the book format (see Figure 3.1a). The price one pays for this in terms of usability is quite high. For example, it is hard to reconstruct a primary source from editorial text and the evidence in the apparatus, and virtually impossible to get a full picture of the source network. Another issue McGann raises is that the book format does not allow the inclusion of non-textual information such as performances of a play or song, or even the physical features of a source.

The solution McGann proposes is HyperEditing, the creation of critical, fully networked hypermedia archives. This concept is illustrated in Figure 3.1b. A critical archive consists of virtual copies of the sources, connections between
Figure 3.1a  Different models of editing: the book format

these, annotations with critical and contextual information, and analytical tools for searching and comparing the materials.

As a networked model, the critical archive documents the genesis, transmission and reception of a text through the material instances by which it survives. It is not a hierarchical model that aims at a reconstruction of the author’s intention. Yet such a reconstruction can be incorporated into the model, for example by defining an edition as a ‘reading path’ through the critical archive. (A related notion of reading path can be found in Kress and in Darnton.)

Figure 3.1b  Different models of editing: HyperEditing

HyperEditing deals with material instances of texts rather than with idealized works abstracted from those instances. This seems a promising perspective for musicological editing, especially if one considers written sources as instructions for—and often the only remaining traces—of past performances.

3. Critical editing in musicology

Critical editing in music has been shaped after traditional models of literary editing.\(^8\) In music too, the task of the editor is to establish the text of a composition by some accepted method, whether this is by means of a stemmatic, best-text or copy-text approach. (From here on ‘text’ is short for the ‘musical text’ of a composition.) This text is then transcribed or adapted to modern notational conventions, so

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\(^8\) Grier, ‘Editing’.
that it is easily legible. Missing information is supplied (e.g. text underlay) and perceived ambiguities are resolved (e.g. musica ficta). All of this makes critical editions usable in performance. At the same time expert performers and scholars may feel that such adaptations add an unwanted layer of interpretation to the work. Transcription and the level of editorial intervention are therefore much more an issue of debate than how to establish the composition’s text.

Philip Brett⁹ observed that there are very few successful applications of the stemmatic method in music. The fundamental problem here is the meaning and weight one attaches to variants that occur between sources of the same work. Text-based editorial methods tend to treat variants as corruptions, whereas in fact they may often reflect adaptation to performance circumstances. To take Brett’s argument one step further, to create an edition as a reconstruction of the “work itself” and not to give full access to the “instances” that together constitute this work is to misrepresent the inherent flexibility and adaptability of a very large repertoire of music.

Music publishing has been strongly affected by ICT, but mainly at a practical level. Scores prepared using music notation software are routinely distributed via the internet. A large number of choral works in decent, practical editions is available through the Choral Public Domain Library.⑩ At the scholarly end of the digital publication spectrum stands a website containing diplomatic transcriptions of the works of the fifteenth-century composer Caron.⑪ Other examples of the influence of mass digitization include a range of conventional digital library projects such as Variations 2⑫ and more advanced ones such as the Digital Image Archive of Medieval Music, (DIAMM)⑬ which features digital restoration of scanned images, and the Online Chopin Variorum Edition,⑭ where sections from different sources can be aligned and compared.

Apart from the last example, hypertextual editions of music do not seem to exist yet, but structured markup has reached music in several ways. An important early example is Standard Music Description Language (SMDL).⑮ SMDL distinguishes four domains in which a composition exists: visual (score), gestural (performance), analytical and logical. The last abstractly represents compositional intent, for which SMDL defines an SGML vocabulary. SMDL was never implemented.

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except in a few demos, but conceptually it influenced several XML-based music encoding systems. The best known of these is MusicXML.\textsuperscript{16} Its purpose is to allow interchange of musical data, particularly between music printing applications, and it has many facilities for precisely recording layout. The Music Encoding Initiative (MEI) is less detailed about layout, but has some basic text-critical structures.\textsuperscript{17}

Some attempts have been made to provide deeper access to the materials from which an edition is created. Thomas Hall\textsuperscript{18} experimented with computer-based stemmatics for the New Josquin Edition, but there has been no follow-up to his experiments. Standard databases can be effectively configured for storing musical variants, as Yo Tomita did in his studies of J.S. Bach's WTC II.\textsuperscript{19} A drawback to this approach is that the information is logically separated from the score. Experiments in integrating the two, using a TEI-based tagset, have been carried out as part of ECOLM.\textsuperscript{20} The separation of logical structure and visual presentation is especially exploited in the Corpus Mensurabilis Musicae Electronicum.\textsuperscript{21} Out of one encoded score, different transcription styles can be generated: one can for example choose between original and modern clefs, and different barline styles. CMME will also provide access to variants and manuscript context of works.

4. A multidimensional model

I perceive several open issues in current methods of critical editing of music:

- No clear distinction between establishing the text of a composition on the one hand, and transcription style and supplying performance information on the other.
- Loss of information about the notation in the sources.
- The weakly acknowledged role of variants to the understanding of a musical work.


Figure 3.2 Multidimensional model for a digital critical edition of a composition

- The usability of text-critical data, particularly when the context from which it is abstracted matters.

All of these relate to the limitations of the book format as a visual, static, two-dimensional representation of a composition. As in literary studies, a HyperEditing approach might offer some solutions for music too. This is the
purpose of the multidimensional model that is proposed in this chapter and illustrated in Figure 3.2.

A digital critical edition of music may ideally consist of the following, interconnected components:

- Digitized sources, from any relevant medium: usually these will be score facsimiles, but video and audio recordings are explicit options.
- Source encodings, making the information content of the sources suitable for computer processing.
- Annotations; categories include text-critical features, inferences (e.g. related to performance), musicological knowledge.
- Links to related works.

Such a collection of information can be imagined as a multidimensional space, in which different categories of information each occupy a different axis. For example, in addition to the two dimensions of the score, one can imagine versions, emendations, transcription styles and adaptations to performance as additional dimensions to the edition. These are not so much dimensions in a mathematical sense, but ways of accessing the edition, for example by projecting information onto a plane or by taking two-dimensional slices from it. Examples of such views are a diplomatic or emended transcription of a source, an apparatus, a stemma, or an edition conceived as a reading path through sources and annotations. At least as important is the possibility of switching views, for example from an apparatus view of a particular passage to the context in which it appears in a source, or – when multiple works are edited in this way – from a collection of similar features to the works in which they appear. Users can contribute to the edition by adding their own views and annotations.

Quite a sophisticated set of tools will be needed to realize these possibilities – but a discussion of these falls outside the scope of this chapter. The music representation these tools will work on has one important requirement that distinguishes it from the ones mentioned above. It is not a representation of the musical surface of a finished product (see Wiggins, this volume, Chapter 2, section 4.2), nor one of the musical logic that underlies it; instead it represents ideally all the information contained in the source that is necessary for deriving, whether by computer or human intelligence, meaningful views of the composition.

Two examples may illustrate this:

- Logically, CMN orders notes in bars of a predictable length, demarcated by barlines; so notes can be represented as the content of a bar, and barlines need not be explicitly indicated. When encoding a source, one can generally not assume that the length of the bar is predictable or correct, or even that a barline has the function it has nowadays. A non-hierarchical representation of the source text is therefore needed.
- Likewise, CMN has clear rules for accidentals, which makes it possible to
represent the accidental as part of the pitch of a note. In mensural notation, it is not always clear to which note(s) an accidental should be applied, so it should be represented separately.

The requirement is thus that the input to the edition, the notational, visual and possibly material aspects of the sources, is represented; editorial decisions about their meaning belong to a layer of inferences that comes on top of the source representation. Formats that encode the ‘logical content’ of a work are unhelpful for supporting the editorial process, which also follows from the fact that, if such a thing as the logical content of a composition exists at all, the task of the editor is to establish the logical content rather than to assume its existence.

It is important to note that the model, even though it is presented as an abstract and generic one, simplifies reality. This is especially important at the representation level. Minute details of ink and damage can sometimes lead to fundamental decisions about the editorial text of a composition, but this does not mean that such details must be routinely encoded. There will always be a negotiating process between simplicity and comprehensiveness, aimed at reaching an optimum effectiveness. Therefore each repertoire will require its own specific representation. At the same time, to allow interchange, it should conform to the requirements formulated in Wiggins (Chapter 2, this volume). The simplification inherent in modelling also explains why the model includes a digital facsimile: it puts a lower boundary on the level of detail of the encoding, and it allows an immediate check for problems and ambiguities in the source that may have been left unencoded.

The multidimensional model solves the issues mentioned at the beginning of this section by giving full access to as many source representations as one needs, by defining an edition as an adaptive layer on top of the sources, and by offering flexible generation and presentation of text-critical information. The model also raises a number of new questions. How can the model be realized in practice, which dimensions does it contain and how useful is it? The following four case studies will help in finding some answers.

5. Case studies

5.1 Ma bouche rit: anonymous mass and Ockeghem's chanson

An anonymous Missa 'Ma bouche rit' survives in the early sixteenth-century manuscript VienNB 11883 (fols 285v–294r). It is remarkable for its exceptional treatment of the model on which it is based: all three voices of Johannes Ockeghem's chanson are used as cantus firmi in at least one of its movements. If these cantus

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firma are compared to Wexler’s edition of the chanson, there appear to be more than ten consistent differences that affect pitch and/or rhythm, one of which is shown in Example 3.1.

Example 3.1a Ockeghem, ‘Ma bouche rit’, superius bars 40–42 after Ockeghem (1992)

Example 3.1b Missa ‘Ma bouche rit’, superius bars 40–43. All note values quartered

Obviously, the mass is not based on this reading of Ma bouche rit, which is a ‘best-text’ edition derived from the manuscript PNiv. As 17 sources of Ockeghem’s chanson survive, one wonders if another one has a closer relation to the mass. The key to the answer is the edition’s apparatus, a fragment of which is shown in Figure 3.3.

39/1-2 bl sbr, bl m (MunSche); 41/1-2 mi col (BerGlo, Cop 1848, Dij, FBNC 176, FR 2356, MunSche, NHMel, PBN 4379, PCord, PPix, RCG XIII.27, WLab, Wol 287); 41/2 c fu, b fu (RISM 15389); before 42/1 sharp (NHMel); 42/3-43/2 bl sbr,

Figure 3.3 Fragment of apparatus for Ockeghem, ‘Ma bouche rit’, after Ockeghem Motets and chansons, p. lxxx; line breaks as shown in original

24 Ibid., p. lxxviii.
First, this fragment demonstrates three reasons why it is hard to use an apparatus: it presents source data outside the context of the score, it uses a specialized ‘code’ for these data and it breaks the connection between data from a single source. Second, it appears that the variant from Example 3.1 does not occur elsewhere. In total, the mass contains at least five variants that make musical sense but are not known from any of the chanson’s sources. It is unlikely that these are Ockeghem’s, but they are surely relevant to a study of the transmission and reception of the chanson.

The principal contribution of a digital critical edition of Ockeghem’s chanson would be to allow direct access to the sources through a third dimension of the edition, rather than indirect access only, through the apparatus. A second contribution would be to make it possible to upload a new source (or reconstruction of a source) to the existing edition. Finally, the mass (and other arrangements of ‘Ma bouche rit’) could be linked to the edition in such granularity that the user can see how they relate to the model.

5.2 J.S. Bach, Mass in B Minor

J.S. Bach’s Mass in B minor (BWV 232) has a very complex source situation, the bare outlines of which are shown in Figure 3.4 and discussed below after Butt, Wolff and Rifkin. Bach commenced work on the autograph score in 1733. The work at that stage consisted only of the ‘Missa’, i.e. Kyrie and Gloria. Most of its twelve movements are parodies from cantatas, but not all of the models survive. A set of mostly autograph parts from 1733 also survives, adding a level of performance detail that is missing from the score. These parts were never altered, unlike the score, which was subjected to a series of additions and revisions. The most important of these took place in 1748–50, when Bach expanded the Missa into a complete Mass. Again, most movements were based on earlier works: the Sanctus of 1724, a Credo intonation of c. 1740 and numerous cantata movements. The Confiteor and possibly the Et incarnatus est were newly composed. There are many signs of revision for all movements including the Missa. Owing to his failing eyesight Bach also introduced a number of errors, particularly in the Sanctus. After Bach’s death the manuscript passed to his son Carl Philipp Emanuel, who added several layers of alterations. The first of these correct apparent errors and improve legibility; later ones are connected to a performance of the Symbolum Nicensum (the movements setting the Credo text) in 1786. Several sources that

Figure 3.4  J.S. Bach, *Mass in B Minor* (BWV 232), relationships between sources, with approximate dates
derive from the main manuscript reflect earlier stages of the manuscript and may therefore be used to distinguish between layers of alteration. The most important of these are the cantata *Gloria in excelsis Deo* of 1745, a copy of the *Mass* in J.F. Hering’s hand (c. 1765), one made for J.P. Kirberger in 1769, and a set of parts (containing an earlier and a later layer) and several scores of the *Symbolum Nicenum* dating from the 1780s.

At least three possible strategies for editing the complete *Mass* emerge from this overview. One is to reconstruct the score as Bach left it at his death and emend it only where it is in error. Another is to construct an ‘optimum text’ by selecting the musically most satisfactory variants from the score, the 1733 parts and possibly also from the models of the movements. The third is to focus on performance and add to the score as it was in 1750 the kind of detail that the parts written in 1733 and 1786 offer. Every consecutive strategy involves a larger number of subjective decisions than the preceding one, but at the same time represents an equally legitimate view of the same underlying source materials. A multidimensional edition of the Mass would therefore represent the information content of the sources and allow a range of different views to be generated from these. Note that it is not the purpose of this model to enforce a particular editorial method: the only requirement is that an edition is a view on the source materials, no matter how and why it is created.

A well-known problem in the *Domine Deus* may illustrate this position. Example 3.2 shows the beginning of the movement, in which the main instrumental motif is played first by the two flutes and then by the first violin. The 1733 parts however indicate performance by flute 1 only; moreover the first bar of the flute is notated with a different rhythm, which reappears in the second violin and viola, bar 27, but nowhere else. Three questions emerge from this situation:

- What does this variant indicate: (an approximation of) a rhythm, a reinforcement of the articulation, or both?
- How should other appearances of the same motif be treated, for example first violin, bar 2?
- What is its relevance to the scoring and performance of the final version of the work?

The answers to these questions influence an editor’s rendition of the passage, but as important as the editorial decision is access to the evidence. One might even claim that the variants together convey a better understanding of this movement than a single editorial solution.

In addition to offering a range of possible views of the ‘text’ of the work, the added value of a digital critical edition is to give direct access to the underlying evidence. An exploration of the work could start from an overview such as that

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Travers. in unisono

Violini

Viola, Sourdini

Soprano

Tenor

pizzicati

Example 3.2a  J.S. Bach, 'Domine Deus', bars 1–3 from *Mass in B Minor* (BWV 232) after manuscript score

Example 3.2b  J.S. Bach, 'Domine Deus', bars 1–3 from *Mass in B Minor* (BWV 232) flute 1 after 1733 parts

in Figure 3.4, from which the user could zoom in to the required level of detail along different dimensions: sources, source layers, relations to models, editorial preferences and emendations, visual presentations and recordings. It is to be expected that in such an environment a user might like to contribute annotations or to create their own view of the work. Thus, the distinction between user and editor
begins to fade, and a concept of editing as an on-going, collective process emerges (Robinson\textsuperscript{31} makes the same observation for textual editions). In complex cases such as Bach’s Mass in particular, this seems an attractive mode of operation, as there is so much evidence involved that it is an almost superhuman task for a single researcher to collect it from scratch and to digest it into a finished product.

5.3 V. Galilei, Fronimo

This case and the next are based upon practical experiments undertaken for the ECOLM project. The aim of ECOLM is to make sources of lute music accessible to scholars, lute players and others. Accessibility means more than just displaying the edited content of the sources. Since the sources employ a specialist form of notation – tablature – they are virtually inaccessible to non-players, including musicologists. Transcription to CMN or sound is not an added extra but an essential property of such an edition in order to give this relatively neglected repertoire its proper place in music research. However, such transcription involves both the addition and the loss of information.

Plate 3.1, taken from Vincenzo Galilei’s lute treatise Fronimo (1568),\textsuperscript{32} illustrates this. The principle of French and Italian lute tablatures is to indicate the moment on which certain frets must be stopped and certain courses (i.e. string or pair of strings) must be struck. Durations and voices are not indicated, and neither is pitch spelling. Therefore, a polyphonic transcription, such as the one shown in Example 3.3, requires a great deal of editorial inference, sometimes even involving durations that are physically absent but plausibly supplied in the listener’s mind. At the same time, precise instructions about frets and courses, which influence timbre, are lost.

This particular composition from Fronimo also gives a dramatic example of a situation that is itself not uncommon, namely, that two or more different realizations can be derived from one score or set of parts. Adaptability to circumstances (liturgy, resources) seems to be the most common explanation. Here the reason is different: black symbols render straightforward transcriptions of the vocal models, whereas the black and red symbols together constitute ornamented intabulations.

The first task a digital critical edition of these works must be able to perform is to separate the two versions. It would also allow transcriptions to be shown. Chordal transcriptions require only a small amount of knowledge to be done automatically. Despite several decades of research, satisfactory algorithms for polyphonic transcriptions have not been found yet, although there is some hope


\textsuperscript{32} V. Galilei, Fronimo dialogo ... sopra l’arte del bene intavolare (Venice: Scotto, 1568).
that in the future techniques for phrase extraction developed in Music Information Retrieval may help. To generate passable MIDI or audio from tablature is not too hard, for two reasons: pitch-class information is exact and durations are not that critical because of the quick decay in amplitude of the lute’s sound.

5.4 S.L. Weiss, Bourrée

Our final case study illustrates some possibilities in displaying text-critical information. As an example we use Silvius Leopold Weiss’s *Bourrée* (from Sonata 44, composed c. 1710–14). It survives in seven sources; four of these were encoded as one document using TabXML. From this encoding we generated a series of visual presentations by means of XSLT sheets and slight adaptations of the standard ECOLM software.

Example 3.4a  S.L. Weiss, *Bourrée*, bars 1–11

33 Wiering et al., ‘Creating an XML Vocabulary for Encoding Lute Music’.
Example 3.4b  S.L. Weiss, *Bourée*, bars 1–10, transcription of Paris source

<table>
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<th>Dresden</th>
<th>Harrach</th>
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**Figure 3.5  S.L. Weiss, *Bourée*, first items of critical apparatus**

*Note: Numbers correspond to the footnote numbers in Example 3.5*
Example 3.5  S.L. Weiss, Bourée, bars 1–11 with variants in parallel

The simplest of these are diplomatic transcriptions of the sources, as in Example 3.4. From the same encoding, a critical apparatus can be generated (Figure 3.5). It is here shown as TabCode,\textsuperscript{34} which is only slightly more cryptic than the apparatus shown in Figure 3.3 (section 5.1 above).

Example 3.5 gives a more intuitive view of the text-critical information, by showing one source and differences in other versions in parallel. It is easy to see now that the sources contain three interpretations of the rhythm of the first bar that differ from the Paris source (Example 3.6; cf. Example 3.4b). Taken together the variants suggest a performance style in which subdivisions of the beat were played.

Example 3.6 S.L. Weiss, *Bourrée*, rhythmic patterns for bar 1 in the Brno, Dresden and Harrach sources

*inégale*. This parallel view already allows zooming out from character level to the level of source relationships.

The third view (Plate 3.2) shows the number of diverging sources for each vertical sonority in the source: the darker the background colour is, the more variants there are. This view captures in one glance how unique a source is and how variants are distributed over the piece. In quite a different way from a printed apparatus we can put variants in context and create high-level views of them.

6. Dimensions and views

The model presented in this chapter is based on the central idea that all information relating to the edition of a composition is ordered in a multidimensional space, from which views of a lower dimensionality may be generated according to user preference.

<table>
<thead>
<tr>
<th>Table 3.1</th>
<th>Dimensions of the model</th>
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</thead>
<tbody>
<tr>
<td><strong>Visual: written sources</strong></td>
<td><strong>Logical: edition</strong></td>
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<tr>
<td>problems in source text</td>
<td>preference (Bach)</td>
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<td>emendation</td>
<td>adaptation to CMN conventions</td>
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<td>transcription (Ockeghem, Galilei, Weiss)</td>
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<tr>
<td>source layers</td>
<td>inference (Galilei, Weiss)</td>
</tr>
<tr>
<td>scribal correction (Bach)</td>
<td><strong>Gestural: performance</strong></td>
</tr>
<tr>
<td>improvement (Bach)</td>
<td>ensemble composition</td>
</tr>
<tr>
<td>performance alternative (Galilei)</td>
<td>interpretation</td>
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<tr>
<td>explication (Bach)</td>
<td>recording</td>
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<tr>
<td>different sources</td>
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<tr>
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<td>knowledge (Bach)</td>
</tr>
<tr>
<td>intertextuality (Ockeghem, Bach)</td>
<td>linking (Ockeghem, Bach)</td>
</tr>
</tbody>
</table>

Table 3.1 summarizes the dimensions we have found so far and several we assume exist in other repertoires. These are classified by SMDL domain (see section 3). Written sources are placed in the visual domain, performances in the gestural domain, and annotations and links in the analytical domain. The dimensions
related to classic editorial tasks are placed in the logical domain (see section 4). Table 3.2 provides a similar listing of views traced so far.

Table 3.2 Sample views that can be generated from the model

<table>
<thead>
<tr>
<th>Linear renditions (notation or sound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>diplomatic transcription</td>
</tr>
<tr>
<td>layers in source</td>
</tr>
<tr>
<td>emended source</td>
</tr>
<tr>
<td>edition (reading path)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composite views</th>
</tr>
</thead>
<tbody>
<tr>
<td>aligned sources, editions</td>
</tr>
<tr>
<td>apparatus</td>
</tr>
<tr>
<td>stemma, source relationships</td>
</tr>
<tr>
<td>musical relationships</td>
</tr>
</tbody>
</table>

7. Evaluation

The multidimensional model has the following advantages:

- It represents a data-rich approach, allowing automatic extraction of information, for example by using information retrieval or statistical techniques.
- It can deal satisfactorily with different instances of a single work.
- It can incorporate performances.
- It prevents information loss caused by transcription.
- Source information can be directly accessed.
- Views can be adapted to specific requirements.
- A composition’s musical context is made explicit by linking it to other compositions.
- Editing can be done incrementally and collectively, preventing duplication of work.
- An edition stores knowledge about the composition.
- Distribution is fast and cheap.

Most importantly, it aims at enhancing accepted musicological methods by overcoming certain shortcomings: for example, scarcity of data or difficulty in dealing with context. If a significant quantity of multidimensional editions becomes available, I expect the strong distinction that now exists between generic and specific approaches to music (e.g. between work analysis and the study of musical style) to blur or even to disappear.
I am aware that the model has a number of potential disadvantages, most of which are not specific to music but pertain to textual editions as well (where some of the solutions may also be found). These include:

- The complexity of the model itself, with its many dimensions and views.
- The required infrastructure, comprising data structures, software and services.
- The technical expertise editors will need to acquire.
- The instability of online resources: they move or disappear.
- Referring to editions that themselves are dynamic.
- The intellectual property of the contributing scholars and the rights of the owners of the sources.
- The status of digital publications, which are often considered less prestigious than paper publications with a renowned publisher.

Even though the model proposed here presents an abstract, extreme view and concrete implementations are likely to be much simpler, creating digital critical editions of music will be a complex task. It is likely to involve a team of specialists, each responsible for a certain aspect of the edition. This is a conspicuous difference from traditional editions, where an editor is typically in charge of almost the entire process. Generally, teamwork is not nearly as common in the humanities as in science, and editing music is very often part of PhD research, which is individual by nature and in practice leaves very little time for learning peripheral skills.

However, it appears that many scholars are willing to acquire complex technical skills, such as the use of music notation software. This type of software maintains the illusion that one is working in the same way as on paper, merely in a different, but neutral, medium. As said above, models simplify reality with a particular aim in view. With a few exceptions, the vast majority of those involved in music research are not used to this type of scientific approach to models. Their closest counterparts in music are theories such as Schenker’s, which are more in the nature of belief systems that may be applied to a very wide range of tasks. As a result they are usually rich in escape mechanisms for solving unexpected problems. Formalized models do not allow for such mechanisms and may therefore seem too simplistic or rigid to the uninitiated. This may be the most serious obstacle to the acceptance of digital, multidimensional music editions. A significant effort to educate the profession seems to be needed to remedy this. However, this burden could be shared with those promoting other areas of computational or empirical musicology, in which the same problem exists.

Future work on the multidimensional model must also address its implementation. For a concrete repertoire only a restricted number of views and dimensions will be needed. This suggests a modular approach. Similarly, it must be possible to edit a work incrementally, by adding new layers of information to the existing ones. A great deal of this research will be done in projects that follow on from the ECOLM project. Other areas where pilot multidimensional
editions might be relevant are liturgical music, which must often be adapted to the occasion; popular music, in which performance is more important than notation; and folksong, where oral transmission has caused much variation. Once a satisfactory incremental model for creating digital critical editions has been created, it makes sense to integrate those efforts with other attempts at digital corpus creation for music analysis, music information retrieval and performance research.

This chapter has sketched only the barest outlines of a model for digital critical editions of music. Before the model is ready to be used in actual implementations, many open issues need to be resolved that have been insufficiently debated within the broad community of historical musicology. I am therefore even more interested in critical reactions, counterproposals and so on to this chapter than in the actual dissemination of this model, and hope that a debate will emerge from it that is similar in passion and richness of ideas to that taking place in literary studies.

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