



# Popular musical arrangements in the nineteenth-century home: A study of *The Harmonicon* supported by digital tools

David Lewis

Kevin R. Page

david.lewis@oerc.ox.ac.uk

kevin.page@oerc.ox.ac.uk

Oxford e-Research Centre, University of Oxford  
Oxford, UK

## ABSTRACT

Musicologists often remove all traces of the scaffolding used to construct their scholarship at the point of completion – presenting information about bibliographic and evidential sources, but not describing the tools and digital resources used. This makes an analysis of the state of digital support for musicology harder to achieve. In this paper, we consider both outcome and scaffolding, presenting a musicological study built upon digitised library resources, which made use of digital tools, and then considering the digital affordances that were required by the study.

We explore the musical content of the music periodicals, *The Harmonicon* (1823-1833) and *The Musical Library* (1834-1837), considering what it tells us about music making and reception in early nineteenth-century England. Journals such as these are important both for bringing a wide range of music into the home, but also for adapting music written for concert halls and the opera for the domestic sphere through musical arrangement. Since this music was more accessible to many than ticket prices, its selection and deployment in such volumes would have been critical for shaping an audiences musical tastes. At the same time, the editor was compelled to tailor the music to the abilities and interests of the audience, in an economically highly challenging environment.

This musicological study was supported by digital tools at multiple stages in the process. We describe the interaction between tools and scholarship, reflecting on where these were strong, but also considering opportunities for future development. We do this in terms of an iterative model of research, digitisation and editing, acknowledging that research must be able to continue despite imperfections and absences in tools, resources and digital data.

## CCS CONCEPTS

• **Applied computing** → *Sound and music computing*; **Arts and humanities**; *Digital libraries and archives*.

## KEYWORDS

digital musicology, digital libraries, linked data, web applications, music encoding



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## 1 INTRODUCTION

The nineteenth century provided music lovers with many paths to discover, and familiarise themselves with, new music. Audiences could hear performances at professional and amateur concerts, in public spaces, or in salons and other semi-private settings. Access to these performance contexts was dependent on wealth, geographical location and social access, meaning that different sections of society would experience music making very differently, in terms of frequency of listening, social context and the musical genres encountered.

Of increasing significance to amateurs was sheet music for works either in their original form or adapted for the more modest space, personnel and technical resources of the home. Printed music might allow a lone amateur pianist to get to know a Beethoven symphony – in arrangement – in the absence of ever hearing a performance with orchestra, or to experience that work repeatedly after a concert in a way that would not be possible otherwise until the invention of recordings and self-playing pianos at the end of the century. Music periodicals and, increasingly, albums or serialised music publications could also inform and direct musical discovery by the public, acting rather like radio or playlists have done since, to curate musical tastes according to an aesthetic or commercial agenda.

Studying these arrangements, and their means of promotion and compilation, gives us an insight into a vital part of musical activity and experience in the musical life of the period. It could be argued that without an understanding of music produced in domestic environments and small public spaces, we would miss the majority of musical experiences – both making and listening – of the time.

In this paper, we examine one particular periodical, the London-based *Harmonicon*<sup>1</sup>, in research that was supported by digital libraries and tools. We then look at the interaction between the tools and the research and consider the advantages and remaining limitations that their use offered.

<sup>1</sup>Although *The Harmonicon* and *The Musical Library* are notionally (and legally and financially) distinct publications, we consider them together in this article, given the continuity of creative team, format and intent. For brevity, when we refer to *The Harmonicon*, we generally encompass both.

We present our research from a 'musicology first' perspective, on the basis that digital tools must be the means by which new scholarship can be undertaken, rather than purely an end unto themselves. To contextualise the required affordances for our application of digital tools, we begin with the musicology study, considering first the history of the periodical (section 2), its target readership – and the evidence for that (section 3), and the significance of this for understanding domestic music of the time (section 3.3). Then, we consider the tools and resources which supported the research through each stages towards completion, relating this to a more generalised schema for iterative research (sections 4.1 and 4.2), and articulating gaps in the tooling (section 4.3), along with opportunities for further development (section 5).

## 2 THE HARMONICON AND THE MUSICAL LIBRARY

The early decades of the nineteenth century witnessed a large range of such publications, almost all of them short-lived. Exceptions to this were primarily in the German-speaking world – including long-standing journals such as the Leipzig-based *Allgemeine Musicalische Zeitung* and *Cäcilia*, both relatively specialist texts, with advanced discussions of musical details, illustrated with inline music examples.

In the English-speaking world, although Langley[7] has identified over 200 UK-based music periodicals in the century, most were short lived or primarily textual. One of the most impactful and long-lived periodical with substantial music notation content was *The Harmonicon* and its successor publication, *The Musical Library*. Between them, these two periodicals, both edited by William Ayrton and printed by William Clowes, spanned the period from 1823 to 1837. Unlike most of their contemporaries, these two journals featured substantial quantities of music notation as well as text, so subscribers could accumulate a broad music library at the same time as being informed about musical culture and new performances and publications in music.

The Ayrton publications appear to have been loss-making for much of their existence, despite fairly substantial print runs and funding from adverts. Although there must have been some altruistic and educational motivation, one must wonder whether the losses absorbed by printers and publishers were seen as a way to advertise and, to some extent, cross subsidise their music printing. The journal reviewed new publications and may have driven sales of these and, although the musical content was sometimes specially created for the periodical, it was also often an extract from a larger publication which might be bought separately. The inconsistent level of reference to these source publications in the musical text does not suggest that Ayrton himself felt any strong need to harness the journal in that way. Perhaps the prestige (and platform) the publication gave to those involved was enough – in the early years, over 200 free copies were sent out to 'Newspapers &c' to ensure its high profile[7], a sizeable proportion of the overall print run of between 1,000 and 1,500.

The Ayrton publications present the result of a conscious grappling with the tensions between educational and commercial imperatives. These considerations are explicitly acknowledged in editorials and, although the changes in material are subtle, the periodicals

certainly adapted at various points over the years to be more accessible and populist. The change in name to 'The Musical Library' acknowledges, however, the aspirations of editor and reader to use the issues as a survey and reference source of music at the time. In navigating the digitisation of music libraries and of musicology itself, we are aware of the parallel concerns pitting fair representation, bias towards popular figures, and broad accessibility of materials.

*The Harmonicon* and *The Musical Library* are complex documents, containing text, text describing music, music examples and full pieces, and connecting with external publications, people and performances. Langley ([6, 7] and elsewhere) has studied the historical context and the practical, financial concerns of the journals in some detail, while Johnson-Hill considers repertory selection from the point of view of *collegiality*[5], and various others have explored the musical attitudes shown in the textual content ([8, 15–17]), but little attention has been given to the music itself and what it reveals about the musical range, abilities and tastes of a perceived readership.

## 3 THE IMAGE OF A READER: INSTRUMENTS AND SKILLS

It is probably impossible, certainly very difficult, to know much about the average reader of *The Harmonicon*. What was their relationship to music? What expertise did they have already? What instruments did they play? To what standard? It seems unlikely that Ayrton or his publishers knew the answers to this either. Nevertheless, they will have known many subscribers personally, will have had correspondence with many more, and were familiar with some parts of the society that their publication targeted. Thus, with the caution that the journal was not a financially successful one, so perhaps not perfectly calibrated, we can try to understand the domestic audience for this music through the choices made by the editor.

Some decisions of material and instrumentation necessarily follow from the format and medium of publication. The binding of the journals precluded publishing separate instrumental parts, so ensemble music was limited to genres that could share a single volume – instrumental solos or duets, or vocal ensembles, optionally with the singers clustered around a piano. Similarly, long pieces would have meant volumes with relatively few separate works or, in the case of *The Musical Library*, could have exceeded the available page count, since this journal was weekly, with each issue quite short.

Within these constraints some decisions made by the editor are unsurprising. The piano dominates the published music, either solo or paired with a single instrument or voice. On occasion, the piano part will be marked as interchangeable with a guitar or harp, but there is little obvious change to accommodate this – as when an instrumental part is marked as for violin or flute (such as the Haydn Symphony movement from the 1828 volume), it usually seems to indicate compatibility rather than active idiomatic consideration. Although the flute as an instrument underwent rapid development in the decades surrounding the arrangements, their deployment is such that no reader still possessing an eighteenth-century instrument would have found anything there to challenge them.



**Figure 1:** Ending of Beethoven’s *Molly’s Abschied* (Op. 52/5), transcribed from the first edition<sup>1</sup> (above) and as it appeared in *The Harmonicon*<sup>2</sup> (below). The final flourish in the piano accompaniment has been greatly simplified – the only significant change in the piece, other than the retexting to English.

### 3.1 Technical skill of the reader

Turning to the expected technical abilities of the readership, we can see that singers are generally expected to be capable of singing operatic arias – if not the most virtuosic ones – without simplification, and presumably having had at least some vocal tuition. Examples such as Pacini’s duet ‘Che Ascolto! or raggio amico’ from *L’ultimo giorno di Pompei*, in the 1831 *Harmonicon* are by no means easy to sing and, while the technically challenging ‘La mie Spada’, from Rossini’s *La Donna Del Lago* (1828 *Harmonicon*) is transferred entirely to flute and piano, this is arguably because it is primarily an instrumental work in the first place rather than to accommodate the abilities of the performer. Vocalists are expected to be comfortable singing in English, French, Italian or Latin as required by the source material, but German is consistently replaced with English texts. This is perhaps unsurprising at a time when *Lieder* in German were not yet so well established internationally, while much opera put on in London was translated into English (and adapted for local sensibilities).

Because the editions are usually quite faithful to their source material, deviations from this to support the readership are easier to interpret than they might be in looser adaptations. For example, in the setting of Beethoven’s song, *Molly’s Abschied* (Op. 52 No. 5), despite the adaptation to English words, the music itself is a close match, including dynamics and articulation, to editions more closely associated with Beethoven himself. The only departure of any significance is also the only part of the accompaniment that would present any challenge to an amateur pianist or sight-reader (see Figure 1): in the penultimate bar, a demi-semiquaver chromatic run is converted to a simple semiquaver gesture in a change that can surely have no purpose other than a reduction in difficulty.

That this sort of change is unusual in *The Harmonicon* is perhaps more because of the materials usually deployed than the process

<sup>1</sup>Ludwig van Beethoven, *Acht Lieder mit Begleitung des Claviers : op 52 / gesetzt von L. van Beethoven*, Kunst und Industrie Comptoir (Wien, 1805), BeethovenHaus Bonn Archive, C52/11

<sup>2</sup>*Harmonicon*, 1829 edition, vol VII/2. This image from the Hathi Trust’s facsimile of the copy in the Bodleian.



**Figure 2:** The piano part from variation IV of Beethoven’s *Air Autrichien* (Op. 105/3), transcribed from the first edition<sup>3</sup> (a-d), and as it appears in the *Harmonicon* (e-f and repeated). *The Harmonicon*<sup>4</sup> uses, and repeats, the easier option for bars 1-2 (a and e), but takes the harder right hand option for bars 5-6 (d and f, though left hand is from b)

itself. *Molly’s Abschied* is a rare instance of a song originally for voice and piano to be reproduced<sup>2</sup>. Most other examples are orchestral reductions, which give more freedom for the arranger to make idiomatic piano parts to any required difficulty, with a few more explicitly parlour or folk song settings.

A more ambiguous example, also from Beethoven, is his ‘Air Autrichien’ from *Variierte Themen für Klavier, Flöte oder Violine* (Op. 105/3), described in *The Harmonicon* (1828 edition, vol. VI/2) as for ‘piano-forte and Flute ad libitum’. In this case, selection has been at the level of individual variations. Some variations have been removed, and the remainder re-ordered. Although the changes made have a net effect of reducing the technical difficulty of the piece, a stronger argument here can be made for reducing the size and cost of the edition. Variation IV is a useful indicator here, preserved, but now presented as the final movement. The editor introduces a repeat sign covering the opening 8 bars, replacing a written-out varied repetition in the first edition. In this case, the version produced selects both harder and easier components of the two repetitions to make the merged version (Figure 2), with large right-hand jumps preserved, but hand crossing avoided, suggesting that, in this case, simplification was not the overriding concern.

<sup>2</sup>This is particularly true if one makes a distinction between ‘art song’, or at least song by a composer of concert music such as Beethoven or Mozart, and ‘parlour song’, in a light, folk style and written usually by specialist composers. This is not a clear distinction, but the difference of composer and, to an extent, genre, helps explain the more challenging accompaniment – a characteristic that would become more clearly seen in later *lieder*.

### 3.2 Repertory

*The Harmonicon* provides a remarkable survey of the music experience of an English enthusiast of the period, taking in new compositions – including some commissioned by the journal – and music dating back as far as the sixteenth century. Genres covered included forms most associated with large-scale, professional performance, such as opera arias (a professional interest of Ayrton himself), sacred polyphony and symphonic movements, and lighter, more explicitly domestic ones, such as canons, dances and more vernacular song forms. Although the balance between these shifts over the life of the publications, the breadth largely remains.

Once again, it is difficult to distinguish selection based on budgetary and space concerns on the one hand from technical ease or lightness of materials on the other. Whole symphonies, for example, could not be included, but single movements could. These latter were almost always minuet and trios, which are usually technically easier, less complex musically, but also shorter in terms of duration and space – the repeating scheme also meaning that a larger amount of musical time could be provided fewer pages. One notable exception to this is the Beethoven's seventh symphony (Op. 72), of which the second movement is provided. In this case, the movement is abridged<sup>3</sup> for brevity. A similar shortening is seen for a sonata movement included in the 1833 edition<sup>4</sup>

### 3.3 Home music making

Understanding the reception of music in the early nineteenth century is impossible without strong, multi-faceted research into home music-making and reading. Journals such as we have considered here by no means tell the whole story, nor can they present a fully representative picture of the repertoire and skills of amateurs at the time. They do give several advantages, however: they are unequivocally for domestic use – unlike chamber arrangements of concert works from music publishers, which sometimes imply concert or salon performance; and they had circulation figures that (at their best) placed their volumes on a large number of shelves in British homes.

It is especially important to consider these publications in terms of the act of making music as a physical activity (something Adorno explicitly addresses in the content of duet arrangements[1]). The difficulty of performance and the skills of the players are only a part of this. The nature of the space, the context of the performance, and the type of instruments being used are all important parts of the way that the music was experienced, and these again take its sensory aspects further away from the sorts of music experience we associate with, say, a Haydn symphonic movement. The range of pianos (or even, perhaps harpsichords) that might be found in the homes of subscribers, not to mention the flutes, guitars and harps,

<sup>3</sup>Ludwig van Beethoven, *Variierte Themen für Klavier, Flöte oder Violine*, (Antaria, 1819), BeethovenHaus Bonn Archive, C105/1

<sup>4</sup>Harmonicon, 1828 edition, vol VI/2 (<https://digital.bodleian.ox.ac.uk/objects/42cb3d38-4c6d-4a37-a449-e569d8bda673/surfaces/ba1dcb85-67af-4626-ba3f-ad6be91b26c4/>)

<sup>5</sup>Harmonicon 1824. Although this movement was very popular and has been arranged and abridged many times, this is earliest known example of a shortened arrangement.

<sup>6</sup>Harmonicon, 1833. For some reason, sonata movements are seldom included. Space concerns can provide only a partial explanation, since plenty of examples, particularly Haydn movements, would have been shorter than the symphonic movements that do appear.

the space, privacy and acoustics of performance are all aspects that we could profitably explore further – perhaps even through practical experiment – if we wish to add colour and depth to our understanding of musical experience of the time.

## 4 A DIGITAL PERSPECTIVE ON *THE HARMONICON* STUDY: ITERATIVE MUSICOLOGICAL RESEARCH SUPPORTED THROUGH DATA AND TOOLS

Having presented the musicological case, it is instructive to now consider the digital scaffolding which enabled this scholarship. The *Harmonicon* study we have sketched above was supported at various points and to different degrees by digital tools and libraries. Many of these will be recognisable, either directly or in type, from most scholars' research process. We argue that a carefully considered assembly of smaller digital tools and resources can be just as effective in providing for digital musicology as a bespoke task-specific super-tool; and that development is better aligned with the inherently iterative and somewhat unpredictable undertaking of musicological research. Using the research lifecycle stages described in [10], and at a higher level in [9], we can review the efficacy of the tools used and consider the opportunities for improvement. Figure 3 enumerates these stages and lists tools and resources used for the present study at each stage.

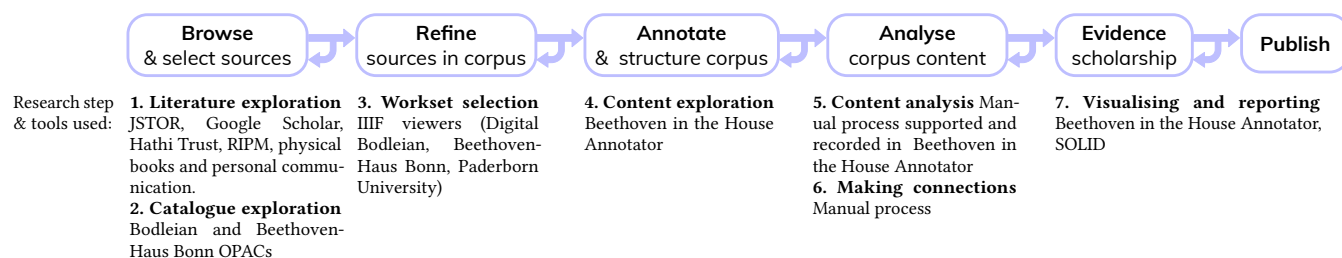
In the sections that follow, we follow [10] in dividing the main research activities into early phase (steps 1-3) and mid phase (4-6) to consider the digital tools and resources used in each case. We then consider gaps in functionality and information transfer between stages.

### 4.1 Early phase

Early stages of research can be characterised as discovering, exploring and selecting materials. As such, much of our research sat squarely within a library context, with literature exploration supported by JSTOR and Google Scholar, along with publishers websites and library catalogues. Musical materials and historical sources were similarly supported by library catalogues, in particular that of the Bodleian libraries and the Beethoven-Haus Bonn Archives. In addition, digitised materials were consulted from RIPM and the Hathi trust.

A further common research step is workset selection, where a long-list of potentially useful resources is reduced to a more manageable set for detailed consideration. At this point, quick and effective navigation between catalogues and the materials they refer to is vital. For this we benefitted from project funds to pay for digitisation and publication online through IIIF servers, based on metadata we ourselves provided.

The periodicals themselves are not catalogued in a publicly-accessible, machine-readable way at the granularity of the individual pieces (or articles) that they contain and their locations in the image stream. Since *The Harmonicon* frequently had over 80 pieces, and *The Music Library* over 120 in a volume (corresponding to a year), this information is necessary for any work that doesn't look at each piece in sequence. For our research, we compiled metadata in a spreadsheet, initially copying and pasting text directly from the scanned images, taking advantage of the inbuilt OCR technology



**Figure 3: A flow diagram giving a schematic overview of a source-based research process (above, from [9]) aligned with a numbered list of the research steps described in [10] and, for each, a description of the tools used at that point in our musicological investigation.**

of modern document viewers (in our case, Apple’s Preview application). A subset of this data was exported as CSV and imported by the Bodleian’s digitisation team into the Digital Bodleian IIF server. This enables quick navigation by musical work in the viewer and gives the additional benefit of making this metadata searchable in the Digital Bodleian’s catalogue, allowing search by composer of these volumes in a way not currently supported in the main catalogue. Other columns in the spreadsheet recorded information that would be useful for our own later research steps, including URLs for name authorities. A cell formula in the spreadsheet was used to output RDF ttl for ingestion in our own applications.

The Beethoven-Haus also publishes digital images through IIF, though for our needs these were all single-work publications, and so required no metadata beyond what was already in the catalogue. Our project also prepared digital editions in MEI of a selection of Beethoven’s works including in arrangements, including the *Allegretto* from his seventh symphony as it appears in *The Harmonicon*. These were also available to use in our mid phase research stages.

## 4.2 Mid phase

The Beethoven in the House Annotator[10] was used to support the content exploration and analysis stages in our research. This tool allows music resources to be compared, connected and annotated, with a uniform interface and data model for IIF images and MEI editions[11]. Linked data is used for catalogue metadata, which can link outwards to external sources. Annotations are made to the scholar’s own cloud storage (using Solid pods[18]). Since the annotator is decentralised, it is straightforward to compare sources from different sources (as in figure 4, showing an image from Digital Bodleian being compared directly with one from the Beethoven-Haus archive).

Once the resources are loaded, arbitrary musical selections can be annotated, marked as relating to others, and those annotations browsed. The scholar can apply commentaries at the level of the musical extract, but also, where parallel passages in multiple sources have been connected, these can also be commented on. Where measure detection has been carried out using a tool such as Cartographer<sup>5</sup> or MEI Friend[4], the Beethoven in the House Annotator can use the MEI they generate, which consists of empty measures and image co-ordinates. This allows the tool to display the measure

bounding boxes on the score image, support selecting whole bars, and align full or selective editions with their matching facsimile.

Each musical region of interest and each annotation is given a URL, which is not only used internally for new annotations, but can be used as a citable unit, allowing other scholars to build on these intermediate elements of research as well as the final, published findings. The use of Solid pods allows a scholar to control which of their statements about the music should be visible to which communities or individuals.

The **late phase** of research in [10] is characterised by visualisation and dissemination. Beethoven in the House Annotator can itself be used for this purpose. Without logging in, a user can view public annotations from other scholars, given a URL for a starting workset. The form taken by the Linked Data produced and consumed by the tool is compatible with previous work on visualising and publishing musicology (for example [12, 13]), and the same framework could be used for this purpose.

## 4.3 Gaps, short-comings and opportunities

**4.3.1 Early phase.** We were fortunate within our project to be able to commission digitisation, prepare metadata and produce digital editions as needed. These activities take time and resources. Libraries are photographing their music holdings at a high rate, which may reduce the need to budget for digitisation, but institutional priorities may not match individual research priorities, and the nature of the objects themselves may cause their own problems. Studies of albums and periodicals pose different challenges for the browsing experience compared with other music notation resources, since a single volume can contain very many musical works. As such, a library catalogue listing that gives an overview title per shelf item will be much less informative, and even more detailed information may be unhelpful without musical incipits or quick and easy links to a facsimile.

A second challenge with digital catalogues for this material is the broad spread of materials to associate with authority files. Many of the *Harmonicon* composers are (now) less well known, including a larger proportion of women than might be seen in some other contemporary sources<sup>6</sup>. Other contributors are given only initials

<sup>5</sup><https://cartographer-app.zenmem.de>

<sup>6</sup>One notable example of the challenges of cataloguing this material is provided by Mary Linwood, whose canzonet ‘Pretty Fairy’ appears in the 1828 edition of *The Harmonicon*. Although Grove Music Online[3] identifies Linwood as the needlework artist born in 1755 in Birmingham, the Oxford Dictionary of National Biography[14] cautions that the composer (and author) was the niece of the artist, and that the two

**Figure 4: The Beethoven in the House Annotator showing the authors labelling the extracts from figure 2 in facsimile, drawing live from the Bodleian IIF servers, and authoring structures stored in the user’s Solid pod (web-accessible cloud storage). The tool supports annotating and comparing images and scores delivered from multiple servers, delivered from libraries anywhere on the web.**

(one of these was a school child from Hackney), or remain anonymous. While this does make research into the music particularly valuable, it also places additional pressure on cataloguing.

Works are also often given generic or vague titles, meaning that unless cataloguing has been already carried out and with great care, exploratory research – especially research focussing on music arrangements – is slow, and dependent on memory or content-based search tools (RISM digital being particularly helpful). This activity resolves not just movements identified as being from a Haydn symphony, but with no further detail, but also true oddities, such as the intriguing version of Beethoven’s concert aria ‘Ah! Perfido’ as a four-voice Agnus Dei with Piano accompaniment (also transposed a semitone down).

**4.3.2 Early to mid phase transition.** Our early phase was entirely carried out using systems with no structured Linked Open Data and, although the Bodleian library catalogue does have some workset export functionality, there was no useful, relevant overlap with our needs. Our research would have benefitted from software supporting a transition from finding and selecting the objects of our study to analysing and annotating them in mid phase research.

**4.3.3 Mid phase.** *The Harmonicon* was presented as a music journal with a large supplement containing sheet music. In reality, it was generally equally divided between text and music, and its reviews of new music, arrangements and performances in particular

are often confused due to the shared name. At the time of writing, VIAF has only one record for Mary Linwood, merging their outputs, while Wikidata recognises only the artist.

are important resources for understanding contemporary musical culture. *The Musical Library* presents itself as a sheet music publication with a textual supplement (and without text in its final year of circulation) but, although the amount of written material is reduced, it is still of great value. [10] describes a research step of connecting musical and extra-musical material is of direct relevance to this topic, but was relatively little supported digitally in our research.

This is for two principle reasons: firstly, budgetary constraints limited digitisation to the music volumes only from *The Harmonicon*, and secondly, even though the tooling is capable of juxtaposition of images whether musical, verbal or even photographic, the ontology Beethoven in the House Annotator uses to capture relationships between extracts is designed for music, or at least for associating similar types of material that have related content, to relate relevant textual information we would need an interface that either supported a novel ontology or used web annotations to create qualified connections between textual or image resources and musical extracts.

## 5 EXTENDING SUPPORT FOR MUSICOLOGICAL RESEARCH

Our experience using our digital workflow as it exists today demonstrates many areas of opportunity for new or extended tools to increase the continuity of support for research as a process. Unsurprisingly, the transitions between areas usually associated with libraries and with university departments, and then between those and publishers, are particularly under-explored.

Our study was selected in part as an opportunity to explore research where the scale of materials is such that information organisation tools become needed to keep track of observations and maintain an overview. As we have described, this was primarily achieved through quick and easy navigation and comparison of digital resources and an annotation system that allows rudimentary capture and navigation of intermediate research notes and observations. A further step in finding and comparing relevant and interesting material in a larger collection of resources would be the integration of additional Music Information Retrieval (MIR) tools into our workflow.

Especially for the study of musical adaptation and arrangement, tools like the VideApp<sup>7</sup>, which highlight differences between two similar musical texts, could support and accelerate the research and annotation process. At a larger scale, and possibly an earlier stage, more generic pattern matching systems, such as the SIA family of algorithms could support quickly establishing clear connections between related musical material, while instrument-specific tools for measuring the technical challenge of passages for performers could help identifying areas of unusual difficulty or where a tricky passage has been modified.

Our approach is designed to support the incorporation of additional MIR tools through the exchange of data using common structures and well-designed pipelines, which [10] argued to be a more robust process in an iterative research context than tool integration in a monolithic software tool. In this context, SIA, for example, could be run over a corpus, annotating patterns it discovers using the same Web Annotations (or, optionally, the Music Annotation Ontology [11]) that the Beethoven in the House Annotator already recognises. This approach allows the selection of research specific tools without requiring substantial re-engineering to support their integration. Nonetheless, a central point made in [10] is the need to support iterative development of digital materials, tools and research. Images of sources are easier to acquire than digital editions in MEI, and so corpus-level MIR tools have their limitations in many settings. Transcriptions using Optical Music Recognition software may help in some situations, particularly for MIR tools that are robust to transcription errors (e.g. [2]) or for repertoires where the current state of the art in automatic transcription is already excellent. Of course, hybrid transcription approaches, or even fully manual editing, can support these tools, but this becomes possible only for smaller volumes of material, at which point, manual analysis may also be practicable. Work with existing digital score corpora is also possible, but may come with concerns about sampling bias. Further research on this practical trade-off and strategies to facilitate large scales of deployment would be particularly welcome.

## 6 CONCLUSIONS

In reporting our study of *The Harmonicon*, we have described the outcome of research alongside the scaffolding – in the form of digital libraries and tools – which supported the musicology. Although the study could, in theory, have been carried out solely with physical materials in the libraries in which they are found, the digital world supported in particular the subset identification, tracking and

juxtaposition of resources in multiple sites, making browsing easier (and safer, given the fragility of old paper), comparison more direct, and helping to organise and structure observations and findings in a form that can be reused, shared and published as supporting evidence to research. The process still lacks many components before it will be fully accessible to the range of musicologists who might use it and, despite our aim to support iterative collection of resources, we are still dependent on digital images and some fragile metadata structures.

Our aim has been to show an almost-complete journey through a research process to expose both the points of effective support and the gaps between them. We have demonstrated that, despite the gaps, it is now possible to conduct historical musicology with tools supporting much of the process and, we believe, that small, focused efforts on workset selection, metadata processing and MIR integration could yield substantial benefits in making this support accessible to a far wider audience. Arguably, just as *The Harmonicon* and *The Musical Library* made a wide range of music accessible and usable to home readers, the work reported here offers a direct parallel, bringing musical libraries of digital resources to the researcher.

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