How accessible to visually impaired musicians in the UK are research materials required for Historically Informed Performance, and what are the implications for these musicians?

Submitted for partial satisfaction of the requirements for

MA in Music, The Open University

by

Matthew Skelton, BSc, MSc, CEng

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ABSTRACT

This study considers the accessibility to visually impaired (VI) musicians working in historically informed performance (HIP) of various research materials including historical scores, written documents (such as journal articles, treatises, and books), and collections of musical instruments. Digital score and document collections are assessed for accessibility, as are sample PDF documents and software applications used for optical music recognition (OMR). A survey of twenty-two musicians aims to assess the accessibility of musical instrument collections in the UK.

An introductory assessment of the issues facing VI HIP musicians is followed by an exploration of how digital technologies used for research affect VI people in chapters 1 and 2. Specific research issues relating to the accessibility of scores, documents, and instrument collections are then explored and evaluated in chapters 3 and 4, using screen readers, website testing tools, software for OCR (optical character recognition) and OMR, and document text extraction.

The study shows that the overall accessibility to VI musicians of written research material (books, documents, journal articles) in digital form is reasonably good, even if some effort on the part of the researcher is required; the accessibility is expected to improve in the next few years as OCR is tailored to older texts. The accessibility of historical musical scores is poor and likely to remain so for the near future, due partly to the complexities of OMR and partly to the nature of older musical scores, whose markings do not always have a modern equivalent. The accessibility of musical instrument collections is varied, with some institutions (such as the Ashmolean Museum, Oxford) being almost entirely inaccessible, and others (such as the Royal Northern College of Music, Manchester and Morpeth Chantry Museum) demonstrating significant accessibility for VI musicians.
The implication for VI musicians is that they are prevented from undertaking the same amount and type of research as their sighted colleagues, putting them at a disadvantage. However, many of the barriers to accessibility of HIP research materials are not fundamental, and further research and development would reduce or eliminate them.

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Some material in the section 'Research Scope' was derived from material previously submitted by the present author for the Project assessment of the A871 course as part of the MA in Music at The Open University in September 2012, and is duly acknowledged as such in a footnote in that section.
I declare that this entire work has been prepared by me alone and is thus entirely my own work. Other than that which uses some conclusions derived from my earlier A871 Project, none of this current work has previously been submitted for any other degree at the Open University or other institution.

Matthew Skelton
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Note: the OU Harvard style of the author-date system for references and citations is used in accordance with the available rubric. The symbol ’ is used both for quotation marks and for the inverted comma.
TERMINOLOGY

The following terminology is used throughout this dissertation:

- BMML – Braille Music Markup Language, a digital music representation based on MusicXML
- DAISY – an accessible text format based on XML
- eBook – electronic (digital) book
- ePUB – a eBook publishing format
- HIP – historically informed performance
- HTML – HyperText Markup Language
- Kindle – an eBook format
- MIDI – Musical Instrument Digital Interface, a technology standard for representing and playing back music in a digital format
- MusicXML – a digital music representation based on XML
- OCR – optical character recognition
- OMR – optical music recognition
- PDF – portable document format, a common digital document standard widely used for publications
- RNIB – Royal National Institute of Blind People, a UK-based organisation
- Screen Reader – software that describes the content of computer screen through audio using a synthetic voice, allowing VI people to use computers effectively
• URL – uniform resource locator, normally known as a web address

• VI – visually impaired

• XML – eXtensible Markup Language, a digital information representation format used widely in internet-connected computer systems

Other terminology is explained at or near the point of use.

Note: the plural third-person pronoun (they) is used instead of male or female singular second-person pronouns (he or she) in order to avoid gendered language and clumsy he/she or s/he constructions.
INTRODUCTION

Overview

The historically informed performance (HIP) movement has tended to place great emphasis on the musical score as the authoritative determiner of the composer’s intentions. However, to play an active and up-to-date role HIP practitioners often seek to consult not only original musical scores, but also journal articles, conference proceedings, and historical treatises, and visit collections of musical instruments (Butt, 2002, p. x; Chanan, 1994, p. 69; Cottrell, 2004, p. 112–119; Kivy, 1995, p. 80–82; Taruskin, 1995, p. 18–22; Price, 2013, pp. 77–78). For blind musicians, access to this extra-musical material is by no means straightforward or guaranteed; most material is not available in Braille, websites may be inaccessible or unhelpful, and PDF documents may not have text data embedded, making them effectively blank to blind and visually impaired (VI) readers (RNIB, 2012b). However, the potential benefits of digital technologies and formats for HIP research are significant, because 'the accessibility barriers to print, audio, and visual media can be much more easily overcome through Web technologies' (W3C & Henry, 2005 para. 6). The extent to which the lack of accessible musical and extra-musical material impedes UK-based blind musicians from participating in HIP research is the subject of this investigation.

Although the number of people registered as blind in the UK is about 150,000 (out of a population of some 63 million), a total of two million people are VI, many of whom have additional accessibility needs (UK Health & Social Care Information Centre, 2011, p. 5, 13; RNIB, 2013a). There are ramifications for performers with other accessibility requirements too (such as those with dyslexia or learning difficulties or those who have difficulties with motor skills), although this study focuses solely on VI musicians (Clark, 2005 section 10), (Turró, 2008, p. 26–27). The timing of this study of VI musicians in the UK is apposite; not only has significant research in this area been undertaken by RNIB in recent years, but also a
large-scale study of the lives of VI musicians is currently underway, involving The Institute of Education, University of London, the RNIB, and the Royal Academy of Music, London (RNIB, 2012b, 2012a; Baker & Green, 2013).

Accessibility

In the context of this study, accessible refers to the extent to which people with physical, cognitive, sensory, or mental impairments (such as blindness, loss of motor control, dyslexia, etc.) are able to use the technologies effectively and satisfactorily (Mifsud, 2011; W3C & Henry, 2005; RNIB, 2012f). However, many digital technologies in 2013 fall short of accessibility standards, leaving people with impairments unable to access data and/or software applications effectively (ISO, 2012; Pye, 2011, p. 25). This study will consider those aspects of digital technology that provide or fail to provide VI HIP musicians with abilities equivalent to those of sighted musicians, rather than focusing on how usable the technology might be in general for musicians (whether sighted or VI) (Mifsud, 2011; Shneiderman, 2000, pp. 85-86; Plaisant & North, 2007, p. 195; Doran, 2011, para. 4; Matera et al., 2006, p. 144). Assessing the accessibility of technology for VI people is a specialist skill, requiring experts such as James Risdon from RNIB in the UK (Cork, 2007; Risdon, 2007; ScienceDaily, 2010; RNIB, 2013c); this research, therefore, can provide only an outline indication of the accessibility of various research materials, rather than a comprehensive assessment. Other interpretations of accessible and accessibility will not be considered in this work, particularly the common-place sense of accessible relating to the comprehensibility of academic prose (Garbutt, 2009, p. 359); nor will the meaning of accessibility related to availability be used (Mayor, 2006, p. 112).

Materials and Structure

The materials consulted for this study will be treated in two ways. First, standard academic reference materials, including journal articles, books, conference proceedings, etc., alongside
primary material such as scores, treatises, historical documents, and data collected specifically for this research will be treated in the normal manner. The second consideration will be what could be called meta-textual information about specific presentations and formats of primary and secondary source material, such as whether a journal article contains accessible text, or whether a particular online digital collection of musical scores is accessible to a screen reader.

Due to the nature of this research, in some cases the same source is referenced more than once in order to distinguish meta-textual aspects of the source when retrieved from different locations; for instance, a source may be available from more than one journal catalogue (such as EBSCO and PROQUEST), but the accessibility of the document may differ between the catalogues. The bibliography, therefore, includes URLs for many references to distinguish between different versions of the same source. A source retrieved from more than one location or catalogue will appear as an additional source from the same publication year: so 'Smith, 1990' sourced from two different catalogues will appear as 'Smith, 1990a' for the first catalogue and 'Smith, 1990b' for the second. In the case where a particular version of a source is being discussed, double square brackets will be used to identify the catalogue or origin of the source like this [[CATALOGUE]], where the word inside the square brackets indicates the distinguishing catalogue from where the source was retrieved. For instance, (Boye, 2002a [[EBSCO]]) indicates that the source was presented by EBSCO whereas (Boye, 2002b [[PROQUEST]]) indicates that the source was presented by PROQUEST; in each case, the reference is to the same underlying source, in this case, *John Dowland, Lute songs: The original first and second books including Dowland's original lute tablature [sic]* by Gary Boye, published in 2002 in *NOTES*, Vol. 58, 3, pp 679-682, whose catalogue-independent reference would appear without the square brackets as simply '(Boye, 2002b)'. Thus if a reference contains square brackets thus [...] it acts as a meta-textual reference, relating to the presentation or format of the source rather than the content of the source; if it appears without square brackets the reference refers to the content of the source in the normal academic manner. Any additional
Following the present introduction, two chapters review the kinds of accessibility challenges facing VI performers undertaking research for HIP, covering musical scores (chapter 1) and documents, articles, books, and musical instrument collections (chapter 2). These two chapters provide a framework for the subsequent evaluation of the accessibility of research material in subsequent chapters: the accessibility of scores (chapter 3); the accessibility of academic materials, documents, and musical instrument collections (chapter 4). A hypothetical UK-based VI theorbo player provides the context for the evaluation of these materials.

Chapters 3 and 4 investigate the accessibility of scores, documents, treatises, and collections relating to the composers Byrd, Purcell, and Handel, who all used the theorbo or lute. These composers were chosen because they are well known in Britain, they have plenty of musical editions available in print, and they have had a good deal written about them (Turbet, 2012; Herissone, 2007; McGegan, 1992); any lack of ability of blind musicians to make use of this material should thus relate to accessibility rather than availability.

A list of less familiar terminology used is found in the 'Terminology' section, and the 'Appendix' contains full details of the survey of musicians relating to musical instrument collections in the UK; other data are presented in the main text.

**Research Scope**

The focus of this research is on the accessibility to VI musicians of HIP research materials: academic articles (especially those in PDF form); instrument collections; scores. Due to the high volume of material that potentially could be assessed for accessibility, focus will be given
to the *types* of accessibility problems rather than their *extent*, which is left as an avenue for further study.

This research will not address the nature of HIP or 'authenticity', assuming instead that those engaged in historically informed performance will incline towards the use of historical material as part of their performance practice (Butt, 2002, p. 46; Taruskin, 1995, pp. 353-59; Rose, 2013, p. 129); indeed, 'notated music [...] has come down to us as a blueprint both for scholarly investigation and imaginative interpretation' (Barker, 2010, p. 141). Nor is the accessibility of audio recordings (both music and 'talking books'), civic documents, newspaper articles, commentary on paintings and other visual art, conferences, and performances addressed here. Similarly, the relative scarcity of Braille versions of printed books and musical scores (particularly for instruments other than keyboard and voice) is left largely unaddressed in this present study, because – as noted in a previous study by the present author¹ – in the UK, VI professionals are able to take advantage of both *The Copyright (Visually Impaired Persons) Act of 2002* (which provides the legal right for VI individuals to have an 'accessible' copy of books and music published in the UK made for them), and the *Access to Work* scheme, which enables VI professional musicians to have the additional costs of their work due to their visual impairment (such as the purchase of special software) met in part by the British state (UK Parliament, 2003; Direct.gov.uk, 2004). Thus, VI musicians have a route to legal, accessible copies of any recently-published book or music score covered by copyright and at a reasonable cost, and therefore VI professional musicians in the UK are not hugely impeded from a legal or financial standpoint in their access to books and other printed materials, even if digital versions of books and other publications can be easier to work with from a practical standpoint (Braille volumes are significantly larger than printed volumes). The accessibility of PDF documents will be specifically considered, due to the substantial additional benefits for

¹ MA in Music A871 Project, 2012
research purposes of digital editions, formats, and technologies (Wiering et al., 2009, p. 23); in particular, by improving the access for VI musicians to recent scholarly editions and research, digital technology may provide the means to reduce the disadvantage of VI musicians working in HIP compared to their sighted colleagues (Thorin & Emanuel, 1987, p. 8). The eBook, although a potentially useful aid to accessibility, is not currently the primary means of disseminating research and so will not be extensively considered in this study beyond it use for a small number of key texts due to space constraints (Hausler & Shaughnessy, 2010; RNIB, 2013b). The accessibility of research websites is a broad and well-researched subject, and – although an important aspect of the accessibility of research materials – will not be systematically investigated beyond an assessment using the industry standard WAVE tool (Theofanos & Redish, 2003, p. 44; Ogbe, 2010, p. 2; RNIB, 2012f; Pye, 2011; Cork, 2007; WebAIM, 2013a, 2012, 2013b). Similarly, although various commercial and freely-available software applications enable researchers to scan historical material and apply OCR in order to extract text, space does not permit an assessment of these possibilities in this study (Breuel, 2008; Google & Hewlett-Packard Corporation, 2013; ABBYY, 2013; Galloway, 2006; OnlineOCR.net, n.d.; Cutter et al., 2010, p. 1). Finally, the legal aspects of website and document accessibility (for example, as covered by the UK Disability Discrimination Act 1995 and the Equality Act 2010) and dissemination of digital copies will not be addressed by this research (NIDirect, 2008; Pye, 2011; RNIB, 2012c; UK Parliament, 1995, 2010; Mankoff et al., 2005; Roos, 2007, p. 879).

**Research Methods**

In order to simulate the experience of VI researchers using a computer, the screen reader software NVDA was used (Ball, 2013; nvda-project.org, n.d.). Screen readers attempt to convert whatever appears on the computer screen to synthesised speech (RNIB, 2012e). NVDA was chosen because at the time of writing it had the highest adoption rate increase of
any screen reader software, and was predicted by 2014 to surpass the previous leader (JAWS) in terms of active users, particularly in the UK. It was, therefore, representative of the technology likely to be used by VI musicians (WebAIM, 2012). NVDA was used in particular to assess the accessibility of PDF documents.

The accessibility of websites was assessed with the WAVE tool from the Web Accessibility in Mind (WebAIM) organisation which performs an automated assessment of the accessibility of a website (WebAIM, 2013a).

The online SurveyMonkey survey website was used to gather responses to questions about the accessibility of musical instrument collections in the UK, chiefly for the simplicity with which surveys can be defined and results collected and analysed (SurveyMonkey, 2013b).

For reading and investigating PDF documents, Adobe Acrobat 11.0.03 – known as Acrobat XI – was used. In particular, the text export feature (File > Save as Other > Text...) was used extensively in order to test the readability of a given PDF with screen readers; screen readers interact with the text in a document on this basis. In other words, screen readers do not convert an image on the screen into text using optical character recognition (OCR); they can only 'speak' when text data is available, and the text export feature provided a rapid means of assessing the presence of text data and therefore the accessibility of the PDF document.

**Literature Review**

Some existing research has addressed the accessibility electroacoustic music and electronic music technology, but has rarely addressed the accessibility of research materials for Western art music (Crombie et al., 2003, 2004; Weale, 2006; Kardos, 2012); indeed, in 2012, 'no specific studies on accessibility of digitized special collections materials [...] exist[ed] in the literature' (Southwell & Slater, 2012, p. 459).
Following the separate recommendations of Coonin and Byerley & Chambers in 2002 (relating to accessibility of online HTML material), and Dermody & Majekodunmi in 2011 (relating to online databases), Southwell & Slater undertook a systematic assessment of the accessibility to VI researchers using screen readers of digitised special collections across 69 academic libraries in the US (Coonin, 2002; Byerley & Chambers, 2002; Dermody & Majekodunmi, 2011; Southwell & Slater, 2012). Although 'published monographs and periodicals were not considered' and only a minority of material assessed was in PDF form the results nonetheless provide an important benchmark for assessing the accessibility to VI researchers of historical materials (Southwell & Slater, 2012, p. 462). The study, using six different screen reader technologies, found that less than half (42%) of digitised materials available from the collections assessed were accessible using screen readers, leaving VI researchers at a significant disadvantage (Southwell & Slater, 2012, p. 467).

The research of Farrar & Young on *Supervising Disabled Research Students* contains further material directly relevant to the accessibility to VI persons of research materials (Farrar & Young, 2007). The project from which that research arose, Premia, aimed 'to improve provision for disabled postgraduate researchers, increase the number of disabled researchers at UK institutions and improve the quality of their experience', and produced a series of related reports about the experiences of researchers in the UK with disabilities (including visual impairment) (Premia, n.d.). For instance, one postgraduate researcher with blindness is quoted as reporting:

> [Many academic research articles] are both difficult to read, even using access technology, and completely impossible for an OCR (scan and read back) system, my preferred method of reading, to handle. (Premia, 2007)

Although the research by Farrar & Young focussed on PhD students, many of the recommendations are relevant to VI HIP musicians too, particularly in relation to accessibility
of the written word through OCR and audio (Farrar & Young, 2007, pp. 12-16). The accessibility of OCR technologies will be assessed in chapter 2.

Peter Bosher and James Risdon (both VI musicians) have researched the accessibility of software applications used by VI musicians, and have advised on the software design (BBC, 2009; Risdon, 2009, 2007; Bosher, 1999, n.d.; Baker & Green, 2013; Nepil, 2013).

Crombie et al. explored approaches for evaluating the accessibility to VI people of music-related technologies including TalkingMusic, XML, and other data formats from the perspective of contemporary music, noting in passing that 'advances in optical character recognition (OCR) [sic, meaning OMR] will open the notation models to a whole new world of applications' (Crombie et al., 2005, p. 216). The role of OMR in accessibility is evaluated in chapter 1.

Mallett et al. provided recommendations for disseminating accessible research, noting that accessibility 'brings increased participation in the research process, as well as wider opportunities for individual development and contributions' (Mallett et al., 2007, p. 206). This research included brief consideration of VI researchers, but limited its scope to live presentation (for example, at conferences), rather than journal articles.

Finally, Olkin considers ways in which participants in research studies are often excluded from that research by the design of experiments or data gathering but does not consider researchers with disabilities (such as visual impairment), only research subjects (Olkin, 2004, p. 332).

**The Theorbo Player as Exemplar – Discussion**

This study will take as an exemplar a hypothetical VI theorbo/lute player involved in HIP. The theorbo is a large stringed and fretted instrument derived from the sixteenth-century lute. It was commonly used in England during the seventeenth and early eighteenth centuries for accompanying solo song and as a continuo instrument providing thoroughbass
accompaniment for operatic and other staged works (Kennedy & Kennedy, 2012; Sayce, 2008; Spring, 2001, pp. 377-97; Tyler, 1990, p. 82; Harwood et al., n.d.; Spencer, 1976, pp. 411-13; North, 1987, pp. 159-60). Indeed, although the theorbo fell out of use during the nineteenth and most of the twentieth century, it is now recognised that the theorbo – and other hand-held plucked instruments such as the archlute, chittarone, and harp – and not keyboard instruments (as had been previously assumed) which was the de facto standard for providing thoroughbass accompaniment throughout the seventeenth and into the eighteenth century (Jones, 1972, pp. 67, 69; Tyler, 1990, p. 82; Williams & Ledbetter, n.d.; Sayce, 1995, pp. 667, 683; O'Dette & Ashworth, 1997, pp. 291-299).

The theorbo/lute was used by three of the most important and most well-researched English/British composers: Byrd, Purcell, and Handel (Brett, 2006, p. 40; Jackson, 2005, p. 106; Keates, 1996, p. 45; Mangsen, 2000, pp. 15-16; Herissone, 2012, p. 157; Holman, 2001, pp. 254, 256; Kennedy & Kennedy, 2012; North, 1987, pp. 5, 7, 14, 41). Because of this any lack of material accessible to VI musicians is likely to be due to inaccessibility rather than availability; that is, had a more obscure composer or work been chosen then a lack of materials could have been due to their obscurity, and distinguishing between accessibility and general availability would have been more challenging.

The theorbo also presents some interesting and important considerations relating to tuning and temperament (Duffin, 2008, p. 47). Crucially, fretted instruments seem to have been tuned in equal temperament since the mid-sixteenth century, but players would make some compensation. In the book Lutes, Viols, and Temperaments by Mark Lindley we read that 'many good players adjusted the [tied-on gut] frets by ear (as they often do today) rather than confirm exactly to a regular spacing [...] Historically inclined players should bear this in mind' (Lindley, 1984, p. 94). More recently, Veroli holds that 'unlike the pure intonations where some considerable mistuning was expected by early audiences and anyway unavoidable [...] in
meantone [...] an accurate tuning is both feasible and expected' (Veroli, 2013, p. 307). The need to investigate and decide on appropriate temperament and tuning for a theorbo thus pivots upon a hugely important point of historical musical practice, one which it would be very much \textit{unn}-historical for any HIP practitioner to ignore (Kite-Powell, 2012, pp. 12, 255-56).

A further reason why the theorbo makes a fruitful choice as an exemplar for HIP is that music for theorbos was written in both lute tablature and in thoroughbass staff notation (Kenny, 2012, pp. 116-17). For this reason, use of the theorbo permits a consideration of issues relating to the use of any musical notation that is no longer in common use, including white mensural notation, German keyboard tablature, and musical signs that have changed shape over time (such as the bass clef) (Rossiter, 2007, p. 5–16; Wikipedia contributors, 2013; Apel, 1961, p. 87–95). Music written or printed using these older forms of musical notation shares a property with handwritten scores: until recently they could not be scanned and recognised as music by digitisation software, thereby rendering them completely inaccessible to VI musicians (Tardón et al., 2009, pp. 20-22).

In a similar way, the fact that the theorbo is rarely played today means that no assumptions can be made about performance practice on the instrument (Spring, 2001, p. 399; Sayce, 2008). Were a form of the instrument still played today (for instance, the modern piano might be considered the descendent of the harpsichord or clavichord), then assumptions and scarcely avoidable prejudices might colour the approach to the instrument and its music. As the theorbo is so unusual the player is forced to approach it without major preconceptions.

Finally, several of the leading contemporary lute and theorbo players are from or based in the UK – Nigel North, Lynda Sayce, Matthew Wadsworth, and Elizabeth Kenny – and there is a substantial amount written about and by these performers concerning the lute and theorbo, again avoiding the conflation of unavailability with inaccessibility (North, 1987; Tyler, 1990; Crawford, 1988; Sayce, 1995, 2008; Wadsworth, 2009, 2012; Kenny, 2012, 2008b, 2008a).
Summary

Musicians working in HIP seek to inform their practice by study of historical documents (particularly treatises and scores), surviving musical instruments, and published research. A small amount of published research specifically addresses the accessibility of research to VI researchers (Farrar & Young, 2007; Premia, 2007). This is complimented by research and advice from practicing VI musicians such as Risdon and Bosher (Risdon, 2007; Bosher, 1999). A somewhat larger but less directly relevant body of research addresses aspects of the accessibility of academic research materials and methods, and that of music-related software, but is generally not focused on the research needs of VI musicians as its focus (Crombie et al., 2005, 2004; Horstmann et al., 2004). A hypothetical VI theorbo player working in HIP would be significantly constrained in their ability to inform their performance practice if they were unable to read academic research and historical documents, interact with historical instruments in collections, or investigate historical musical scores. This need for access to documents, articles, instruments, and scores would apply across the full repertory of the theorbo (and lute) in England, from the sixteenth century to the early eighteenth century, encompassing the music of Byrd (and contemporaries), Purcell, and Handel. The remainder of this study will evaluate the nature of this accessibility and go some way to characterise its extent.
CHAPTER 1 – ACCESSIBILITY OF SCORES

Overview

VI musicians use several means to read musical scores; Braille music (invented along with the standard alphabet by Louis Braille in the 1820s) is an important medium, but not the only one that VI musicians might use, partly due to the difficulty in learning the Braille music code, its limitations in representing simultaneous parts, the limited repertory available, and the high cost of transcription from print to embossed paper (RNIB, 2012a; Crombie et al., 2005, p. 210; Encelle et al., 2009, p. 123; Firman, 1997, pp. 321-32). Musicians with some vision might choose to use large-print editions or digital editions connected to a computer display (MusicReader, 2013; Dancing Dots, 2010; MGS Development, 2013); others prefer to hear the score played to them aurally using MIDI, which partially circumvents the problems of conflating hearing the music and hearing another’s performance of the music, as MIDI renditions of scores tend to lack expression (Selfridge-Field, 1997a, pp. 41, 69; Mnatzaganian, 2004, p. 931). Digital music formats such as MusicXML provide an important medium-independent representation of musical scores, allowing translation to and from Braille (and other accessible formats) and printed scores (MakeMusic Inc., n.d.; Goto et al., 2006, p. 8). Further technologies, such as TalkingMusic, allow a piece of music encoded in MusicXML to be described in natural language to the listener, for example: 'This piece contains 8 bars and consists of 2 sections. The piece is read in eighth notes, except where otherwise indicated' (Crombie et al., 2005, p. 214). However, although research into the automatic digital recognition of early music has been undertaken since the 1970s, only since about 2009 have the software tools and formats to provide VI musicians access to original scores been developed and made generally available (Carter, 1989; Carter & Bacon, 1992; Tardón et al., 2009; Rebelo et al., 2012).
There are four principal challenges facing VI HIP musicians investigating historical musical scores, the first two of which are also faced by sighted musicians. First, the technology used to convert scanned printed musical scores into digital representation – Optical Music Recognition (OMR) – is generally designed to recognise modern printed Western staff notation with its clear, well-defined printing. Its performance with older scores, which show low contrast, unfamiliar musical shapes, or distortions and degradations of the page, is often poor (DIAMM, 2012). Second, older scores contain symbols and musical conventions that are no longer in use or whose meaning has changed since the score was printed. Digital music representation schemes, used by software whose primary markets tend to be for Western popular music and contemporary church music, generally assume that the music is tonal and in equal-temperament (MakeMusic Inc., 2013). Capturing and retaining more obscure meanings from the original score is therefore a challenge for the digital music formats. Third, VI researchers may find online digital score archives inaccessible, preventing them from retrieving digital copies of original historical scores (Dixon, 1996, p. 65). Finally, OMR software applications themselves may be inaccessible to VI researchers, meaning that even if the researcher had successfully downloaded a digital score, they may not be able to scan and convert the score into an accessible format for them to study (Lazar et al., 2007, pp. 248-49). Thus, the process for a VI musician to be able to read a historical musical score is as follows: find the score in a digital archive and download a copy; convert the score into an image format recognised by OMR software; import the image(s) into the OMR software package, run the recognition routines, and export the reconstructed score to MusicXML, MIDI, or similar digital format; and finally, to open the MusicXML or MIDI file in a software application for playback or analysis (Contrapunctus, 2012b; Goto et al., 2006, p. 8). This study considers only the first and third of these steps; the editing of images and the playback of digital music formats (MusicXML, BMML, TabCode, MIDI) was deemed sufficiently

**Digital Score Archives**

Libraries and archives of scanned and digitised musical scores provide the possibility for VI musicians to access older scores through the use of OMR scanning of the scores into MusicXML (Rose, 2013, p. 129; Mondrup, 2012). Digital archives or musical scores can be classified into two types: those which hold copies of scores themselves, and those which only hold an index of scores held in other collections; this study will focus on the former type. Digitised musical scores are typically held in one of two main formats: as PDF documents, or as digital image files such as JPEG (International Telecommunication Union, 1993). The digital archives are typically made available via a website requiring a standard web browser, and so the ability of a VI researcher to find and download copies of scores is strongly determined by the accessibility of the score archive website (Mankoff et al., 2005, pp. 41-42).

**Optical Music Recognition**

The process of recognising printed music using a digital computer is known as Optical Music Recognition (OMR). OMR techniques in development since the 1970s and 1980s are now (in 2013) maturing significantly, although Rebelo et al. consider that 'the results to date are far from ideal' (Bainbridge & Bell, 2001, p. 95; Rebelo et al., 2012, p. 173; Bellini et al., 2007, p. 68–69; Carter, 1989; Carter & Bacon, 1992, p. 456–7). This appears to be because commercial music typesetting products 'are focused primarily on recognition of typeset and printed music documents' leading to poor results with handwritten, medieval, and Renaissance music (Rebelo et al., 2012, p. 174, 186). For example, the fragment of notation in Figure 1 is taken from Thomas Morley's *A Plaine and Easie Introduction to Practicall Musicke*, published in 1597 by the printer to Byrd, Thomas East (Clulow, 1966, pp. 4-5). Due to the printing methods of the
time, the staff lines are discontinuous and note-forms are more medieval than contemporary, a property shared the printed music of Byrd (Morley, 1597, p. 19; Clulow, 1966, pp. 4-5).

A similar problem exists with lute-song music from 1652 by Byrd's close contemporary John Wilson, shown in Figure 2. The lower stave in each pair is the unrealised bass part for theorbo, and the upper stave is for voice; many musical forms are barely recognisable, including the G-clef, F-clef, and the sharp symbol.

Figure 1 - Discontinuous staff lines and older note-forms from Morley, 1597, p.19

Figure 2 - Lute-song music by John Wilson, showing fragmented staff lines and old note forms (Wilson, 1652, [[Yale]])
Discontinuous staff lines, different note forms, and even paper/parchment degradation due to the long-term chemical effects of ink all mean that 'OMR applied to ancient music shows several additional difficulties with respect to classic OMR' (Tardón et al., 2009, p. 1; Ng, 2005, p. 109). Even with the significant progress made by Tardón et al. using advanced image processing techniques to recover and identify staves and notes from the scanned original scores, between 6% and 20% of scanned notes are lost during the recognition process, a figure too high for professional musicians to accept (Tardón et al., 2009, p. 18; Bellini et al., 2007, p. 81). Tardón et al. are some the few researchers to be working in the field of OMR as applied to non-standard written music. Until about 2003, work from 1992 by Carter on the OMR of white mensural notation in seventeenth century madrigal books was the key reference (Carter, 1992, pp. 223-34). Since then, Cardoso et al. and Ng have made progress with OMR for older printed music and handwritten music respectively so that 'lines affected by curvature, discontinuities, and inclination are robustly detected' (Cardoso et al., 2008, p. 1005) and OMR can 'detect tonality based on note distributions and rhythmical analysis' (Ng, 2005, p. 108).

However, more significant progress in OMR is needed before VI musicians undertaking HIP research will be able to rely on the technology for accurate representations of older music: The benefits of further improvements to OMR are clear to researchers, including 'enabling translations, for instance to Braille notations' (Rebelo et al., 2012, p. 187). Furthermore, as of 2012 most OMR software included MusicXML as an output option so providing a path to both Braille and audio representations of the score (Rebelo et al., 2012, p. 184; Contrapunctus, 2012b).

**Digital Music Formats**

As a output-independent representation of music, MusicXML is a vital tool in digital editions which are not tailored to a single publication format (historically, printed staff notation) but can be adapted to new needs, such as formats accessible to VI musicians (Good, 2002, p. 47–
48). However, the variable quality and limited accuracy of the scores generated using the various MusicXML-plus-Braille music schemes has until recently largely been limited to use by students and non-professionals (Goto et al., 2006, p. 8). In principle, if original scores from the sixteenth, seventeenth, and eighteenth centuries could be turned into a digital representation, then VI musicians engaged in HIP research would have significantly enhanced access to those scores, rather than having to rely (as at present) on contemporary (or out-of-date) transcriptions into modern staff notation, and then to Braille or other formats. Various computer software applications exist to scan printed music and produce a digital representation, usually in MusicXML or an equivalent format such as Digital Alternate Representation of Musical Scores (DARMS) (Selfridge-Field, 1997b, p. 30).

Of particular interest to the VI theorbo/lute player is the *Electronic Corpus of Lute Music* (ECOLM), which uses accessible text-based format – TabCode – to represent lute tablature (Selfridge-Field, 1997a, p. 607). (Crawford, 1991), and can be used with the DARMS extensions for Lute Tablature, converted – due to the work of blind lutenist Matthew Wadsworth and academic Tim Crawford – to Braille Music Markup Language (BMML) via MusicXML, or converted to staff notation (Selfridge-Field, 1997a, p. 607; Crawford, 1991, pp. 57-59; Wiering, 1997, pp. 201-02; Crawford, n.d.; BBC, 2003 11’10”-11’50”; Contrapunctus, 2012a; Lewis et al., 2004, p. 4; Rhodes & Lewis, 2006, p. 260).

**Investigation Methods**

To retrieve and make use of a score from a digital library, a VI musician must typically use four separate software applications: a web browser for the score library; a standard image extraction and conversion package to extract the score images in TIFF format; a desktop software package for OMR, reading TIFF images and exporting to a format such as MusicXML; and a final desktop software package for converting from MusicXML into Braille, MIDI, or some other accessible format chosen by the musician (Berinstein, 1999, p. 39). For
the purposes of this study it was assumed that Adobe Reader, the web browser itself, the image extraction/conversion software, and any software designed to work with Braille music are accessible to VI people, so only the score libraries and OMR software were assessed for accessibility (AFB Consulting & Adobe, Inc., 2008). The WebAIM WAVE web accessibility checker was used to produce an accessibility report for each digital score library investigated (WebAIM, 2013a). Due to limitations of space, only the home (start) page and the page resulting from a simple text search were assessed. The screen reader NVDA was used to check whether the basic functions required in an OMR software package were recognised by the screen reader, including score recognition and exporting to MusicXML format (nvda-project.org, n.d.); a software function was considered available to NVDA if, when the mouse pointer was placed on the screen element relating to that function, NVDA read out useful corresponding text that would allow a VI person to recognise the function described. Although assessment of the OMR software by VI subjects would likely produce useful results, this was not undertaken in this study due to time and space constraints.

Summary

Several recent initiatives in the area of digital music representation have benefitted VI musicians. The development of MusicXML as a digital music interchange format in 2000 was the foundation of these developments, because it presented for the first time a format which was usage independent and so is amenable to conversion to many accessible formats, including Braille (Good, 2002; MakeMusic Inc., n.d.). The ECOLM online repository of lute music from the UK and Europe is held in a special format specific to lute tablature but easily convertible to other formats such as MusicXML and Braille, making it in principle accessible to VI musicians working in HIP (Merrill, 2012; Lewis et al., 2004, p. 4).

Furthermore, large-scale scanning and digitisation of older printed and handwritten scores is an important step towards making such musical documents accessible to VI musicians. Where
these scores are made available in online libraries through accessible websites, VI musicians are able to download the scores and read any textual information they contain. Through the use of Optical Music Recognition (OMR) technologies it is possible to convert some scores to a digital format such as MusicXML, which can then be output in an accessible form such as Braille music, MIDI, or simply audio (Rebelo et al., 2012). If these techniques and technologies are found to be accessible to VI musicians, a major barrier to active HIP research by VI musicians will have been lifted, because VI musicians engaged in HIP will have access to original scores in a comparable manner to their sighted colleagues.
CHAPTER 2 – ACCESSIBILITY OF DOCUMENTS, ARTICLES, BOOKS, AND INSTRUMENT COLLECTIONS

Overview

HIP practitioners would assume that musicians engaged in research, VI or sighted, would need to consult historical documents (particularly treatises), in addition to academic journal articles, books, and musical instrument collections (Butt, 2002, p. 25). The reason for investigating such material is that

the [non-score] sources of information (the treatises, visual arts, and lately recordings as well), offer a great [...] potential for individuality in performance, suggesting innumerable ways in which the score (the notes on the page) might be imaginatively enhanced. (Jackson, 1996, p. 8)

It is now widespread practice to provide online versions of peer-reviewed journal articles – one example of how 'e-research' (that is, research facilitated by electronic media and systems) is becoming commonplace in academia (Jankowski, 2012, pp. 7, 15). For instance, music students at RHUL 'used Early English Books Online to see how few performance instructions are given in the original printed editions of Purcell’s music' (Rose, 2013, p. 130). Three computer technologies are central to making historical documents, articles, and books accessible to VI people: optical character recognition (OCR), eBooks, and screen readers. The accessibility of OCR and the availability of eBooks will be evaluated in this study (screen readers would be impractical if not accessible to VI users)².

Musical instrument collections can be virtual (digital, with sound samples and images) or physical (with real historical or copy instruments on display), although only physical collections are considered here because – unlike with text-based materials, where digitisation renders almost all of the original information to the reader – digital instrument collections can

² As noted in 'Research Scope', the availability of books in Braille is not considered in this study.
transmit only a small part of the information about the original instruments, at least until the mould-casting, x-ray imaging, or three-dimensional printing of instruments becomes common, allowing accurate copies of unique musical instruments to be made (Gatti, 1999, p. 203; Pinnock et al., 2013; Kaur, 2012, p. 360; Nowak, 2013, p. 16).

**Material Available through OCR**

Many older documents, journal articles, theses, and conference proceedings are now available as PDF documents, and where OCR has been applied to these PDFs there is the potential for the documents to be accessible to VI researchers (Sun et al., 1992, pp. 422-23; Al-Marakeby et al., 2013, p. 249). VI researchers would use screen reader software to recognise text in the PDF document and read the text through the computer's audio system using a synthetic voice. Recently published PDF documents often need no OCR applied because the text data is available and used at the point of PDF generation; however, PDFs generated from scanned documents require OCR in order to retrieve the text (Ramel et al., 2013, pp. 301-02). That OCR can act to increase accessibility can be seen from the accessible example of *Ornamentation as Indicated by Signs in Lute Tablature* by Janet Dodge, published in 1908, many decades prior to digital typesetting (Dodge, 1908 [[EBSCO]]); such material would have been time consuming and costly to make accessible to VI researchers before OCR. However, although large-scale OCR efforts, such as those driven by Google and the University of Oxford, have led to a great deal of previously inaccessible research material now being available digitally (online), 'the promise of OCR has gone largely unfulfilled. While modern printed sources are easily read, older ones are not' (Bodleian Library, 2009; Beatty, n.d.). OCR has been in use since the 1960s, but researchers in the field of OCR technology have only recently begun to address the need for enhancements to OCR to accommodate early documents, books, and manuscripts, specifically those whose typeface or printing quality (due to changes in typography or degradation of the original material) does not match the modern letter-forms expected by
standard Western, Latin-script OCR software (Management Review, 1970, p. 58; Nagy et al., 1999, p. 66; Boschetti et al., 2009, p. 3; Brener et al., 2005, p. 1274; Blanke et al., 2012, pp. 659-60; Bag & Harit, 2013, pp. 133-34; Vamvakas et al., 2008, p. 525; Silva & Lins, 2011, pp. 553-54; Kae et al., 2011, p.289-90; Holley, 2009). These standard OCR rules were developed from 'well-defined commercial use cases for business environments' which can be far removed from the parameters needed for historical material (Blanke et al., 2012, p. 661); indeed, 'commercial OCR often fails to deliver sufficient results [because] processing is optimised towards large-scale commercially relevant collections' rather than historical documents (Blanke et al., 2012, p. 659). Furthermore, 'digitisation specifically for humanities research is a somewhat piecemeal affair, and is carried out to different extents (e.g. image only or image plus optical character recognition (OCR)) and quality levels' (Blanke et al., 2012, p. 660). For instance, although the 1731 work *A Treatise of the Natural Grounds, and Principles of Harmony* by Holder & Keller is available via Google Books as a PDF, the PDF is not accessible to blind readers, as it has not had OCR applied (the PDF pages are essentially facsimiles of the original) and so contains no text data for screen reader to convert to speech for blind readers (Holder & Keller, 1731 [[Google Books]]). The details of these and other OCR limitations will be considered in chapter 4, along with further issues relating to PDF documents, in the context of documents and articles which a VI theorbo player might consult.

**Material Available via eBooks**

The RNIB in the UK and the National Foundation for the Blind (NFB) in the USA have researched the accessibility of eBooks and their reading devices (RNIB, 2013b; NFB, 2012b). Hausler & Shaughnessy (2010) also evaluated the suitability of five eBook devices for various users with different accessibility needs, including VI users. Three of the five devices were unsuitable for VI users, but two (Amazon Kindle 3 and Apple iPad) were deemed suitable, with some improvements needed in terms of physical manipulation of the device: 'it appears
that Apple has not given publishers an "opt out" for accessibility, largely because the reading of the text is tied to the VoiceOver screen reader, and therefore unlikely to be used by the general public' (Hausler & Shaughnessy, 2010, p. 7). The NFB in the USA has highlighted significant accessibility shortcomings with Amazon's Kindle devices and software applications; for example, 'without the ability to read by character, by word, by line, information is lost in these books', and footnotes and endnotes are inaccessible to VI users in the Kindle software (NFB, 2012a, 5'10"-5’20’; Cummings, 2013; Mason, 2013). These kinds of limitations represent accessibility barriers for VI musicians. Some recent developments appear to have increased the accessibility of eBook devices, however:

Kindle for PC, software which allows Kindle e-books to be read via a Windows computer, now has a free accessibility plug-in, which addresses several of the access barriers that blind or low vision individuals would find when using the Kindle. (ATC, 2011)

The software facilitates screen reader access to all Kindle books, even if an author or publisher has not granted text-to-speech (TTS) functionality. You use your own screen reader such as JAWS or NVDA to access the interface for the software. (Burton, 2011, para. 3)

Furthermore, in April 2013 Amazon released 'a version of its Kindle app that allows blind readers to access Kindle content on Apple devices' which suggests that the accessibility of eBook devices is steadily improving, reducing the accessibility problems for VI researchers (NFB, 2013).

**Musical Instrument Collections**

Collections of historical musical instruments offer the HIP musician several opportunities for learning. Most collections offer a detailed catalogue of instruments, and some collections maintain playable examples, allowing musicians to see, touch, and hear 'the instruments themselves: their dimensions and proportions' (Currier, 2010, p. 16). The strategy for keeping musical instruments differs between collections, with some institutions regarding instruments as 'objects' to be locked behind glass, and others seeking to ensure the instruments remain
playable and played (Dawe, 2001, p. 219; Ruhe, 1997, p. 1230; Paine, 1996, pp. 41-42; Hoover, 1996, pp. 4-5; Barclay, 1996, p. 9–10; Currier, 2010, p. 17); since VI musicians cannot by definition see well, an inability to even handle the instrument (if not actually play it) represents a barrier to learning and research. Whether or not instruments in a collection are available to handle or play, other aspects of the collection can be assessed for accessibility to VI musicians: the collection may provide an accessible guide to the collection, such as an audio tour, or a Braille or large-print version of a printed guide; and the catalogue may be provided online, as audio, or in Braille or large-print.

**Investigation Methods**

To retrieve and make use of a document from a digital library a VI musician must typically use two software applications: a web browser for the digital library and a document reader, typically Adobe Reader for PDF documents. As noted in chapter 1, it was assumed that Adobe Reader and the web browser itself are accessible to VI people, so only the online document libraries were assessed for accessibility (AFB Consulting & Adobe, Inc., 2008). The WebAIM WAVE web accessibility checker was used to produce an accessibility report for each digital document library investigated (WebAIM, 2013a). Due to limitations of space, only the 'home' (start) page and the page resulting from a simple text search were assessed. The Adobe Reader *Save as Other... > Text...* feature was used to generate text-only representation of the PDF documents, which was then inspected by eye for OCR errors and completeness. The *Read Out Loud* feature of Adobe Reader was also used in selected cases (Adobe, Inc., 2011). To assess the accessibility to VI musicians of musical instrument collections, a survey of musicians was conducted using an online (web-based) survey, partly because travel to each institution holding a collection in order to perform the assessment in person would have been a major undertaking, and also because the opinions and direct experiences of several VI and
sighted musicians were expected to offer much more value than the experience of a single sighted researcher.

**Summary**

The digitisation of journal articles, books, and historical documents in recent decades has made possible a significant increase in the range and type of material available to VI musicians researching for HIP. Technologies such as Optical Character Recognition (OCR) and eBooks are capable of further extending the depth and fidelity of material available. However, present inaccuracies with OCR technology could make digital documents either completely or largely inaccessible to VI musicians; PDF documents might include no text, unreadable text due to poorly recognised letter forms, missing text, or unextractable text, all of which would prevent the VI musician from being able to read the document. The situation is expected to improve in coming years in line with research efforts to improve the performance of OCR with historical material. The accessibility of musical instrument collections depends on the availability of accessible collection guides in Braille, large print, or eBook formats, or audio, combined with whether the instruments in the collection are available to handle and/or play by VI visitors.
CHAPTER 3 – INVESTIGATION: SCORES

Digital Score Catalogues

Fourteen English-language digital score libraries were selected for assessment, most of which were hosted in either the UK or the USA; all libraries were open-access and academic rather than commercial. A full assessment of every aspect of each library catalogue would be a major undertaking, and so this study assessed only two pages from each catalogue for accessibility: the 'home' page (from which searches for scores would typically begin), and the page resulting from a simple text search (such as byrd, purcell, or handel). The tool used for accessibility assessment was the WebAIM WAVE tester tool which analyses a given URL and produces a report on accessibility (WebAIM, 2013a). The name, location (URL), and total number of scores available for each catalogue is provided in Table 7 under 'Digital Score Catalogues' in the Appendix, and the total number of items for each of Byrd, Purcell, and Handel is given in the same section in Table 8. As a control, the library catalogue of RNIB was used (RNIB, 2012d); being aimed at VI users, this catalogue has no WAVE errors, either on the home page, or on the search results page.

The full results of running the WAVE tool against each of the score catalogues are given in Table 9 in the Appendix. Some catalogues did not produce a definitive URL, and so only their home page could be assessed using WAVE. In order to discount the possibility that reported accessibility errors simply increased in line with page size, the total size of each page was recorded. Only five out of eleven catalogues assessed had fewer than five errors for the home page, and only five out of nine catalogues had fewer than five errors on the results page; furthermore, only the search results page of ECOLM had no errors; all other pages across all catalogues had at least one error. This is shown in Figure 3.
No strong correlation was found between the number of accessibility errors and the size of the pages, discounting the possibility that errors increase with page size. This is shown in Figure 4 and Figure 5; least-squares $R^2$ values for a linear fit were 0.0116 for the home page data, and 0.0642 for the search results page data, indicating no meaningful relationship between number of errors and page size, although the sample size was too small to be completely certain of this.
Thus around half of the digital score collections assessed had more than five accessibility errors for both the home page and the search results page. Whether these errors would in practice prevent a VI researcher from finding a score is not known, but it is likely that they would find it more difficult than when using the collections with fewer errors.

During the evaluation, several specific accessibility problems were noticed with some of the websites. The British Library holds a digital copy of Byrd's *My Ladye Nevells Booke*, a keyboard tutor from 1591 (Byrd, 1591 [British Library]; Harvell, 2006; Woolley, 2006, pp. 34-35; Musical Opinion, 2006, p. 6). However, access to the digital copy of this important manuscript
is restricted not only to those using the Windows operating system, but to sighted users of that system, because the digital viewer works only on Windows, and does not present information for the NVDA screen reader to convert to speech (Figure 6).

The Munich Digitization Center presents online search results in a manner which prevents both VI and sighted researchers from distinguishing one result from the next, where many results share the same categorisation. This is especially awkward when searching for the works of Handel ('Händel' in German), when many identical results are given – shown in Figure 7.
Finally, the digital score browser provided by the Juilliard Collection appears to have some kind of technical malfunction which overlays a portion of the inside manuscript cover onto each page of the manuscript score images, as shown in Figure 8 when reading the score of Purcell's *Dido and Aeneas* (Purcell, 1688, p. 55 [[Juilliard Collection]]).
This problem would prevent a VI researcher from capturing score images for use in OMR.

**OMR Software**

Two separate assessments of OMR software were planned for this study: first, whether the software could effectively scan and recognise older scores with minimal errors; second, for those software packages not specifically known to be accessible, whether the software was accessible to screen readers. Five software packages for OMR were considered, as shown in Table 1; the basis for the list was the survey of OMR software undertaken by Desaedeleer (Desaedeleer, 2006, pp. 8-11). Of these five packages, two used the OMR engine of a third package (SharpEye 2), reducing the effective number of distinct OMR engines to three (PhotoScore, SharpEye 2, and SmartScore).

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
<th>Website</th>
<th>Known <em>a priori</em> to be accessible?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>GoodFeel</td>
<td>3.2</td>
<td><a href="http://www.dancingdots.com/">http://www.dancingdots.com/</a></td>
<td>Yes</td>
<td>Uses SharpEye 2 for OMR. Designed for VI users.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>main/goodfeel.htm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 8 - Technical problems with the display of scores from the Juilliard Collection, in this case Purcell's Dido and Aeneas (Purcell, 1688 [[Juilliard Collection]])
<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
<th>Website</th>
<th>Accessibility</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhotoScore</td>
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<td><a href="http://www.neuratron.com/photoscore.htm">http://www.neuratron.com/photoscore.htm</a></td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>SharpEye 2</td>
<td>2.68</td>
<td><a href="http://www.visiv.co.uk/">http://www.visiv.co.uk/</a></td>
<td>Yes – see (RNIB, 2011)</td>
<td></td>
</tr>
<tr>
<td>SmartScore X2</td>
<td>10.5.4</td>
<td><a href="http://www.musitek.com/smartscore-pro.html">http://www.musitek.com/smartscore-pro.html</a></td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 - OMR software packages considered

During the early stages of assessment it became clear that only one software package (PhotoScore) was able to scan and convert historical scores with anything approaching a useful degree of accuracy; only PhotoScore was therefore assessed for accessibility.

In order to assess the effectiveness of the three OMR engines at reading historical scores, the first page of the aria *How Beautiful are the Feet* from the 1767 copy of *Messiah* by Handel from the UNT digital score collection was used (Handel, 1767, p. 126 [[UNT]]). First, a high-resolution image was downloaded from the collection, before being converted to the TIFF image format recognised by the OMR packages (Berinstein, 1999). The image was then made brighter and had the contrast increased (as recommended by the software packages). A comparison of the appearance of the original image versus the tuned image can be seen in Figure 9.
The processed image was then imported into the OMR software package for score detection. SharpEye 2 was unable to detect any staves and so could not extract any music (Figure 10). This appears to be due to some kind of image processing within the software which reduced the fidelity of the image.
SmartScore could read the image, but it could detect only about half of the notes, perhaps due to the marked 'bleed' between notes from the printing (Figure 11). Furthermore, the solo alto part on the second stave was not recognised at all, leaving only the violin and continuo staves.
PhotoScore produced a reasonably accurate rendition of the original music, which could be heard with the built-in audio player (Figure 12).
The performance of PhotoScore was markedly better than both SharpEye and SmartScore, however, the Handel score is relatively modern in appearance, and therefore to exercise the software further a much older score was presented, the piece by Thomas Morley shown in Figure 1 (Morley, 1597). PhotoScore 'is the world's first and only commercial program available that is also designed to read handwritten scores', and achieves this through the use of a distinct 'handwritten' mode of operation (Neuratron Ltd., 2011). When the Morley was presented to PhotoScore running in normal printed mode (for engraved scores), results were unsurprisingly poor (Figure 13).
However, when the same score image was presented to PhotoScore in handwritten mode, the results were surprisingly good, with all three lines of music recognised, including accidentals and even the correct C-clef, even though the printed form of the music is substantially different from modern printing (Figure 14).

This result was slightly surprising at first, as the music in the Morley score is actually engraved. It is likely that the software algorithms which are able to detect handwritten music make
different assumptions and decisions about the note-forms and staff layout compared to the settings for printed/engraved music, leading to a positive result for recognising music from a historic score such as the Morley, whose note-forms are substantially different from modern engraved music. It should be noted, however, that the number of errors in the OMR is still significant enough to require substantial input from a sighted colleague in order to correct them. Attempting to read the Morley score with either SharpEye or SmartScore was unsuccessful, as neither package could detect any notes.

Having some indication that PhotoScore could be made to read historic scores, it was then assessed for use with a screen reader by using the NVDA screen-reader software to read aloud the various parts of the user interface. In almost all aspects PhotoScore provided accessible descriptions and the ability to navigate to elements in the software; however, one part of the software was not accessible by NVDA: the option to choose between Handwritten and Printed music (Figure 15). It was also not possible to use the keyboard to switch to these options, only a mouse.
In practice, this which would prevent a blind user from using the software to read some historical scores, even if the scanning and recognition were perfect.

The accessibility of the feature to export the OMR reconstruction as MusicXML was not possible to verify fully in any of the OMR packages assessed due to licensing restrictions; however, the menu commands to achieve the export were available to NVDA in all three packages, suggesting that a VI user would be able to export any OMR reconstruction as a MusicXML file and therefore be able to make use of the MusicXML file in a separate software package for converting MusicXML to an accessible format such as Braille music, MIDI, etc.
CHAPTER 4 – INVESTIGATION: DOCUMENTS, ARTICLES, BOOKS, AND INSTRUMENT COLLECTIONS

PDF Documents

A selection of PDF documents likely to be of interest to a VI theorbo player was assessed for accessibility, including journal articles, treatises, and historical documents. A PDF produced from a scanned historical paper document without any OCR is categorized by Turró as a PDF Image (Turró, 2008, p. 27); such a document is inherently inaccessible because the content of the document is an image, not searchable text. Assistive technology cannot read or extract the words but once OCR is properly applied to the scanned files, however, the image becomes searchable text. (Zhou, 2010, p. 155)

However, 'PDF files [containing OCR text] do not naturally "know" the correct order of text' (Johnson, 2006); for instance, text which appears in two columns would present no problem to sighted readers, who would naturally read the first column before the second, but could be read by PDF software from left to right across the whole page, taking the first line of the first column followed by the first line of the second column, and so on (Hoffman et al., 2005, p. 174). Figure 16, taken from the catalogue of musical scores at the Juilliard Collection shows an example of this problem. The text order in the document reads from 'Dido and Aeneas' in the left column directly to 'Eighteenth-century...' before continuing with 'together with...' from the left column (Opitz, 2010, p. 16). Similar problems were found to exist in some journal articles with columns.
However, if the text within the PDF contains metadata about reading order, the PDF software can read the entire first column before the second column. If the PDF also contains structural information, known as tags, the reader software can navigate semantically within the document by identifying sections such as the abstract and bibliography (for a journal article), and this structure makes the PDF accessible, even if the process of creating such a tagged PDF is neither trivial nor fully automatic (Turró, 2008, p. 28; Graells et al., 2008, p. 569; Clark, 2005, section 12; WebAIM, n.d.; AFB Consulting & Adobe, Inc., 2008, pp. 10-13; Huddy, 2012, section 10).

There are more subtle problems with PDFs, however. For instance, in the Oxford University Press online PDF version of the seminal 1976 article *Chitarrone, Theorbo and Archlute* by Robert Spencer, the opening paragraph is clear to sighted readers in the PDF as follows:

> Defining the differences between the chitarrone, theorbo and archlute has always been difficult. (Spencer, 1976, p. 407)

Indeed, the full text is present as a result of OCR, but viewed within the Mozilla Firefox browser\(^3\), the embedded text is rendered in a fragmented form (in the original, new lines have been replaced here with the / character):

---

\(^3\) Mozilla Firefox version 21.0, available from http://www.mozilla.com/
Defining the differences between the chitarrone, theorbo and archlute has always been difficult. (Spencer, 1976, p. 407 [Oxford Journals])

This fragmentation of text makes it virtually impossible for a screen reader to be effective.

Viewed using a different PDF reader (Adobe Reader XI), the text is rendered correctly, albeit with a line break (signified again by / to match the column ending in the print original):

Defining the differences between the chitarrone, theorbo and archlute has always been difficult. (Spencer, 1976, p. 407 [Oxford Journals] (Adobe Reader XI))

The impact on the VI researcher of this kind of text fragmentation would be to force them to download every affected PDF and open in one PDF reader after another until their screen reader produced intelligible results, rather than read the PDF directly in the browser – an onerous task.

Even well-formed text within PDFs can be problematic where advertisements are sited in line with the article. For instance, in the 1988 review of Continuo Playing on the Lute, Archlute and Theorbo by Crawford, the PDF text reads:

While several early treatises attempt to teach figured-bass playing by a mechanical translation of the figures /

EARLY MUSIC MAY 1988 275 /

Charles Wells / "Early / Woodwinds / .00 / Maker, restorer and / repairer of early /
[w]oodwind instruments

into intabulated chords, they all / stress-in their own ways-the im- / portance of / understanding the under- / lying harmonic and compositional / structure of the music.
(Crawford, 1988, pp. 275-76 [JSTOR])

This likely indicates a lack of text-flow metadata, and would result in a VI reader having some difficulty in making sense of the document or navigating backwards and forwards.

---

4 The main article text is shown underlined.
Many full-text PDF documents also suffer from OCR limitations relating to changes in typography and letter forms. In particular the so-called 'long s' grapheme is often read by OCR as 'f' (Fens-De Zeeuw & Straaijer, 2012, p. 319); this results in text such as

First, the Voetry. Secondly, the Composition of *Mufiel* (Mace, 1676, p. 1 [[IMSLP]])

and

Those only reach that blissful place, / Who enter in through sovereign grace (Breuel, 2012 (image 0069))

A further problem with OCR text is that characters can be misplaced or swapped in the text data. For instance, in the 1995 article by Sayce *Continuo Lutes in 17th and 18th-Century England*, we find:

The next / plucked continuo part is Walter Porter's very Italianate Madrigales and Ayres. Of two, three, foure and five Voyces, with the continued Base, ... / To be performed with the HarpesechordL, utes, Theorboes, ase Violl, two / Violins, or two viols (London, 1632). (Sayce, 1995, p. 667 [[[STOR]])

Here, the starting letter of some words has been transposed to the end of the previous word, a feature not visible to sighted readers, as shown in Figure 17:
A similar problem besets the JSTOR PDF of Some Improvements in Music Noted by Willi
am Turner in 1697 by Tilmouth which provides quotations from the 1697 book A Compleat History... by Turner (Turner, 1697; Tilmouth, 1957 [[JSTOR]]). For instance, the phrase 'the Theorbo,
which is no other than an Arch-Lute, keeping to the old Tuning...' in the PDF text is rendered
as "the Theorbow, hich is no other than an Arch-Lute' due to errors in OCR (error underlined) (Tilmouth, 1957, p. 58 [[JSTOR]]).

Many PDF files use 'hard' line breaks at the end of lines, causing screen readers to pause when
configured in a certain mode, thus forcing VI readers to interact with the reader software after
every line of text to continue reading (van der Werf, 1988 [[Claremont]]). Footnotes in PDF
documents also cause problems for VI readers because they are read by the screen reader as if
part of the main text, so disrupting the flow and potentially making it difficult to follow the
text. For instance, a 2009 journal article Come, Ye Sons of Art—Again has the following text
where a footnote appears:
may have engineered overlaps for which Purcell himself was not responsible. \footnote{22} On a different plane, however (Pinnock & Wood, 2009, p. 449) [\citename{Oxford Journals}]

Here, the footnote details (underlined for clarity), visible as an unobtrusive number by sighted readers (Figure 18), are rendered in OCR text as 'fn22 [line break] 22', which would break the flow of the text when read by a screen reader.

![Figure 18 - Unobtrusive footnote number visible in Pinnock & Wood, 2009](image)

Some PDFs with OCR text have portions of text missing entirely. For example, almost an entire paragraph of text plus footnotes is missing from a 1997 article by Tyler; the text should read

With the rise of the galant and early classical styles in the 18th century, the guitar, which for more than a century and a half had maintained its own unique sound and idiom, now was adapted to fit the requirements of the new music. [\textit{Continues for four further lines, plus footnotes}] (Tyler, 1997, p. 67)

However, the OCR text is truncated at '[...] century and a half', leaving the VI reader with missing information; Figure 19 shows the extent of the available text at the foot of page 67 (highlighted).
The Read Out Loud feature of Adobe Reader allows text in the PDF to be 'read' aloud using a digital text-to-speech processor on a personal computer (Adobe, Inc., 2011). However, even with high-fidelity embedded OCR text, some PDFs are structured in such a way as to prevent the Read Out Loud feature working, and when text export is attempted (using the Save As > Other > Text... menu options), no text is available. It is reasonable to assume that the inability to save the embedded OCR text and the inability of Read Out Loud to find text to read stem from the same underlying document problem: what could be termed unextractable text. For instance, in a 1993 article by Wood for Early Music, OCR text is clearly available in the PDF, and when all the text is selected and copied, it can be pasted into another document without hindrance, containing the full text (OCR errors excepted) (Wood, 1993, p. 149 [[Oxford Journals]]); this is shown in Figure 20.
Henry Purcell

COMPLETE ODES AND WELCOME SONGS
VOL. 3
THE TRUMPET, BEAT THE DRUM,
CELEBRATE THIS FESTIVAL
VOL. 4: FROM HARDY CLIMES, YE
TUNEFUL MUSES, CELESTIAL MUSIC DID
THE GODS INSPIRE
VOL. 5: WELCOME, WELCOME, GLORIOUS
MORN; GREAT PARENT, HAIL; THE
SUMMER'S ABSENCE UNCONCERNED WE

Figure 20 - Text present and selectable but not accessible, in Wood, 1993 [[Oxford Journals]]

However, the Read Out Loud feature simply reads the word 'blank' for all parts of the
document except the 'Downloaded from [...] text generated dynamically by the archive (Figure
21).

Figure 21 - Auto-inserted 'downloaded from ...' text readable by Read Out Loud in Wood, 1993 [[Oxford Journals]]

The same unextractable text problem applies to the renowned treatise The Singers Preceptor by
Corri as held by Archive.org (Figure 22) (Corri, 1810 [[Archive.org]]).
Furthermore, the screen reader NVDA was unable to read the text in these PDF documents, suggesting that there is some error or deficiency in the way in which the available OCR text is stored or made available for text extraction. The result of the unextractable text problem is that PDF documents that are nearly accessible to VI researchers are in practice completely inaccessible, with no text available to them.

Journal distributors appear to differ in their application of OCR to journal texts, even for the same journal title. For instance, the catalogue at JSTOR has issues of *Galpin Society Journal* as OCR PDFs, but the catalogue at ProQuest has non-OCR PDFs (MacMillan, 2007a [[JSTOR]], 2007b [[ProQuest]]); thus journal articles retrieved via one distributor are potentially accessible, while those from the second are inaccessible.

Several useful older documents – especially musical treatises – are only partially accessible even with OCR text present, due to their use of languages and scripts which are different from those expected by modern OCR, such as Latin, Greek, or German (with Gothic script), as shown in Figure 23.
The HIP cellist Anner Bylsma specifically recommends that performers read *Syntagma Musicum* by Michael Praetorius (Sherman, 2003, p. 209; Praetorius, 1619b). In the Archive.org copy of this renowned treatise, the Gothic script is completely unintelligible within the PDF text, and the Latin script is only barely intelligible. For example, in this extract Latin is underlined, and the symbol \ is used to denote line breaks because the / symbol is present in the OCR output:

**FALSO BORDONE.**

1. "fürs erste werden die Psalmen / so im anfang der Vesper / als Nota contra Notam in einer reige nach einander in unisono gesetzt fern"

To a sighted reader of German and Latin, the text is possible to read fairly easily, as shown in Figure 24.
A DAISY version of the text is available at Archive.org, but the text is as garbled as that in the PDF version (Praetorius, 1619b [[Internet Archive]]).

A final but apparently rare problem is extremely poor scanned image quality. Figure 25 shows one such example at larger than full size from the Archive.org copy of Songs for the Lute, Viol and Voice by John Danyel (Danyel, 1606, p. 1 [[Archive.org]]).

The poor scan quality results in OCR text which contains significant errors:

```
IHat which was onelyprinawlyeompo'i.i. / IFfor your debghtj"*iM Ornament ol Worthy / IhharejCame/o bkpublicfycydiflos'd: / IAnd to an vnierfall view put forth. (Danyel, 1606, p. 1 [[Archive.org]])
```
The NVDA screen reader is unsurprisingly unable to read more than a few words from such documents, leaving them inaccessible to VI researchers.

Some notably accessible journal articles demonstrate how others fall short in accessibility. In *Spatial Effects in English Instrumental Consort Music, c. 1560-1605* by Rastall, which asks the question 'How ... should a consort [including theorbs] be disposed for concert performance and for recording sessions?', not only is the text in the PDF extractable and therefore accessible, but also the diagrams and pictures in the article are explained in a manner which provides information to VI researchers, as shown in Figure 26 (Rastall, 1997, pp. 285-85, 272 [em.oxfordjournals.org]).

The article *Byrd, Sidney, and the art of melting* by Milsom (2003) – concerned with the performance of songs by Byrd with lute accompaniment – demonstrates a correct use of text reading order within the PDF, so that the first column read by NVDA prior to column 2 (Milsom, 2003, p. 437 [em.oxfordjournals.org]). Figure 27 shows that text in the second column is selectable only after that in the first, rather than from left to right across both columns.
Documents that originated digitally, such as the thesis Lute Realizations for the English Cavalier Songs (1630 – 1670) - A Guide for Performers, demonstrate full-fidelity text, because the text was generated directly from the digital original, rather than as the result of OCR (Denhard, 2006 [dartmouth.edu]). Textual errors in this kind of document are minimal, demonstrating the benefit of digital originals for VI researchers. However, even with a digital original, the text may not be accessible; the thesis English Lute Manuscripts and Scribes 1530-1630 by Craig-McFeely is available as PDFs with embedded text, but the text is not extractable because the PDF has been 'secured', preventing access by VI researchers (Craig-McFeely, 1994).

A solution to the problems of poor OCR-derived text is suggested by the 2005 edition by Project Gutenberg of Dent's book Handel (Dent, 2005 [Project Gutenberg]). This copy has high-fidelity text in several formats along including PDF, and the text for all formats has been
proofread 'by Stan Goodman, and Distributed Proofreaders', that is, not simply generated from the OCR-scanned pages; this makes for a better reading experience for VI users.

**Academic Journals**

The websites of selected academic journals likely to be of interest to a VI theorbo player were assessed for accessibility using the WebAIM WAVE tool. The journals were chosen as those which each provided the greatest number of academic articles cited in this study. Full details of the assessment are provided in Table 10 in the Appendix, which shows that the home page of all eight journal websites assessed had fewer than five WAVE errors, and so could thus be considered reasonably accessible to VI researchers. However, only five of the search results pages from these websites could be assessed with WAVE, and of those only two – those of *Performance Practice Review* and *Library Hi Tech* – were found to have fewer than five errors. This represents a low degree of accessibility for VI researchers when attempting to find research material using the websites of specific academic journals.

**Journal Distributors and Indexes**

The websites of selected journal distributors were assessed for accessibility using the WebAIM WAVE tool. The distributors were chosen as those which together provided the majority of the academic articles cited in this study. Full details of the assessment are provided in Table 11 in the Appendix, which shows a wide range of accessibility, even between the home page and search results page of the same publisher. Two distributors – JSTOR and ProQuest – could not be assessed at all due to technical reasons which possibly indicate a fundamental lack of accessibility. The EBSCO website had many errors, while the Emerald website was the most accessible, with no errors reported for the search results page. The accessibility of the websites of journal distributors and indexes can thus be described as *mixed*; with such a small sample
size, combined with the technical limitations encountered, it is difficult to draw any more general conclusions.

**Other Digital Formats**

Some academic publications are available in DAISY format, which enables special machines to render text as Braille (DAISY Consortium, 2013; Risdon, 2007). The online collection of documents at Archive.org generally provides a wide range of document formats for each source document, including image-only PDF, PDF with OCR text, DAISY, Kindle, ePUB, and plain text (shown in Figure 28).

![Figure 28 - Formats generally available on Archive.org, showing the index page for Byrd, 1589 [[Archive.org]](http://archive.org/details/imslp-of-sundry-natures-byrd-william)](http://archive.org/details/imslp-of-sundry-natures-byrd-william)

However, the DAISY, ePUB, Kindle, and plain text formats on Archive.org appear to be generated directly from the OCR text, and so these theoretically accessible formats contain just as many errors in the text as the OCR PDF version, thereby adding little accessibility in practice. If the same provenance applies to DAISY versions of journal articles, which seems
likely, then academic journals and catalogues could *appear* to be providing accessibility through formats such as DAISY while actually *denying* VI researchers effective access.

An indication of the novelty of the eBook format for academic works can be gleaned from the fact that only the most recent 2012 edition of the essential research guides to William Byrd by Turbet is available in ePUB format; the earlier editions are available only in print form (Turbet, 1987, 2006, 2012 [[Routledge]]). A brief inspection of other academic books relating to HIP suggests a date of about 2008 for when the eBook started to become more widely used as a format; there seem to be few eBooks available commercially for printed books published before that date. For instance, *Authenticity and Early Music: A Symposium* edited by Nicholas Kenyon (Kenyon, 1988) has no PDF or Kindle version, and – unlike many more recent books – is searchable neither on Google Books nor Amazon (Google, n.d.; Amazon, n.d.). The book *Music Theory in Seventeenth-Century England* by Herissone (Herissone, 2000) has no PDF version, no Amazon Kindle or Kobo version, and is not searchable on Google Books (Kobo, Inc., n.d.). For books published from about 2003, accessibility improves: Sherman's *Inside Early Music* (2003) is searchable on Google Books and Amazon, although not available as an eBook as such, and *The Art of Accompaniment from a Thorough-Bass* (Arnold, 2003) is available as a Kindle eBook, and the text is searchable in Google Books. This book is especially useful to the HIP researcher because it contains the entire text of a short treatise (B.M. Add. 34072, ff 1-5) by English composer John Blow present in the British Museum, whose digital document presentation systems are not all highly accessible, as discussed in *Digital Score Catalogues* in chapter 3; the treatise by Blow 'gives far more information than any of its predecessors' (Arnold, 2003, p. 172). *The End of Early Music* by Bruce Haynes (Haynes, 2007) is available as eBook via Google, but more some important more recent works do not have eBook versions, notably *A Performer's Guide to Renaissance Music* (Kite-Powell, 2007), and *A Performer's Guide to Seventeenth-Century Music* (Kite-Powell, 2012), both of which are searchable in Google and Amazon but neither of which has a PDF or Kindle version listed.
Finally, *Musick's Monument* by Thomas Mace (1676) is useful to theorbo players engaged in HIP research because Mace provides accounts of earlier lute players such as Dowland and Robert Johnson, and goes into detail about how to repair, re-string and generally maintain a lute, all of which provide the modern player with additional context for playing the instrument in an historically informed way. (Mace & Shephard-Smith, 2011, p. 60)

The treatise contains an 'elaborate, virtuosic approach to the theorbo' (Denhard, 2006, p. 4). However, the version of *Musick's Monument* at Archive.org has poor-quality text, likely due to OCR problems with the old type face (Mace & Faithorne, 1676 [[Archive.org]]). The version available from IMSLP is not much better (Mace, 1676 [[IMSLP]]). A new 2011 edition, including an eBook version, is available (Mace & Shephard-Smith, 2011 [[Google]]). However, the musical examples are presented as images rather than in a digital music format like MusicXML and are thus inaccessible to VI musicians; indeed, the entire book contains no flowing text, just page images (Figure 29) and is thus entirely inaccessible to VI users.

![Figure 29 - Lack of flowing text for the eBook version of Mace & Shephard-Smith, 2011](image)

An early eBook is *William Byrd and His Contemporaries* by Philip Brett (editor of the Byrd Edition), which is available on as a Kindle eBook with Text-to-Speech enabled (Brett, 2006 [[Kindle]]). Text-to-Speech is a feature of Kindle books which enables the Kindle device to
read aloud the text embedded in the eBook file, much as the Adobe Reader Read Out Loud feature does for PDF document (Francis, 2011, p. 408; Adobe, Inc., 2011). Some commercial publishers have chosen to disable such accessibility features in eBooks; for the Kindle edition of How Equal Temperament Rained Harmony (and Why You Should Care) by Ross Duffin, 'the publisher has requested not to enable Text-to-Speech', thereby preventing access by VI researchers, a stance which has caused some controversy (Duffin, 2008 [[Amazon]]; Higginbotham, 2010).

**Musical Instrument Collections**

A survey was devised to assess aspects of VI accessibility relating to musical instruments collections in the UK. Both VI and sighted responders were invited to take the survey, with the sighted responders acting as a control group. Twenty-two people took part. Most of the details of the survey are contained in the Appendix under the section 'Survey: Musical Instrument Collections in the UK'; only the salient results are presented here. The design of the survey was guided by the recommendations of Podsakoff et al, particularly to avoid response bias (Podsakoff et al., 2003, p. 883–4). The ethical considerations applied to the survey are discussed in the Appendix under 'Ethical and Accessibility Considerations'. The full list of questions is given in Table 6 under 'Questions' in the Appendix.

**Results**

Responder 18 had intermittent visual impairment, highlighting that it is not possible to establish a simple distinction between sighted and VI responders, an aspect not explored further in the current study. Responder 14, a professional musician, commented:

> As a performer who specialises in historic performance (recorder) [...] I have never had the chance to touch, let alone play, any historic instruments which would be invaluable for my professional work as a recorder player.

The provision of a visual only inspection of instruments by instrument collections is therefore a barrier to accessibility for VI musicians.
Technology that provides accessibility is beneficial not only for VI people, but also sighted people too; responder 20 commented 'I would have liked an audio guide, I like to use them', highlighting the usefulness of audio guides for both VI and sighted people. Responder 11, a full-time professional sighted musician working in HIP, commented: 'Most visits [to musical instrument collections] have been useful, and most curators extremely helpful. Some lack up to date catalogues, and the provision of these [...] would be a huge step forward'. The lack of accurate catalogues clearly would hinder musicians, whether sighted or VI. Unfortunately, some collections appear unwilling to offer an electronic or accessible version of their catalogue even for catalogues published as recently as 2011; for instance, the publisher of the 2011 catalogue of musical instruments at the Ashmolean Museum in Oxford (Ashmolean Museum & Milnes, 2011) reported: 'There is only one version of the Ashmolean catalogue [...] and I think that it is highly unlikely that any other version will be produced' (Personal communication, 2013). A request to the publisher for their position on accessibility for VI people went unanswered; the lack of access at the Ashmolean Museum is corroborated by the responders. Responder 7 commented 'I would prefer it if the instruments could be played (by experts if necessary) rather than kept in cases'. Of the six distinct collections on which responders chose to comment, three (Bate Collection, Oxford; Finchcocks Musical Museum, Kent; and RNCM, Manchester) allowed visitors to play instruments:

<table>
<thead>
<tr>
<th>Responder</th>
<th>Collection</th>
<th>Instruments Playable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Ashmolean Museum</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>Horniman Museum</td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>Ashmolean Museum</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>Finchcocks</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>Royal Academy of Music</td>
<td>No</td>
</tr>
<tr>
<td>14</td>
<td>Horniman Museum</td>
<td>No</td>
</tr>
<tr>
<td>15</td>
<td>RNCM</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>Bate Collection</td>
<td>Yes</td>
</tr>
<tr>
<td>19</td>
<td>Bate Collection</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>Ashmolean Museum</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 2 - Playable Instruments within Collections
All nine responders who completed questions 5 indicated that no audio guide was available for their visit; furthermore, not a single responder identified that an accessible collection guide or catalogue was available, either as Braille, large print, or eReader (PDF, ePUB) format, as shown in Table 3 below.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Facebook</td>
<td>Sighted</td>
<td>Ashmolean Museum</td>
<td>No</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
</tr>
<tr>
<td>8</td>
<td>Facebook</td>
<td>Sighted</td>
<td>Horniman Museum</td>
<td>No</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
</tr>
<tr>
<td>11</td>
<td>Email</td>
<td>Sighted</td>
<td>Ashmolean Museum</td>
<td>No</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
</tr>
<tr>
<td>13</td>
<td>Braille Music Chat</td>
<td>Sighted</td>
<td>Royal Academy of Music</td>
<td>No</td>
<td>N.A</td>
<td>N.A</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
<td>N.A</td>
</tr>
<tr>
<td>14</td>
<td>Braille Music Chat</td>
<td>Sighted</td>
<td>Royal Academy of Music</td>
<td>No</td>
<td>N.A</td>
<td>N.A</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
<td>N.A</td>
</tr>
<tr>
<td>15</td>
<td>Email</td>
<td>VI</td>
<td>RNCM</td>
<td>No</td>
<td>N.S</td>
<td>N.S</td>
<td>N.P</td>
<td>N.P</td>
<td>N.S</td>
<td>N.S</td>
</tr>
<tr>
<td>17</td>
<td>Facebook</td>
<td>Sighted</td>
<td>Bate Collection</td>
<td>No</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
</tr>
<tr>
<td>19</td>
<td>Facebook</td>
<td>Sighted</td>
<td>Ashmolean Museum</td>
<td>No</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
</tr>
<tr>
<td>20</td>
<td>Facebook</td>
<td>Sighted</td>
<td>Ashmolean Museum</td>
<td>No</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
<td>N.P</td>
</tr>
</tbody>
</table>

Table 3 - Availability of accessible guides and catalogues: NS = Not Sure; NP = Not Applicable; NA = Not Available

Some responders were clear that no such options were available, and others were not sure; the aggregate response seems to indicate that even were such options available in the collection, their availability was not sufficiently advertised. One responder commented about another museum where audio guides were available:

The audio guides at the Morpeth Chantry Museum, and the opportunity to have some instruments audio described and then to play them, made our visit so exciting (with twenty 8 to 12 year olds, all of whom were VI) that we went back again in our holiday week!

This is surely a strong indication of the value of audio guides for museum collections.

Three separate communication channels were used in order to reach potential survey respondents: emails to specific people; a message to contacts on the social media website Facebook, and a message to people on the Braille Music Chat group on Yahoo Groups; several members of Braille Music Chat had taken part in a survey in 2012. Those people emailed directly were chosen as sighted or VI musicians either known to the author personally from

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5 http://launch.groups.yahoo.com/group/braille-music-chat/message/1538
previous research (OU MA in Music A871 Project, present author), or through direct recommendation from others.

<table>
<thead>
<tr>
<th>Collector Name (Method)</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Email Specific People (Web Link)</td>
<td>4</td>
</tr>
<tr>
<td>New Facebook Collector (Facebook)</td>
<td>14</td>
</tr>
<tr>
<td>Web Link - Braille Music Chat (Web Link)</td>
<td>4</td>
</tr>
<tr>
<td>Grand Total</td>
<td>22</td>
</tr>
</tbody>
</table>

**Table 4 - Communication mechanisms for survey respondents**

The majority of sighted responders came via Facebook, with VI responders coming in equal number via email and the *Braille Music Chat* group, as shown in Table 5:

<table>
<thead>
<tr>
<th>Collector Name (Method)</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sighted</td>
<td>16</td>
</tr>
<tr>
<td>Email Specific People (Web Link)</td>
<td>1</td>
</tr>
<tr>
<td>New Facebook Collector (Facebook)</td>
<td>14</td>
</tr>
<tr>
<td>Web Link - Braille Music Chat (Web Link)</td>
<td>1</td>
</tr>
<tr>
<td>VI</td>
<td>6</td>
</tr>
<tr>
<td>Email Specific People (Web Link)</td>
<td>3</td>
</tr>
<tr>
<td>Web Link - Braille Music Chat (Web Link)</td>
<td>3</td>
</tr>
<tr>
<td>Grand Total</td>
<td>22</td>
</tr>
</tbody>
</table>

**Table 5 - Responders segmented by channel and sighted/VI**

**Limitations of the Survey**

The survey had two major drawbacks. First, the survey did not ask the date of the visit queried in question 4, which makes any analysis of a change in accessibility over time impossible, and comments suggested that some responders last visited a collection several years ago. For instance, in response to question 3, responder 18 said 'V&A [Victoria & Albert Museum], but too long ago to remember details'. Pressure to keep the survey short to avoid fatigue means that the ideal full range of questions can seldom be explored, a fundamental tension in these kinds of surveys. Second, the survey was not particularly accessible for at least one VI responder (see page 93), and likely for other responders too, including those with sight. No
explicit prior test of the accessibility or usability of the SurveyMonkey web site was undertaken; however, the SurveyMonkey website claims compatibility with Section 508 of the United States' Rehabilitation Act of 1973, aimed at making websites accessible: 'All standard survey designs are 508 compliant for respondents with disabilities' (SurveyMonkey, 2013a). Were a similar survey to be conducted for future research, a test of the design and accessibility of the survey prior to opening the survey to responders, and modifying the layout and type of questions where necessary, would be beneficial.
RESULTS AND DISCUSSION

*Digital Score Catalogues and OMR*

All the digital score catalogues assessed had at least one accessibility error on their home page, and over half had five or more errors, a pattern repeated for the search results page. These results were found not to be related to page size. Therefore, VI musicians would have some difficulty when using these digital score libraries, although the small sample size means that the trend in the results need careful interpretation. Most OMR software is designed to recognise only printed Western music notation from the past 200 years or so; only PhotoScore is capable of recognising non-standard scores, and while this feature performs surprising well with older printed music, its accuracy is not sufficient for reliable transcription from the digital score images. Furthermore, the tested version of the PhotoScore software has a crucially inaccessible feature that would prevent a screen reader – and therefore a VI musician – from using the software effectively.

*Documents, Articles, Books, and Instrument Collections*

Problems with PDF documents render many journal articles, books, and historical documents either completely or substantially inaccessible to VI musicians, either due to technical limitations, or to errors and inaccuracies with OCR. Even where alternatives to PDF exist, the text available often appears to have been taken from the PDF, and many printed books do not have a fully accessible eBook version. Furthermore, the websites of academic journals and of journal distributors are far from consistently accessible, with many websites presenting strong challenges to VI researchers wishing to find articles relating to HIP. Collections of musical instruments in the UK appear to show a wide variation in accessibility, with some collections providing almost no accessibility to VI researchers, and others a good degree of accessibility.
Implications for VI Musicians and Others

With improvements in OCR, OMR, website design, and desktop software design, it should be possible to overcome many (if not most) of the accessibility problems discussed here. Some problems are more fundamental, however, and are unlikely to be solved technically: 'secured' PDFs; eBooks with Text-to-Speech disabled by the publisher; the digital representation of older music notation; and the need for sighted colleagues to inspect visually the results of OMR. Until the soluble problems have been overcome, VI musicians working in HIP – and indeed anyone wishing to rely on text-based information retrieval and presentation, including dyslexic and physically-disabled researchers, and even sighted researchers wishing to search and cross-reference older material digitally – will be at a disadvantage, because their access to the full range of research materials will be restricted.

Areas for Further Research

This study has explored the nature of accessibility problems for VI musicians working in HIP; however, a comprehensive cataloguing of the accessibility of key texts, journals, document archives and catalogues (such as *Early Music*, *Performance Practice Review*, *JSTOR*, *EBSCO*, etc.), musical scores, historical documents, and instrument collections would represent a substantial undertaking, meaning that an assessment of the extent of accessibility problems for VI musicians working in HIP remains a candidate for further study. Such research would assess the extent and quality of OCR text within PDF documents, the prevalence of PDF problems such as 'unextractable text', the practical readability of accessible formats such as DAISY, and the extent of the accessibility of journal and index websites themselves for a defined corpus of research material, perhaps that which contained a specific but rare keyword such as *theorbo*.

The increasing availability and performance of OCR software applications for personal computers offers the possibility of enabling VI researchers to extract text from historical documents themselves, rather than having to rely on institutions to do this (Breuel, 2008;
Google & Hewlett-Packard Corporation, 2013; Blanke et al., 2012; ABBYY, 2013); the accessibility to VI researchers of these OCR software applications would therefore be useful to assess, as would the effectiveness and accuracy of these software applications in extracting text from historical material.

Additional research and innovation in the area of automated document conversion and recognition would bring substantial benefits to VI musicians and other scholars (both VI and sighted), particularly concerning the application of OCR and OMR to PDF documents and musical scores where the OCR has been tuned for older typefaces, and the OMR 'tuned' for handwritten or older printed musical scores. Such processing would allow a large collection of older documents, treatises, and musical scores to be made not only accessible to VI people, but also amenable to automated semantic analysis (Hofmann, 2001 , pp. 177-78; Brants et al., 2002, p. 212; University of Oxford, 2012a; Rayar et al., 2012, pp. 2-3).

Drawing on research into gesture based control of software could be a fruitful area of study, particularly in relation to the use and accessibility of PDF documents and eBook readers (Guerreiro et al., 2008; Sandnes et al., 2012; Eghtesadi et al., 2012). Research into how 'sensory substitution' (for example, using audio to replace visual input) could be used in order to help 'visualise' historical scores and images (such as paintings) for VI researchers could address some of the shortfalls of OCR and OMR (Proulx et al., 2008); in particular, the work of Amit Amedi and others from the Lab for Multisensory Research at the Hebrew University of Jerusalem has used music to help blind people 'visualise' information (Striem-Amit et al., 2011; Striem-Amit, Cohen, et al., 2012; Striem-Amit, Guendelman, et al., 2012; Reich et al., 2011).

The pioneering work done by Andrew Pinnock and colleagues in the three-dimensional computer imaging of the Bressan recorder in the Bate Collection at the University of Oxford could be extended to other historical instruments to allow accurate and playable copies to be
made, thereby increasing the accessibility for VI and sighted musicians alike (Pinnock et al., 2013).

Finally, the research into the accessibility of auditoriums, theatres, conferences and musical workshops relating to HIP would help to establish the extent to which VI musicians are able practically to engage in HIP practice with their peers and sighted colleagues (SCIE, 2012; Mills, 2000; Pfanstiehl, 1997; Premia, n.d.).

**Conclusion**

Due to the recent and ongoing digitisation of musical scores, journal articles, books, and other documents, VI musicians in HIP have access to a wider range and type of research materials than in the past. However, the quality and nature of the digitisations causes problems in many cases for VI people. Text data contained in PDFs is often missing, incomplete, or even faulty, eBooks are available only for a fraction of the texts useful to a HIP researcher, and musical scores from the Renaissance and Baroque periods are typically not well-recognised by music scanning technologies, rendering these texts and scores inaccessible to VI musicians. The lack of access to such materials is likely to impede VI musicians in their HIP research, making them reliant on transcriptions and possibly dubious editions. However, the digital technologies involved in providing greater access are maturing and improving; there are indications that improvements in OCR could soon make accessible a significant body of historical material printed in sixteenth and seventeenth century typefaces, and improvements in the ability of OMR to recognise handwritten music and printed music from the Medieval, Renaissance, and Baroque periods could make available a large range of digitised original scores and other pieces of music. Finally, some instrument collections appear to have neglected the needs of VI visitors, by not allowing VI visitors to handle and play the instruments in their collections. This acts as a barrier to VI musicians being able to study the instruments.


http://switch.dl.sourceforge.net/project/openomr/openomr/initial%20release/OpenOMR.tar.


Holder, William and Keller, Gottfried (1731) *A Treatise of the Natural Grounds, and Principles of Harmony*, Printed by W. Pearson, ... for J. Wilcox ... and T. Osborne, [online] Available from: http://books.google.co.uk/books?id=tscUAAAAQAAJ.


Mace, Thomas (1676) Musick’s Monument, CNRS Editions.

Mace, Thomas and Faithorne, William (1676) Musick’s monument; or, A remembrance of the best practical musick, both divine, and civil, that has ever been known, to have been in the world. : Divided into three parts. The first part, shews a necessity of singing psalms well, in parochial churches, or not to sing at all; directing, how they may be well sung, certainly: by two several ways, or means; with an assurance of perpetual national-quire; and also shewing, how cathedral musick, may be much improved, and refined. The second part, Treats of the noble lute, (the best of instruments) now made easie; and all its occult-locked-up-secrets plainly laid open, never before discovered; ... directing the most ample way, for the use of the Theorboe, from off the note, in confort, &c. ... In the third part, the generous viol, in its rightest use, is treated upon; ... London : Printed by T. Ratcliffe, and N. Thompson, for the author, and are to be sold by himself, at his house in Cambridge, and by John Carr, at his shop at the Middle-Temple Gate in Fleetstreet, [online] Available from: http://archive.org/details/musicksmonumento00mace (Accessed 5 August 2013).

Mace, Thomas and Shepard-Smith, Andrew (2011) Complete Anthology of Lute Music from Musick’s Monument, Mel Bay Publications.


Turner, William (1697) A Compleat History Of the Most Remarkable Providences, Both Of Judgment and Mercy, Which have Happned in this Present Age. Extracted From the Best Writers, the Author’s own Observations, and the Numerous Relations sent him from divers Parts of the Three Kingdoms. To which is Added, Whatever is Curious in the Works of Nature and Art. The Whole Digested into One Volume, under Proper Heads; being a Work set on Foot Thirty Years ago, by the Reverend Mr. Pool, Author of the Synopsis Criticorum: And since Undertaken and Finish’d., London.


Williams, Peter and Ledbetter, David (n.d.) ‘Continuo’, *Grove Music Online*.


APPENDIX

Survey: Musical Instrument Collections in the UK

Ethical and Accessibility Considerations

People with disabilities, including visual impairments, 'can feel exploited by researchers who come to collect data but don’t give anything back to the community'; care was therefore taken to 'remove the pathologizing lens' when designing the survey (Olkin, 2004, pp. 335-36). The survey asked responders questions relating to their visual ability and also about their financial circumstances, both questions which could be sensitive for responders. In order to provide a means for responders to voice concerns about the survey, a contact email address was provided in the opening blurb; expectations about the layout of the survey were also set. The opening wording was:

Note: all answers will remain anonymous unless you choose to supply your name/initials. Please address any concerns to [email address supplied]. Many thanks for taking part. There are three pages of questions, ending with question 10.

Furthermore, where appropriate, questions were phrased in an exclusive, 'reflective' way, giving agency to the responder to interpret the question in their terms, rather than assuming predefined categories. Thus, question 1 asked 'Do you consider yourself to be blind or partially sighted...?' rather than 'Are you blind or partially sighted...?' (see below), allowing the responder to choose how they defined their visual capability.

The survey technology (SurveyMonkey) was chosen for simplicity of survey setup and data gathering, but not explicitly for its accessibility features, and, in fact, one responder commented that the survey itself was not particularly friendly for blind users (see Survey Completion below) (SurveyMonkey, 2013b). At the end of the survey, responders were given the option of supplying their name or initials to help with responder identification:
Please provide either your name (if you wish) or simply your initials (to remain anonymous). This information will be used only to refer to specific survey responses within the related research, where ONLY initials will be used.

Because only 12 out of 22 responders chose to supply identifying information, all responders are referred to in this study by number (1-22) instead of initials.

**Questions**

Question response types were: single choice (only one response permitted from list); multiple-choice; free text single line; and free text multi line. The questions were split across three pages, requiring the responder twice to move to the next page of questions. For every question with a predefined set of responses, an 'other' option was included as an answer to avoid response bias (Podsakoff et al., 2003, p. 883–4).

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Approximately what proportion of your income do you earn through your musical activities?</td>
<td>Single-choice</td>
<td>1</td>
</tr>
<tr>
<td>2. Do you consider yourself to be blind or partially sighted, or to have significant visual impairment?</td>
<td>Single-choice</td>
<td>1</td>
</tr>
<tr>
<td>3. Please indicate which of the following Musical Instrument Collections you have visited</td>
<td>Multiple-choice</td>
<td>2</td>
</tr>
<tr>
<td>4. Now consider a particular Musical Instrument Collection in the UK which you have visited in the past. This can be one of the collections listed in Question 3 or a different collection. NOTE: If you have never visited a Musical Instrument Collection, please leave blank Questions 5 to 9, and skip straight to Question 10.</td>
<td>Free-text single-line</td>
<td>2</td>
</tr>
<tr>
<td>5. At the Collection, was an Audio Guide available? Did you use the Audio Guide?</td>
<td>Single-choice (each sub-question)</td>
<td>2</td>
</tr>
<tr>
<td>6. If you use Braille, Large Print, or other accessible format, was that format available at the Collection, and did you use it?</td>
<td>Single-choice (each sub-question)</td>
<td>2</td>
</tr>
<tr>
<td>7. Were you allowed to play the instruments in the Collection? Did you play any instruments during your visit?</td>
<td>Single-choice (each sub-question)</td>
<td>2</td>
</tr>
<tr>
<td>8. What was the purpose of your visit? Did you achieve your aims during the visit? If not, why not?</td>
<td>Free-text single-line (each sub-question)</td>
<td>2</td>
</tr>
<tr>
<td>9. Considering now any and all of your visits to Musical Instrument Collections in the UK, how useful have your visits been, and how satisfied are you with the results? What changes or improvements would you prefer to happen at these Collections?</td>
<td>Free-text multi-line (each sub-question)</td>
<td>2</td>
</tr>
<tr>
<td>10. Please provide either your name (if you wish) or simply your initials (to remain anonymous).</td>
<td>Free-text single-line (each sub-question)</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 6 - Survey question types
Survey Completion

Just less than 70% of responders completed the survey, at least visiting each of the three pages in the survey (Figure 30).

With so few responders, it is not possible to draw any firm conclusions about why 30% of responders did not complete the survey, but anecdotal evidence suggests that the survey was difficult for both VI and sighted users to work with; one VI responder (responder 18) commented:

I have just completed the survey but it was not the easiest to complete owing to the layout of the various boxes, just too much going on and not as clear as it could have been about regarding how the boxes related to the questions. Might look fine visually, but not so good using access technology. (Personal communication, 2013)

This was partially confirmed using the NVDA software to simulate a VI experience: the 'next page' button was not reliably detected by the NVDA screen reader when tested by the author during repeated previews of the survey. Furthermore, due to the layout of the questions, the 'next' button was found to be effectively hidden until the window was scrolled to the bottom,
perhaps explaining why some sighted responders did not move beyond the first page; this is shown in Figure 31 and Figure 32:

Figure 31 - Next button hidden initially

Figure 32 - Next button visible after scrolling down the page
While this appears to be an unfortunate aspect of the SurveyMonkey technology used for the survey, it also serves to highlight the widespread problems of inaccessibility in many websites, and the effect of that inaccessibility on sighted as well as VI users.

**Digital Score Catalogues**

The number of scores in each catalogue was derived in one of three ways: if an advertised number of scores was provided, this was used; otherwise, either the total number of results for a blank search was used, or the summation of all items listed in each given category was used. For some catalogues, none of these possibilities produced a value, so \( n/a \) is shown.

<table>
<thead>
<tr>
<th>Digital Collection</th>
<th>URL</th>
<th>Scores</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Library</td>
<td>See RISM UK</td>
<td>-</td>
<td>Now housed at RISM</td>
</tr>
<tr>
<td>DIAMM</td>
<td><a href="http://www.diamm.ac.uk/advanced-search/">http://www.diamm.ac.uk/advanced-search/</a></td>
<td>92,620</td>
<td>The offline archive is much larger than that seen online.</td>
</tr>
<tr>
<td>Early Music Online</td>
<td><a href="http://digirep.rhul.ac.uk/">http://digirep.rhul.ac.uk/</a> and <a href="http://www.rism.org.uk/manuscripts?strategy=index&amp;search_1=%22early+music+online%22&amp;search_b=Go">http://www.rism.org.uk/manuscripts?strategy=index&amp;search_1=%22early+music+online%22&amp;search_b=Go</a>!</td>
<td>321</td>
<td>Related to RISM, as both are held at Royal Holloway (RHUL).</td>
</tr>
<tr>
<td>ECOLM</td>
<td><a href="http://doc.gold.ac.uk/isms/ecolm/database/">http://doc.gold.ac.uk/isms/ecolm/database/</a></td>
<td>313</td>
<td></td>
</tr>
<tr>
<td>Hath't Trust</td>
<td><a href="http://www.hathitrust.org/">http://www.hathitrust.org/</a></td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>IMSLP</td>
<td><a href="http://imslp.org/">http://imslp.org/</a></td>
<td>234,000</td>
<td>Many, if not most scores are modern editions.</td>
</tr>
<tr>
<td>Internet Archive / Open Library</td>
<td><a href="http://archive.org/">http://archive.org/</a> and <a href="http://openlibrary.org/">http://openlibrary.org/</a></td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Juilliard Manuscript Collection</td>
<td><a href="http://www.juilliardmanuscriptcollection.org/">http://www.juilliardmanuscriptcollection.org/</a></td>
<td>136</td>
<td>Contains an early Messiah score</td>
</tr>
<tr>
<td>Library of Congress Music Treasures Consortium</td>
<td><a href="http://lcweb2.loc.gov/diglib/ihas/html/treasures/treasures-home.html">http://lcweb2.loc.gov/diglib/ihas/html/treasures/treasures-home.html</a></td>
<td>n/a</td>
<td>This is a meta-catalogue containing details of scores held elsewhere.</td>
</tr>
<tr>
<td>Loeb Music Library, Harvard</td>
<td><a href="http://vc.lib.harvard.edu/vc/deliver/home?_collection=scores">http://vc.lib.harvard.edu/vc/deliver/home?_collection=scores</a></td>
<td>34</td>
<td>Includes a digitised version of Handel Messiah of 1741 (Handel, 1741 [Loeb])</td>
</tr>
<tr>
<td>Munich Digitization Center</td>
<td><a href="http://www.digitale-sammlungen.de/index.html?c=startseite&amp;l=en">http://www.digitale-sammlungen.de/index.html?c=startseite&amp;l=en</a></td>
<td>n/a</td>
<td>Includes the collected works of Handel</td>
</tr>
<tr>
<td>RISM UK</td>
<td><a href="http://www.rism.org.uk/">http://www.rism.org.uk/</a></td>
<td>300</td>
<td>This is a meta-catalogue containing details of scores held elsewhere.</td>
</tr>
<tr>
<td>University of Rochester</td>
<td><a href="https://urrresearch.rochester.edu/browseCollectionItems.action?collectionId=63">https://urrresearch.rochester.edu/browseCollectionItems.action?collectionId=63</a></td>
<td>21620</td>
<td></td>
</tr>
<tr>
<td>University of North Texas</td>
<td><a href="http://digital.library.unt.edu/search/">http://digital.library.unt.edu/search/</a></td>
<td>139</td>
<td>Many original scores, including some autographs</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------------------</td>
<td>-----</td>
<td>---------------------------------------------</td>
</tr>
</tbody>
</table>

**TOTALS** | 349,483 |

Table 7 - Key digital score collections

The number of items in each collection by a particular composer was derived from a search as specific as possible within each collection, discounting any spurious or irrelevant results.

<table>
<thead>
<tr>
<th>Digital Collection</th>
<th>Items by Byrd</th>
<th>Items by Purcell</th>
<th>Items by Handel</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Library</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DIAMM</td>
<td>1173</td>
<td>51</td>
<td>0</td>
</tr>
<tr>
<td>Early Music Online</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ECOLM</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hathi Trust</td>
<td>13</td>
<td>20</td>
<td>83</td>
</tr>
<tr>
<td>IMSLP</td>
<td>70</td>
<td>64</td>
<td>311</td>
</tr>
<tr>
<td>Internet Archive / Open Library</td>
<td>38</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Juilliard Manuscript Collection</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Library of Congress Music Treasures Consortium</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Loeb Music Library, Harvard</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Munich Digitization Center</td>
<td>0</td>
<td>1</td>
<td>352</td>
</tr>
<tr>
<td>RISM UK</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>University of Rochester</td>
<td>6</td>
<td>13</td>
<td>91</td>
</tr>
<tr>
<td>University of North Texas</td>
<td>0</td>
<td>0</td>
<td>17</td>
</tr>
</tbody>
</table>

**TOTALS** | 1302 | 156 | 865 |

Table 8 – Items by Byrd, Purcell, and Handel in the digital score collections

<table>
<thead>
<tr>
<th>Digital Collection</th>
<th>WAVE report (home page)</th>
<th>WAVE report (search results)</th>
<th>Comments / URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Library</td>
<td><em>See RISM UK</em></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DIAMM</td>
<td>13 Errors 2,153 bytes</td>
<td>n/a</td>
<td><em>The search results did not use a definitive URL.</em> <a href="http://www.diamm.ac.uk/jsp/SearchManager">http://www.diamm.ac.uk/jsp/SearchManager</a></td>
</tr>
<tr>
<td>Early Music Online</td>
<td>9 Errors 8,052 bytes</td>
<td>26 Errors 5,508 bytes</td>
<td>[<a href="http://www.rism.org.uk/manuscripts/165325?peek=true&amp;wheel=manuscript">http://www.rism.org.uk/manuscripts/165325?peek=true&amp;wheel=manuscript</a>]</td>
</tr>
<tr>
<td>ECOLM</td>
<td>2 Errors 2,502 bytes</td>
<td>0 Errors 1,468 bytes</td>
<td>[<a href="http://doc.gold.ac.uk/isms/ecolm/database/?type=11&amp;ID=67">http://doc.gold.ac.uk/isms/ecolm/database/?type=11&amp;ID=67</a>]</td>
</tr>
<tr>
<td>Hathi Trust</td>
<td>8 Errors 3,709 bytes</td>
<td>20 Errors 14,005 bytes</td>
<td>[<a href="http://catalog.hathitrust.org/Search/Home?lookfor=george%20handel&amp;searchtype=all&amp;ft=fr&amp;setft=true">http://catalog.hathitrust.org/Search/Home?lookfor=george%20handel&amp;searchtype=all&amp;ft=fr&amp;setft=true</a>]</td>
</tr>
</tbody>
</table>
Online Academic Journals and Publishers

The websites of several academic journals and publishers of interest to a VI theorbo player were assessed for accessibility using the WebAIM WAVE tool. Table 10 shows the accessibility errors for journal websites, and Table 11 shows the errors for publisher websites.

Having found no significant relationship between page size and number of WAVE errors for digital score archives (see Table 9), the same was assumed to hold for journal and publisher websites, and page size was therefore not recorded. In all cases, the search term 'purcell' was used unless indicated.

### Table 9 - Accessibility of digital score catalogues as assessed using the WebAIM WAVE tool

<table>
<thead>
<tr>
<th>Journal and home page</th>
<th>WAVE report (home page)</th>
<th>WAVE report (search results)</th>
<th>Search Results URL and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet Archive / Open Library</td>
<td>7 Errors 7,409 bytes</td>
<td>7 Errors 2,143 bytes</td>
<td><a href="http://archive.org/stream/imslp-of-sundry-natures-byrd-william/PMLP236910-Songs_of_Sundry_Natures#page/n17/mode/2up">http://archive.org/stream/imslp-of-sundry-natures-byrd-william/PMLP236910-Songs_of_Sundry_Natures#page/n17/mode/2up</a></td>
</tr>
<tr>
<td>Juilliard Manuscript Collection</td>
<td>n/a</td>
<td>n/a</td>
<td>Requires both JavaScript and Flash – no elements for a screen reader to read</td>
</tr>
<tr>
<td>Loeb Music Library, Harvard</td>
<td>1 Errors 4,531 bytes</td>
<td>n/a</td>
<td>The search results did not use a definitive URL. <a href="http://vc.lib.harvard.edu/vc/deliver/executeQuery?_collection=scores">http://vc.lib.harvard.edu/vc/deliver/executeQuery?_collection=scores</a></td>
</tr>
<tr>
<td>Munich Digitization Center</td>
<td>3 Errors 6,187 bytes</td>
<td>4 Errors 7,993 bytes</td>
<td><a href="http://www.digitale-sammlungen.de/index.html?suchbegriff=georg+handel&amp;c=suchen">http://www.digitale-sammlungen.de/index.html?suchbegriff=georg+handel&amp;c=suchen</a></td>
</tr>
<tr>
<td>RISM UK</td>
<td>See Early Music Online</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>University of Rochester</td>
<td>5 Errors 7,553 bytes</td>
<td>3 Errors 7,692 bytes</td>
<td><a href="https://urresearch.rochester.edu/filterSearchCollectionItems.action?query=purcell&amp;collectionId=63">https://urresearch.rochester.edu/filterSearchCollectionItems.action?query=purcell&amp;collectionId=63</a></td>
</tr>
<tr>
<td>University of North Texas</td>
<td>3 Errors 3,367 bytes</td>
<td>8 Errors 14,026 bytes</td>
<td><a href="http://digital.library.unt.edu/search/?q=handel&amp;t=fulltext">http://digital.library.unt.edu/search/?q=handel&amp;t=fulltext</a></td>
</tr>
</tbody>
</table>

**FEWER THAN 5 ERRORS**

| 5 / 11 | 5 / 9 | |

Table 9 - Accessibility of digital score catalogues as assessed using the WebAIM WAVE tool
<table>
<thead>
<tr>
<th>Journal and home page</th>
<th>WAVE report (home page)</th>
<th>WAVE report (search results)</th>
<th>Search Results URL and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBSCO</td>
<td>12 errors</td>
<td>4 errors</td>
<td><a href="http://web.ebscohost.com/ehost/results?sid=725f60e2-396a-4d75-8872-8cb2bd428b94%40sessionmgr115&amp;vbid=4&amp;hid=117&amp;bquery=accessibility&amp;bdata=JmRiPWx4aCZ0eXBlPTAmc2l0aG9zdC1saXZlMusic-related">http://web.ebscohost.com/ehost/results?sid=725f60e2-396a-4d75-8872-8cb2bd428b94%40sessionmgr115&amp;vbid=4&amp;hid=117&amp;bquery=accessibility&amp;bdata=JmRiPWx4aCZ0eXBlPTAmc2l0aG9zdC1saXZlMusic-related</a> indexes were not testable with WAVE</td>
</tr>
<tr>
<td>Emerald</td>
<td>3 errors</td>
<td>0 errors</td>
<td><a href="http://www.emeraldinsight.com/search?q=purcell&amp;start=0&amp;context=2416192">http://www.emeraldinsight.com/search?q=purcell&amp;start=0&amp;context=2416192</a></td>
</tr>
</tbody>
</table>

Table 10 - Accessibility of selected academic journal websites as assessed using the WebAIM WAVE tool
Table 11 - Accessibility of selected journal publisher websites as assessed using the WebAIM WAVE tool

<table>
<thead>
<tr>
<th>Publisher</th>
<th>URL</th>
<th>Errors</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>JSTOR</td>
<td><a href="http://www.jstor.org/">http://www.jstor.org/</a></td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>ProQuest</td>
<td><a href="http://pqdtopen.proquest.com/">http://pqdtopen.proquest.com/</a></td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

FEWER THAN 5 ERRORS 2 / 2 1 / 2

Other Sources Consulted

The following additional sources were consulted during the preparation of this study, grouped thematically, and listed chronologically within each group:

- **Accessibility**: (Horstmann et al., 2004), (Kenny, 2008a), (Bigham & Cavender, 2009), (Garbutt, 2009), (Carnegie Mellon University, 2010), (Dancing Dots, 2010) (Wieseman, 2013)
- **HIP**: (Corri, 1810), (Dean, 1990), (McGee, 1990), (Chanan, 1994), (Taruskin, 1995), (Mitchell, 2001), (Butt, 2002), (Sherman, 2003), (Wibberley, 2004), (Haynes, 2007), (Vervliet & Looy, 2010), (Holden, 2012), (Price, 2013)
- **OCR**: (Graells et al., 2008), (Voces & Codina, 2008), (Reffle & Ringlstetter, 2013)
- **Theorbo**: (Mace & Faithorne, 1676), (Dart, 1967), (Christensen, 1992), (Lawrence-King, 1992), (Lester, 1992), (Smith, 1992), (Strohm, 1992), (Thomas, 1992), (Court, 1995), (Herissone, 2000), (Jackson, 2005), (Denhard, 2006), (Kosman, 2011), (Herissone, 2012)

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