John Wallis

Writings on Music

Edited by
David Cram and
Benjamin Wardhaugh

Music Theory in Britain, 1500–1700: Critical Editions

JOHN WALLIS: WRITINGS ON MUSIC

Music Theory in Britain, 1500–1700: Critical Editions

SERIES EDITOR

Jessie Ann Owens, University of California, Davis, USA

Also published in this series:

The Music Treatises of Thomas Ravenscroft
'Treatise of Practicall Musicke' and A Briefe Discourse
Ross W. Duffin

Thomas Salmon: Writings on Music
Volume I: An Essay to the Advancement of Musick *and the Ensuing Controversy,* 1672–3
Benjamin Wardhaugh

Thomas Salmon: Writings on Music
Volume II: A Proposal to Perform Musick *and Related Writings, 1685–1706*
Benjamin Wardhaugh

'The Temple of Music' *by Robert Fludd*
Peter Hauge

John Birchensha: Writings on Music
Christopher D.S. Field and Benjamin Wardhaugh

A Briefe and Short Instruction of the Art of Musicke by Elway Bevin
Edited by Denis Collins

Synopsis of Vocal Musick by A.B. Philo-Mus.
Edited by Rebecca Herissone

A Briefe Introduction to the Skill of Song by William Bathe
Edited by Kevin C. Karnes

A New Way of Making Fowre Parts in Counterpoint by Thomas Campion and *Rules how to Compose* by Giovanni Coprario
Edited by Christopher R. Wilson

John Wallis: Writings on Music

Edited by

DAVID CRAM
Jesus College, University of Oxford, UK

BENJAMIN WARDHAUGH
All Souls College, University of Oxford, UK

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2014 by Ashgate Publishing

Published 2016 by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN
711 Third Avenue, New York, NY 10017, USA

Routledge is an imprint of the Taylor & Francis Group, an informa business

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

The Library of Congress has cataloged the printed edition as follows:
Wallis, John, 1616–1703.
[Prose works. Selections]
John Wallis : writings on music / edited by David Cram and Benjamin Wardhaugh.
pages cm. – (Music theory in Britain, 1500-1700. Critical editions)
Includes bibliographical references and index.
ISBN 978-0-7546-6870-1 (hardcover) 1. Wallis, John, 1616-1703 – Correspondence. 2. Oldenburg, Henry, approximately 1615–1677 – Correspondence. 3. Pepys, Samuel, 1633–1703 – Correspondence. 4. Fletcher, Andrew, 1655–1716 – Correspondence. 5. Music theory – Early works to 1800. I. Cram, David, editor of compilation. II. Wardhaugh, Benjamin, 1979–, editor of compilation. III. Title.

ML174.W15 2014
781–dc23

2014005013

ISBN 9780754668701 (hbk)

Contents

Series Editor's Preface

The purpose of this series is to provide critical editions of music theory in Britain (primarily England, but Scotland, Ireland and Wales also) from 1500 to 1700. By 'theory' is meant all sorts of writing about music, from textbooks aimed at the beginner to treatises written for a more sophisticated audience. These foundational texts have immense value in revealing attitudes, ways of thinking and even vocabulary crucial for understanding and analysing music. They reveal beliefs about the power of music, its function in society and its role in education, and they furnish valuable information about performance practice and about the context of performance. They are a window into musical culture every bit as important as the music itself.

The editions in this series present the text in its original form. That is, they retain original spelling, capitalization and punctuation, as well as certain salient features of the type, for example the choice of font. A textual commentary in each volume offers an explication of difficult or unfamiliar terminology as well as suggested corrections of printing errors; the introduction situates the work and its author in a larger historical context.

Jessie Ann Owens
Professor of Music
Department of Music
University of California, Davis, USA

Taylor & Francis
Taylor & Francis Group
http://taylorandfrancis.com

List of Figures

Taylor & Francis
Taylor & Francis Group
http://taylorandfrancis.com

Acknowledgements

It is a pleasure once again to acknowledge the kindness and support of Jessie Ann Owens, the editor of this series of volumes, who took an interest in this project from its inception. It is a matter of regret that the pressure of other work prevented her from being, as originally planned, one of the editors named on the title page. She and her assistant Minji Kim have provided invaluable assistance with the later stages of this project. The editors also acknowledge the support of the Arts and Humanities Research Council for the John Wallis Project, under which work on this volume began.

Particular thanks are due to the staff of Ashgate Publishing, in particular Heidi Bishop and Pam Bertram, for their work. All Souls College, Jesus College, and Wolfson College, Oxford supported the editors during periods of work on this book, and we have pleasure in recording our gratitude to those institutions.

Philip Beeley has been of particular help in matters connected with Wallis's correspondence. The editors of this volume are specialists in early modern mathematics (Wardhaugh) and linguistics (Cram). The publication of Chapter 3 would not have been possible without the very generous help of Richard Ashdowne and Armand d'Angour with the translation of Wallis's Latin. Our English text owes its merits to them, its remaining defects to us.

We are grateful to Marsh's Library, Dublin and the Bodleian Library, Oxford, for permission to reproduce the illustrations in this volume.

Taylor & Francis
Taylor & Francis Group
http://taylorandfrancis.com

List of Abbreviations

DNB	Leslie Stephen and Sidney Lee (eds), *The Dictionary of National Biography* (63 vols; London, 1885–1900)
ECCO	*Eighteenth-Century Collections Online*: galenet.galegroup.com/servlet/ECCO
EEBO	*Early English Books Online*: eebo.chadwyck.com
EMLO	*Early Modern Letters Online*: emlo.bodleian.ox.ac.uk
ESTC	*The Electronic Short-Title Catalogue*: estc.bl.uk
GMW	Andrew Barker (ed.), *Greek Musical Writings II: harmonic and acoustic theory* (Cambridge, 1989)
GMO	Stanley Sadie (ed.), *The New Grove Dictionary of Music and Musicians* (29 vols; 2nd edn; London, 2001; online edn; 2007–10: www.oxfordmusiconline.com)
OCD	Simon Hornblower and Antony Spawforth (eds), *The Oxford Classical Dictionary* (3rd edn; Oxford, 1996)
ODNB	H.C.G. Matthew and Brian Harrison (eds), *Oxford Dictionary of National Biography: from the earliest times to the year 2000* (60 vols; Oxford, 2004; online edn; 2008: www.oxforddnb.com).

Taylor & Francis
Taylor & Francis Group
http://taylorandfrancis.com

Introduction

This volume presents the main writings on music of John Wallis (1616–1703), doctor of divinity, Savilian Professor of Geometry, and fellow of the Royal Society. Chief among these is 'The Harmonics of the Ancients compared with Today's', the appendix to his 1682 edition of Ptolemy's *Harmonics*; also included are three letters to Henry Oldenburg, the secretary of the Royal Society, written in 1664, and five letters published in the *Philosophical Transactions* of the Royal Society: two in 1677 and three in 1698. These writings are concerned with several aspects of the theory of music, including the mechanical production of musical sound and the effects of music on the human person. A principal and recurring concern is the mathematical foundation of musical harmony and the relationship between ancient thinking on that subject – as represented in particular by Ptolemy (*c.* A.D. 90–168) – and the music of seventeenth-century England. The sources presented here enable the evolution of Wallis's ideas on this subject to be discerned and provide evidence for the place which music held in his intellectual life. The purpose of this volume is to situate these texts within Wallis's life and intellectual biography, and within the wider discussion of musical theory taking place in England at the time. It is not to situate Wallis himself within a wider intellectual or political milieu, nor to examine more widely the Greek musical tradition on which he at times reflected, or its reception.[1]

This introduction comprises a discussion, roughly in chronological order, of the various pieces of evidence for Wallis's interest in music, including the texts edited in this volume. It outlines the contexts for the production of those texts and sketches the intellectual backgrounds to Wallis's work on the musical topics he addressed in them: his sources, his relationship with Thomas Salmon, his interest in experimentalism, and his views on the nature and human effects of music. The editors thus attempt to provide the materials for a fuller appreciation for this substantial and significant body of musical writings from Restoration England.

John Wallis, 1616–1703

Most of John Wallis's published works have yet to receive modern editions; the edition of his correspondence, which will be a vital resource for the study of his intellectual biography, so far covers only the first part of his life.[2] Biographical work on him is therefore necessarily somewhat provisional, and this introduction will present only the brief sketch necessary for understanding when and how his main writings on music were produced.[3]

John Wallis was born in 1616 in Ashford, Kent, and educated at schools in Kent and Essex and at Emmanuel College, Cambridge. During the 1640s he became increasingly prominent as a public intellectual; he also became known for his cryptographical work for the government, which would continue after the Restoration. In 1649 he was appointed to the Savilian Chair of Geometry at Oxford in place of Peter Turner. Wallis remained in that position for more than 50 years, until his death in 1703, and became one of the most important English mathematicians of his generation.

He was a fellow of the Royal Society from 1661, although his continuing residence in Oxford resulted in a relatively slight visibility at meetings compared with other early fellows of comparable intellectual range and seriousness.[4] Nevertheless, he published frequently in the *Philosophical Transactions* (more than 60 papers). Mathematics had no exclusive claim on his attention. He became keeper of the university archives in 1658, having been ordained in 1640 and become a doctor of divinity in 1654, and published quite frequently on theological subjects. In 1660 he became a royal chaplain; several of his sermons were printed.[5] Wallis's publications during his lifetime numbered several dozen,[6] and they ranged very widely: grammar, logic, the mechanics of speech, mathematics of all kinds, mathematical mechanics, theology. He was eclectic rather than, perhaps, encyclopaedic in his interests, but there were very few even among the most versatile of his contemporaries who could have claimed to have made real contributions to so many fields.

Those contributions were not made without controversy, and indeed Wallis's pattern of publication suggests that at times he sought out topics on which he could engage in robust refutation. Individuals including the Danish philologist and mathematician Marcus Meibom, the English clergyman and natural philosopher William Holder, and most famously the English political thinker and natural scientist (and mathematician) Thomas Hobbes all came in for attack.[7] A combative and vigorous manner of writing, and possibly a sometimes cavalier attitude to giving credit, seem to have marked his interventions in musical topics too, as we will see.

It will be evident from all of this, and from the contents of the present volume, that Wallis considered his responsibilities as Savilian Professor of Geometry in no narrow sense; the Savilian statues, indeed, required him to do so, specifying that the professor of geometry should teach not just the classics of ancient Greek geometry but also arithmetic, surveying (with practical demonstrations 'in the fields or spots adjacent to the University'), mechanics, and 'canonics or music'.[8] Although some of Wallis's lectures on Euclid's *Elements* survive,[9] no lectures on 'canonics' by him are known. It is not clear just when he began to take a deeper interest in that particular subject.

'My present un polished thoughts': the letters of 1664

Our earliest direct evidence for Wallis's interest in music is contained in correspondence with Henry Oldenburg (*c*. 1619–77) in 1664. On 27 April John

Birchensha (*c*. 1605–?1681), the subject of an earlier volume in this series, had appeared before the Royal Society, to receive the society's thanks for a letter he had submitted setting out in brief his views on music theory.[10] The musical committee (containing William Brouncker, Robert Boyle, and others) which the society set up to examine Birchensha's ideas does not seem to have come to any conclusion – indeed, we have no evidence that it met at all – but the incident produced some resonance in the correspondence of Oldenburg, the secretary of the society. He wrote to Wallis on 4 May, in a letter – now lost – which apparently gave a 'large account' of the Royal Society's recent activities and mentioned Birchensha and his paper without giving any details. (The letter also seems to have discussed the handling of the papers of the astronomer Jeremiah Horrox and to have asked Wallis to press Thomas Hyde concerning work on the Latin translation of works by Ulugh Beg.) Birchensha undertook 'to bring the art of music to that perfection, that even those, who could neither sing nor play, should be able, by his rules, to make good airs, and compose two, three, four, or more parts artificially'.[11] It is clear from what followed that Oldenburg was correct in his belief that the information about Birchensha would be of particular interest to Wallis.

Wallis wrote three letters to Oldenburg during the remainder of May 1664, which represent three stages in his response (Chapter 1 below). In the first, dated 7 May, he remarked briefly that his limited reading had shown him that the modern theory of music was defective, but said little more. There possibly followed another letter from Oldenburg, also now lost, in which he invited or seemed to Wallis to invite further comment. On 14 May Wallis obliged, providing a treatise of a little under 5,000 words dealing with the mathematics of music: in particular with the construction of a satisfactory mathematical description of the modern musical scale.

Hedged though it was with disclaimers about his scanty expertise and scantier reading, this text in fact made it clear that Wallis had given some thought to questions of musical tuning. What seems to be draft material for it, indeed, survives in the Bodleian Library, in a single opening of one of Wallis's notebooks. Here he can be seen sketching out some of the diagrams which appeared in his letter, including a large table of ratios, and performing the calculations and tabulation of musical intervals and ratios which underlay them.[12]

The letter set out several elements which were to recur in all his subsequent discussions of the subject, as well as what amounted to Wallis's programme for the study of music. Most prominent was what has more recently been called the 'coincidence' theory of consonance.[13] On the assumption that musical sound consisted of or was somehow associated with a series of distinct pulses or vibrations, the idea of the coincidence theory was that reasonably frequent coincidence between those vibrations was a requirement for two sounds to be perceived as harmonious. That was only possible if the frequencies of the two sets of vibrations formed a ratio of small whole numbers. Thus Wallis suggested that

> two strings that are Unisons, be therefore Harmonious, because (supposing them to haue one common beginning) the Vibrations of the one doe exactly answer

> to those of the other: And next unto these, Octaves; because that, the Vibrations of the more Acute being twice as many in the same time, every vibration of the more Graue or slower string, is coincident with every second Vibration of the Quicker or more Acute[.][14]

The argument continued for other consonances; the perfect fifth was associated with a ratio of 3 : 2 and the perfect fourth with a ratio of 4 : 3. By this means the traditional association of mathematical ratios with musical intervals was transformed from an observed fact about the harmoniousness of combinations of strings of different lengths into a mechanical explanation founded on the properties of musical sound and capable in principle of being investigated experimentally.

Wallis did his best to avoid committing himself, but made it clear that he considered this account adequate as at least a working hypothesis concerning the phenomena of consonance. His subsequent discussion depended upon it quite heavily, since he relied at more than one point on an assessment of the relative degree of consonance of musical intervals which derived from the coincidence theory: more coincidences meant greater harmoniousness. Further, his discussion of musical ratios in this letter consistently worked with the relative frequencies of sounds, rather than (as was more traditional) with the lengths of the strings that would produce them.

A second important element, and one that was to remain characteristic of Wallis's musical thought, was what is known variously as the just intonation, the just scale, or the syntonic diatonic scale. In his hands this was a mathematical description specifying the position of the diatonic notes within the octave, in terms of their relative frequencies of vibration.[15] The octave (with ratio 2 : 1) was divided into fifth (3 : 2) and fourth (4 : 3) and the fifth into major (5 : 4) and minor (6 : 5) thirds. The major third was further divided into major (9 : 8) and minor (10 : 9) tones. In each case the division was by the same procedure: double the terms of the original ratio and form a middle term as their mean; this middle term would produce two new ratios with the original terms. Thus, for example, 2 : 1 is equal to 4 : 2; the mean is 3, and the new ratios into which 4 : 2 may be divided are 4 : 3 and 3 : 2.

Finally, the diatonic semitone was defined as the difference between a fourth and a major third. With this set of intervals, a complete scale could be built up.[16] Characteristic of this scale was the distinction between two different sizes of tone; by contrast, in both the 'Pythagorean' scale of many medieval and early modern theoretical discussions (including that of John Birchensha), and in the mean-tone scale favoured by some performers, all whole tones were equal.[17] The fact that this scale did indeed occur as one of the many which Ptolemy had listed in his *Harmonics* added an ancient veneer to a set of musical ratios whose serious discussion by theorists was less than two centuries old when Wallis was writing.[18]

In Wallis's account, certain questions followed from this construction of the scale. The octave, the fifth, and the major third could each be divided mathematically into two parts, producing musically useful results: why not the fourth? Wallis gave

some attention to the intervals that would result from a mathematical division of the fourth, with ratios 7 : 6 and 8 : 7.[19]

Another feature of Wallis's account of music was his scepticism about 'modern' musical theorists (though precisely whom he meant is a difficult question: see below). Some spoke of the tone and semitone as though one was unproblematically half of the other, something which would introduce into music surd numbers which Wallis considered 'absolutely Unmusicall'.[20] Some wrote as though six tones with ratios 9 : 8 equalled an octave with ratio 2 : 1, which had been shown to be false as long ago as Euclid's *Sectio canonis*. Some described a 'Pythagorean' tuning all of whose tones had ratio 9 : 8, and whose major thirds, with the ratio 81 : 64 as a result, would according to the coincidence theory sound dreadful.

This last was indeed a commonly cited reason for the adoption of the just intonation by writers of the sixteenth and seventeenth centuries. For Wallis, too, it showed that the ear and hand were doing something different from and better than what he took to be prescribed by modern theory. Thus,

> the sounds wee sing, are not the same wee prick (according to the scale as it is now supposed to be divided) … the ear, in these niceties, guiding the Voice, better than the Scale (if a little erroneous) can do.[21]

The aim of Wallis's mathematical ratiocinations was therefore to produce a correct theory, one which would better describe what ear and hand were in fact doing. Wallis did not remark on the possibility that his description was, in turn, more 'nice' than anything that ear and hand could really achieve.

In these two letters Wallis acknowledged by name only the Euclidean *Sectio canonis* and the *De institutione musica* of Boethius. It is not clear that he had any other sources for his remarks about ancient music: the terminology, the ratios, and the ascription of certain ideas to Pythagoras which we find in his letters could all have come from these two texts. (The Savilian statutes left the choice of music textbooks to the professor himself, although the wording – 'canonics or music', 'canonicam, sive musicam' – suggested the Euclidean *Sectio*, while Boethius had long been a standard reference on music for university curricula.)[22]

Vague references to 'those Ancient or Modern Musicians that I have read', 'our modern Composers', and 'the moderns' seem intended to give the impression of some acquaintance with material more recent than Boethius, but here the question of Wallis's sources is more complex. He acknowledged no source for the just intonation and the coincidence theory; neither did he specifically claim originality for those ideas. It is not plausible that Wallis had arrived at those two pieces of modern musical mathematics independently of those who had written about them over the previous century, although there is no particular reason to suppose that Oldenburg knew that.

Oldenburg, however, 'produced' Wallis's letters at the meeting of the Royal Society on 18 May, apparently telling Wallis he had done so in another letter – now lost – written shortly afterwards. Wallis had not specifically consented to this,

although it was common for letters to the secretary of the Royal Society to be read to the society. 'It was ordered, that these letters should be referred to the president to peruse and consider them, and to make report thereof to the society'.[23] The president, William Brouncker, was, with another fellow, Walter Charleton, one of the only two men in England who had published on the mathematical theory of music and he might have been expected to raise questions about the sources of Wallis's ideas.[24] In fact he does not seem to have made the requested report.

We have no record of just what Oldenburg conveyed to Wallis about the reading of his letters. But Wallis responded in a rather unexpected way. Instead of acknowledging his dependence on earlier writers, he wrote a third letter to Oldenburg specifically claiming independence from them.[25] To two of the copies of his second letter now extant – made apparently for Robert Boyle and Narcissus Marsh – he also added a postscript to much the same effect. 'I find', Wallis wrote in the postscript,

> that our modern Writers of the Theory of Musick (in this & part of the last Century) haue, upon like Principles, divided the Monochord much after the same proportion as I haue done.[26]

These 'modern Writers' included Johannes Kepler; the postscript also mentioned 'our practicall Musicians', without naming them, and Ptolemy's *Harmonics*, which Wallis insisted he had not seen when the bulk of his long letter was written. In his new letter to Oldenburg he added 'Mersennus' to the list of his sources '& some others'. He repeated his insistence that he had spent 'very little time, & very few thoughts' on music.

This is a difficult action to explain, and efforts to understand it are hindered by the loss of Oldenburg's letters to Wallis. A charitable interpretation is that notes Wallis had made at the time of earlier reading in Kepler and Mersenne formed the basis of his second letter without him recollecting how far those notes recorded other men's ideas rather than his own. A different possibility is that Wallis relied not on his own notes but on unpublished text from, or discussion with, a third party, not realising how widespread were the ideas involved. It is perhaps more likely that Wallis was to some degree deliberately uncandid, but what he could have hoped to achieve by this, or whom he could have imagined he would deceive, is not clear. As far as we know no contemporary challenged him about the matter.

Thus the details of Wallis's debts to earlier musical writers remain in part unclear. The coincidence theory seems likely to have come from Mersenne – discussions of coincidence and frequency were to be found in his main Latin work, the *Harmonicorum libri* of 1636 – or perhaps from Galileo (in the *Discorsi e dimostrazioni* of 1638). It had also been discussed by Giovanni Battista Benedetti in his rather more obscure *Diversarum speculationum ... liber* of 1585; although the Bodleian Library owned a copy of the book, we have no direct evidence that Wallis was acquainted with it.[27] Wallis's admission in his third letter that he had studied Mersenne makes it almost impossible to believe that he had not done so before writing the second letter.

A source Wallis did not acknowledge in 1664, although he would do so in his later writings on music, was Descartes' *Compendium musicæ*, published in 1650. Some of Wallis's terminology, notably the word 'schism' for the discrepancy with ratio 81 : 80 between different forms of some pitches, seems unmistakably to derive from here.[28]

Where Wallis had found the just intonation is open to doubt. It had been quite widely discussed for over a century, since Zarlino's presentation of it in the *Istitutioni harmoniche* in 1558.[29] In 1682 Wallis would name Zarlino himself as a source; at this earlier stage either Mersenne or Descartes could have given Wallis the information he put in his second letter.

Also unclear as to their source are Wallis's claims about the views and practices of 'Modern Musicians'. Most, perhaps all, of what Wallis said on this subject could in fact have been his response to Boethius, but it would be pleasant to think he had consulted some writer more modern and more practical. The language of tones and semitones – 'notes' and 'half notes' – to which he referred, with the implication that one was half of the other and thus that six tones made an octave, could have been found in many introductions to music from early modern England:

> the ♭ cliefe which is comon to euery part, is made thus ♭ or thus ♯ the one signifying the halfe note and flatt singing: the other signifying the whole note or sharpe singing.[30]

Thus Thomas Morley in 1597; in Wallis's time John Playford put it like this:

> the *B fa* or *B flat* doth alter both the name and property of the Notes before which he is placed, and they are called *Fa*, making them halfe a tone or sound, lower then they were before.[31]

Wallis's assertion that practitioners described the tone as always and only bearing the ratio 9 : 8 is more mysterious; few practitioners had much to say about mathematical ratios in respect of musical pitch. Wallis may simply have been thinking of Boethius. One of the few seventeenth-century theorists who would fit the bill was John Birchensha, and it is curious therefore that Wallis's letters were prompted by Oldenburg's report of his appearance before the Royal Society. Wallis's letters, though, seem to indicate that details like this were absent from what Oldenburg had reported to him.

Certainty about these questions is regrettably elusive, and thus the beginnings of Wallis's thinking about music and the exact nature of his reliance on the writings of others are to some degree irrecoverable. What is certain is that by the end of May 1664 he had read some of the key texts: Ptolemy and Euclid among the ancients; Boethius, Kepler, Mersenne, and very probably Descartes among the moderns. He was known to Oldenburg and now to the Royal Society to be interested in music, and he had committed himself to positions concerning musical methodology and the correct description of the diatonic scale which he would never substantially modify.

In 1665–6 the Royal Society suspended its London meetings as a result of the outbreak of plague. Several fellows moved to Oxford, and during the autumn a series of informal meetings took place there. On 28 September Robert Moray wrote to Oldenburg from Oxford that

> yesterday 7. or 8. of our Society met at Mr Boiles … there was, S[ir]. W. Petty: Dr Cox. Dr Wallis; C. Graunt, & I. Sr P. Neile, & Mr Williamson come … Wee talked much of the Monochord … Wee intend to prosecute Musick, & meet at least once a week.[32]

Boyle left Oxford for Stanton some time between 18 November and 9 December: if the meetings continued weekly until he did so there would have been at least eight, perhaps up to eleven of them. We can be confident that musical subjects continued to be discussed, since the following March the meetings were mentioned to the Royal Society:

> DR WALLIS being asked, what experiments had been made during the last summer at the committee of the society, which had frequently met at Oxford, related, that, among others, there had been tried divers musical experiments; whereof he mentioned some, but referred for more particulars to Mr. BOYLE, who had caused them to be put into writing. Mr. OLDENBURG was desired to write to Mr BOYLE to communicate them.[33]

Oldenburg duly relayed the request to Boyle,[34] but Boyle never complied. At a meeting in April at which he was present,

> Mr. BOYLE was called upon for the experiments of sounds, made at Oxford the preceding summer by some of the members of the society, and said by Dr. WALLIS to have been put in writing by him: to which he answered, that they were not perfect.[35]

The matter does not appear again either in the minutes of the Royal Society or in Boyle's correspondence. It is possible that the discussion of various vibrational effects eventually published in Boyle's 1685 *Essay of the Great Effects of Even Languid and Unheeded Local Motion* owed something to the meetings of 1665, but the notes taken at them do not seem to have survived.[36] Wallis's involvement shows that his interest in music continued and that it could take an experimental turn; sadly it tells us nothing more specific.

'A new Musical Discovery': the letters of 1677

The music historian Sir John Hawkins (1719–89) reports that in 1675 Wallis contributed £1 to the refurnishing of the Oxford Music School with instruments

and books.[37] But our next substantial evidence for Wallis's interest in music dates from slightly later and concerns a discovery connected with nodes of vibration, which was made at Oxford during the 1670s. As Wallis put it:

> it hath been long since observed, that if a Viol string, or Lute-string, be touched with the Bow or Hand; another string on the same or another Instrument not far from it, (if an Unisone to it or an Octave, or the like,) will at the same time tremble of its own accord. … But adde this to the former observation; That, not the whole of that other string doth thus tremble, but the several parts severally, according as they are unisones to the whole or the parts of that string which is so struck.[38]

In other words, sympathetic resonance could cause a string to vibrate not just as a whole, but as a set of two, three, four, or more parts. It could be demonstrated, as Wallis explained, that the points which separated those parts remained stationary.

The antiquary Anthony à Wood (1632–95) is informative about the affair. In his account William Noble, MA, of Merton College, made the discovery first, during 1673. He passed it on only to 'one or more friends'. Some time later Thomas Pigot, BA, of Wadham College, a younger and 'a more forward and mercurial man', came to the same discovery apparently independently, despite his lesser skill in practical music. Wood judged that Pigot, unjustly, 'got the glory of it among most Scholars'. Having taken his MA in 1678 Pigot went on to be vicar of Yarnton near Oxford, a fellow of Wadham, 'and afterwards Chaplain to *James* Earl of *Ossory*', in whose service he died in 1686. He became a fellow of the Royal Society in 1681 and published a paper in the *Philosophical Transactions* in his own right in 1683, dealing with an earthquake at Oxford. Noble, for his part, became a chaplain at Christ Church and died there in 1681.[39]

From Pigot the discovery passed to Robert Plot (1640–96), antiquary, fellow of the Royal Society, and keeper of the Ashmolean Museum. Plot received (and may well have commissioned) a full discussion of the phenomenon and its implications from the scholar and musical enthusiast Narcissus Marsh, who was by this time principal of St Alban Hall, Oxford. (Marsh hosted a weekly music meeting at his lodgings in Oxford during the 1660s and 1670s.[40]) This Plot printed in his *Natural History of Oxfordshire* in 1677, giving credit to both Pigot and Noble. The brief treatise covered 11 pages and went into some considerable detail about the nature and behaviour of sound and the different phenomena that could be observed in relation to sympathetic strings of unequal length.[41]

Information on the subject also passed to Wallis, who wrote it up in a letter to Henry Oldenburg dated 14 March 1676/7. Wallis credited Pigot and Noble, mentioned Plot's *Natural History*, but failed to mention Narcissus Marsh. The letter was read to the Royal Society, and Oldenburg reported that the society had received it enthusiastically and proposed to print it in the *Philosophical Transactions*, 'which I believe you will not oppose, especially since you adde something of your owne observations, which perhaps Dr Plot takes no notice of in his book'.[42] Wallis added

a postscript, dated 27 March, remarking that 'it will be convenient to do it quickly, that it may be abroad as soon as the other Book; & not be like stale news'. The letters were published in the *Philosophical Transactions* later in 1677 (Chapter 2 below).[43] They were printed under a title which emphasised the supposed novelty of the matter by describing it as it as 'a New Musical Discovery', and the printed text omitted the aside in which Wallis mentioned Plot's book.

The same matter was republished in Latin as chapter 107 of Wallis's *De algebra* in 1693; the introductory and concluding remarks were somewhat rearranged, but the main exposition of the new musical observations was simply a translation of what had appeared in the *Transactions*.[44] One change was a few extra remarks on the phenomenon of sympathetic resonance itself, including that the faint motion of the sympathetic string could be displayed by placing a small piece of paper on it. Another was an acknowledgement that it had been Marsh who first showed the phenomenon to Wallis in 1676. Indeed, Marsh had been a fellow of Exeter College – the college through which Wallis was incorporated MA in 1649 – until he became principal of St Alban Hall in 1673,[45] and Marsh at some stage acquired a copy of Wallis's second, long letter to Oldenburg on music of 1664;[46] since both wrote on the subject, it would be strange if they had not discussed Noble and Pigot's discovery.

Wallis was certainly aware of the existence of Marsh's much more extensive discussion of the phenomenon when he wrote his letters to Oldenburg; it is not quite clear whether he had seen it. Thus, once again, Wallis produced a discussion about music whose relationship to the ideas of other men is not completely clear. His keenness to pre-empt its appearance in Plot's *Natural History* looks a little churlish; perhaps Wallis was aware of this, since he attempted to excuse himself in the letter of 27 March: 'I think that [*sc.* the *Transactions*] a proper place for communicating new discoveries: which perhaps would be less universal if onely in the other book [*sc.* Plot's *Natural History*].'

It is also not clear how much there was of genuine novelty about the discovery, which evidently drew some attention at least among the natural philosophers of Oxford. The fact that a bowed or plucked string can be made to sound at a range of pitches (the fundamental and its harmonics) by touching it at certain places (the vibrational nodes) was essential to the functioning of the trumpet marine, a bowed stringed instrument whose pitches were the harmonics of a single string and which enjoyed some popularity during the late seventeenth and early eighteenth centuries.[47] (The use of harmonics in playing instruments of the violin family seems to date from the 1730s.) The trumpet marine was described by Glarean in the sixteenth century and by Mersenne earlier in the seventeenth; Pepys heard a performance at Charing Cross in 1667. Particularly relevant to Noble and Pigot's discovery is that fact that some trumpets marine possessed sympathetic strings; Praetorius provided an illustration in 1620.[48]

All of this may have provided some motivation for Noble and Pigot to set up the apparatus they did: a string forced, not by touching at a node but by sympathetic resonance, to vibrate at a pitch higher than its fundamental, and

whose behaviour – visibly vibrating not as a whole but as separate parts, with stationary points in between those parts – could be observed. The novelty lay less in the string's behaviour, which was substantially that of the string(s) in a trumpet marine, but in their deliberately isolating and studying it and characterising it as a natural philosophical phenomenon. The whole affair, indeed, amounted to a re-description of a phenomenon which had previously held musical rather than natural philosophical interest.

Wallis, in his paper, also remarked on a related novel observation that he 'took notice of upon occasion of making trial of the other'. If a string was struck at a vibrational node – its midpoint, or a point a third or a quarter of the way along – it would 'give no clear Sound at all; but very confused'. Wallis accounted for this by reference to 'the contemporary vibrations of the several unisone parts',[49] an obscure phrase which may have been intended to indicate that when struck or bowed in the normal way a string vibrated at several frequencies simultaneously.

The thought of Francis North (1637–85) seems to have been running along very similar lines during the same year, 1677. In his *Philosophical Essay of Musick* North commented at some length on the ways that the sound of a string or pipe could vary or 'break'. 'In a false string two or more sorts of vibrations are blended', while

> if a musical string be so struck, that the whole string is not removed out of its place to cause the greatest vibration in the middle, there must be a crossing of vibrations: for before the motion communicated to the farther end, the part of the string that was struck may have restored it self to its first place. This crossing of vibrations, if the string be true, will be upon equall parts, and produce an Octave fifth, or some other Chord.
>
> The *Trumpet marine* that sounds wholly upon such breaks, is a large and long monochord play'd on by a Bow near the end, which causes the string to break into shrill Notes. The removing the thumb that stops upon the string gives measure to these breaks, and consequently directs the *Tone* to be produced.[50]

The fact that these ideas – the vibration of strings at more than one frequency at once, the 'breaking' of such patterns of vibration and the trumpet marine as an example – were evidently circulating among natural philosophers may suggest that Wallis did no more in his *Transactions* paper than recite what he had heard from others. But in fact he claimed – and there seems no good reason to doubt him – that he had seen and tested the phenomena for himself.

Indeed, he stated that the phenomenon of sympathetic resonance on which the observation depended had been tested in a number of different configurations: lutes and viols would 'answer to' one another; a viol would answer to a chamber organ but rather less well to a harpsichord. (In the version of 1693 Wallis said slightly more about the transmission of vibrations from one string to another: a string vibrated at a rate determined by its tension, striking the surrounding air; the