Unlocking the Mysteries of the Venetian Cornett: *ad imitar piu la voce humana*[1]

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This essay draws together some empirical, practice-based research from three related projects on the pitch, intonation, and fingering systems of historical cornetts that I have undertaken since 2013: first, a reevaluation of the cornetts of the *Accademia Filarmonica*, Verona; second, the use of CAD modeling and 3D printing to understand the fingering system of the cornetts at Christ Church, Oxford; and third, an investigation of similar questions in a replica of one of the cornetts in the *Kunsthistorisches Museum*, Vienna (SAM 230), based on recently published CT-scan data, and made for me by John McCann in the hope that I might "unlock the mysteries of its design and tuning."[2]

Each of these projects has a particular focus on historical instruments bearing the famous !! "rabbit's foot" or "silkworm moth" makers' mark that David Lasocki and other scholars have argued is that of the Bassano family, although Maggie Lyndon-Jones suggests it was perhaps not exclusive to the Bassanos.[3] What we can say with some certainty is that instruments bearing these marks may be identified as Venetian, or possibly Anglo-Venetian, through networks of trade established by the branch of the Bassano family that settled in England in the sixteenth century.[4] Cornetts bearing this mark share many similar characteristics—of construction, of decoration, and indeed of fingering and intonation.

Taken together, these projects reveal a common Venetian fingering system that is conceptually different from that of the "modern" cornett, and which provides a key to understanding specific aspects of performance practice—including transposition, solmization, and differentiation of enharmonic sharps and flats—that enabled the cornett (according to contemporary commentators) to imitate the human voice more effectively than other wind instruments of the time.

The "modern" cornett

In order to understand fully the implications of this study it is first necessary to sketch a little contextual background to the modern revival (or perhaps we might even say "reinvention") of the cornett. Undoubtedly the key figure in this process was Christopher Monk, who developed a new method for making cornetts from molded polymer resin during the 1960s—an innovation of profound importance for the revival of the instrument in the second half of the twentieth century.[5] For the first time, reliable, replicable, and inexpensive cornetts were available for aspiring players, and indeed the vast majority of cornettists active today took their first steps on one of Monk's instruments.

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Monk based his resin cornett on an original (probably Venetian) seventeenth-century instrument then in his own possession—subsequently acquired by Arnold Myers and now on loan to the University of Edinburgh Musical Instrument Museum (Acc. No. 3189)—at a pitch in the region of a^1=470 Hz.[6] However, rather than making an exact copy of this instrument, Monk chose to use it as the basis of an enlarged model to be played at a^1=440 Hz; this was a common approach adopted by makers of other Renaissance woodwinds (recorders, crumhorns, etc.) at that time. According to Monk's 1968 patent application for "Improvements Relating to Cornetts," this was not a straightforward process: he describes the "great difficulty … experienced in placing the finger holes and in making them the correct size in relation to the bore in order to obtain accurate pitch."[7] The result is an instrument that succeeds very well on its own terms, but with playing characteristics that are somewhat different from those found in historical originals—especially those produced in Venice and/or London in the late sixteenth and early seventeenth centuries.

Naturally, as players schooled on Monk's resin cornetts became more proficient and began to "upgrade" their instruments they sought hand-crafted cornetts of wood and leather that would replicate certain characteristics of the Monk instruments with which they were familiar. As a result, most wooden cornetts played today are essentially descendants of Christopher Monk's molded resin instrument: incremental improvements on Monk's original design.[8]

Figure 1a is an attempt to summarize the fingering system of these "modern" cornetts.[9] The key feature to note here is the clear expectation that *b♭*^{1} and f^2 can be played with all holes closed: T123456, and that the interval between these harmonics is therefore a perfect fifth—and indeed the tuning of this interval has become something of a "holy grail" for modern cornett makers.

But these notes were originally fingered somewhat differently according to historical fingering charts, such as that given by Daniel Speer in 1697 (Figure 2). In Speer's chart—and indeed in every subsequently published fingering chart for cornett of which I am aware—*b♭*^{1} is fingered with the thumb-hole open: 123456; whereas f^2 is played with a forked fingering: T13.

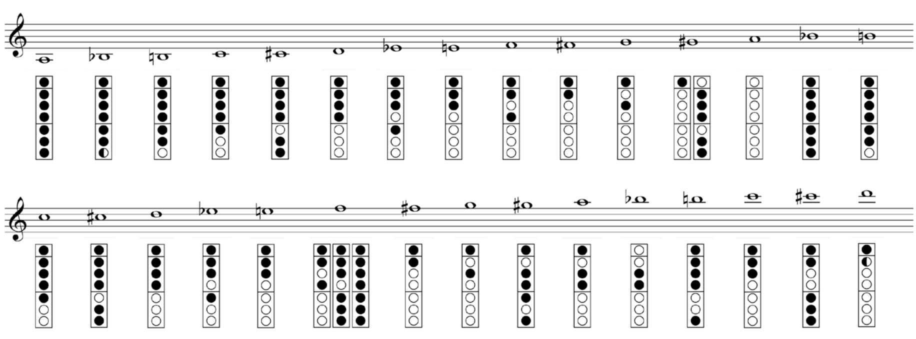

Figure 1a: Fingering chart for the "modern" cornett.

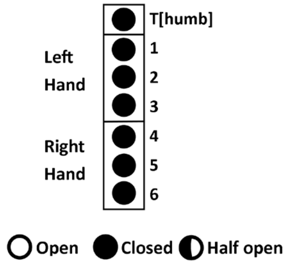

Figure 1b: Key to fingering chart for the “modern” cornett.

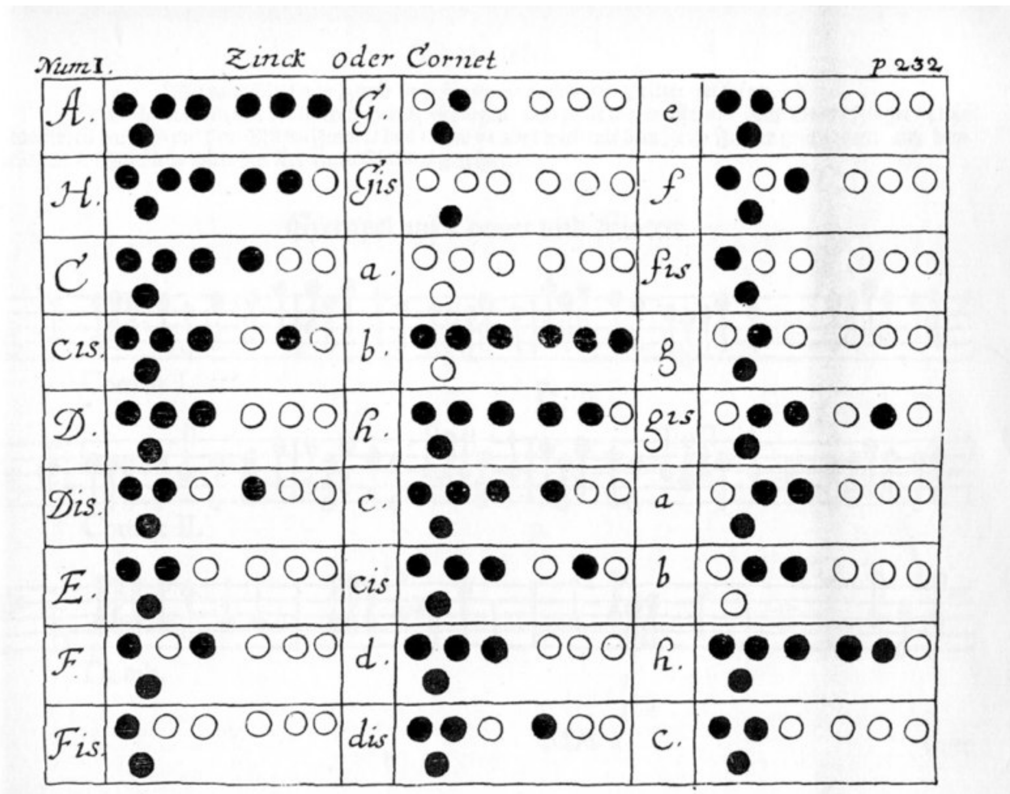

Figure 2: Fingering chart from Daniel Speer, *Grund-richtiger … Unterricht der Musicalischen Kunst* (Ulm, 1697).

Cornetts at the Accademia Filarmonica di Verona

The Accademia Filarmonica di Verona, founded in 1543 and home to one of the world's most important collections of historical wind instruments, was the archetypal Renaissance musical academy; many of the instruments surviving in its museum collection today date from the first decades of the Accademia's existence as a private club for aristocratic, humanist-inspired, amateur musicians and literati.[10]

My first direct experience of the Verona instruments was as a student of Bruce Dickey's cornett class at the Schola Cantorum Basiliensis during a study trip to Venice and the wider Veneto region in the summer of 2002. We spent an extraordinary afternoon in Verona, where Bruce had negotiated special permission for his students to play the cornetts. Our time at the Accademia was short, and although we were able to test each of the treble instruments briefly, it was difficult to decide which ones played the best and at what pitch; there was also insufficient time to figure out the idiosyncrasies of their fingerings. There was simply too much information to process on that one brief occasion, but I was left with a number of very firm impressions:

- The quality of the craftsmanship of many of these instruments is superb, especially those marked with the !! "rabbit's-foot"/"silkworm moth" insignia.

- Most of the instruments were in very good playing condition (as a result of restoration work undertaken by Rainer Weber in 1973), but they often did not conform to our expectations in terms of mean-tone intonation when played using the standard fingerings familiar from our modern instruments.

- The pitch measurements we took informally on that occasion did not always match up with the pitch measurements published in Edward H. Tarr's catalogue (1981).[11]

On leaving Verona that day with more questions than answers about these antique instruments, I knew I had to return to investigate more fully. In February 2013 I was able to do so, generously aided by a grant from the Faculty of Humanities and Social Sciences at Newcastle University.[12] This time I had the enormous luxury of five full mornings to work at the Accademia, undisturbed, playing each instrument in turn, taking careful measurements regarding pitch and intonation, and recording every note I played on a portable hard-drive recording device.[13]

There are eleven treble cornetts, seven mute cornetts, and six tenors in the collection; I played them all, and my measurements for the pitch of these instruments are presented in Table 1, together with those from Tarr's catalogue and an earlier set of measurements published by Rainer Weber.[14] Those instruments bearing the !! mark are further categorized according to Maggie Lyndon-Jones's "Checklist" as types B, C, D, E, J, K, and UC (unclassified).[15]

acc. no.	cornett type	maker's mark	pitch Weber 1975	pitch Tarr 1981	pitch Savan 2013	notes (February 2013)
13257	treble		a^1=410	a^1=445	a^1=440	Not well in tune with itself—upper octave sharper than lower.
13264	treble		a^1=450	a^1=473		Leaky and unplayable.
13265	treble	!! !! (UC)	a^1=450	a^1=482	a^1=465	Seam leaking slightly at mouthpiece end.
13266	treble	!! !! (E)	a^1=410	a^1=450	a^1=440	
13267	treble	!! !! (K)	a^1=450	a^1=473	a^1=471	
13268	treble	!! !! (K)	a^1=450	a^1=464	a^1=471	The best instrument in terms of response and intonation.
13269	treble	!! !! (E)	a^1=465	a^1=493	a^1=494	
13270	treble		a^1=450	a^1=471	a^1=473	
13271	treble		a^1=450	a^1=471	a^1=465	
13272	treble		a^1=450	a^1=476	a^1=469	
13291	treble		a^1=450	a^1=480	-	Quadruple curved—doesn't play any recognizable scale. A theatrical/display instrument?
13256	mute		a^1=465	a^1=493	a^1=474 to 476	In F (6 finger G)
13258	mute	!! !! (J)	a^1=450	a^1=493	a^1=470 to 478	In F (6 finger G). Mouthpiece a little too small for me to be confident about pitch center.
13259	mute	!! !! (J)	a^1=450	a^1=476	$a^1$465	In F (6 finger G)
13260	mute	!! !! (J)	a^1=450	a^1=482	a^1=474	In F (6 finger G)
13261	mute	!! !! (C)	a^1=410	a^1=430	a^1=421	In F (6 finger G), but pitched a tone lower than 13260.
13262	mute	!! !! (UC)	a^1=450	a^1=462	a^1=452	In G (6 finger A; 7 finger G)
13263	mute	!! !! (C)	a^1=450	a^1=468	a^1=465	In G (6 finger A; 7 finger G)
13290	mute		About a tone higher	a^1=484	a^1=465	With carved dragon's/serpent's head at the bell. Note pitch of this instrument is quite unfocused, but it seems to play one tone higher than the others, i.e., "in D" rather than "in C" at A=465.
13292	tenor	!! !! !! (D)	a^1=450	-	a^1=465	
13293	tenor	!! !! !! (B)	a^1=410	a^1=438	a^1=415	i.e., one tone lower than the others.
13294	tenor	!! !! !! (D)	a^1=450	a^1=478	a^1=465	
13295	tenor	!! !! (B)	a^1=450	-	a^1=463	
13296	tenor	!! !! (B)	a^1=450	-	a^1=465	

Table 1: Pitch measurements for the cornetts of the Accademia Filarmonica, Verona.

My measurements were taken using a Korg OT-12 multi-temperament tuner, and verified using the *Cleartune* app on a smartphone. The ambient temperature was between 17 and 18° C. The mouthpieces used for measuring the pitch of the treble and tenor instruments were those that I use normally for professional performance, with the stem of the mouthpiece protruding from the end of the instrument by ca. 4 mm in what I would describe as a "normal" playing position.

It is clear that the pitch data previously published by Weber and by Tarr deviates quite widely.[16] Weber's measurements are all rounded, and he explained that "with these instruments there are limitations to the extent to which exact pitch measurements can be made. It is well known that different players blowing the same instrument can play accurate scales more than a tone apart."[17] However, I am not sure that professional cornett players of the current generation would agree with this statement (and we must remember that Weber's article was written when the cornett revival was in its infancy), although it is certainly true that different players can achieve somewhat different pitch levels depending on their individual technique and approach to the instrument. I am reminded of a piece of advice I once received from the renowned German trumpet teacher, Prof. Horst-Dieter Bolz: "the trumpet is not a musical instrument; *we* are the musical instrument! The trumpet is simply our loudspeaker." Organologists may wish to debate the veracity of this statement, but the point he made certainly rings true from a practical perspective; the player of the trumpet—or any lip-reed instrument (including the cornett)—is ultimately responsible for the sound production, and the way in which each individual player breathes, forms his/her embouchure, and blows the instrument will have a marked effect on the way it sounds. Pitch is just one of the many parameters that may be affected by the individual player.

It is in this context that I add my own measurements to the table, as an additional and alternative set of data to those already published. My measurements are consistently rather higher than Weber's, whereas most of my measurements for the treble instruments concur with Tarr's fairly closely (although instruments 13265 and 13266 are notable exceptions where we diverge by 10Hz or more). However, the differences between Tarr's and my measurements for the mute and tenor cornetts are rather more extreme (Tarr provides measurements for only three of the six tenors, but they are very different from mine). It must be noted, of course, that few players had much experience of playing either mute or tenor cornetts in 1981. Three decades on, the situation is very different; I am one of a growing number of players to have diversified from the "standard" treble cornett, and I have regularly played treble, mute, and tenor cornetts in professional ensembles since concluding my studies in Basel in 2003.

In 1981 most professional players of the cornett (including Tarr and his colleagues) were also trumpet players, or had a recent background in trumpet technique. Since then, a new generation of specialist cornett players has emerged, many of whom have come to the instrument from other woodwinds (e.g., recorders) rather than the trumpet. My own background was as a player of the modern trumpet, but since I made the decision to specialize on cornett some fifteen years ago, I have substantially adapted my technique and consciously "deconstructed" my trumpet embouchure to reduce tension to the minimum necessary for the cornett. I would say this has made me more effective and efficient as a cornett player, but the corollary is that, for me, there is now no going back to the trumpet! It is interesting that in most instances of discrepancy between my measurements and Tarr's, my measurements are lower. This therefore seems to bear out Bruce Haynes's observation that

> the natural tendency of players trained on modern instruments is to use more pressure and tension on early instruments than necessary.… Since higher tension and pressure normally result in higher pitch, the logical conclusion is that, coming from a matrix of modern technique, contemporary players are more likely to play early instruments higher than they were originally meant to be played, rather than lower.[18]

The key point here is the notion of "necessary" tension. Conversely, it takes a while for inexperienced players coming from disciplines other than the trumpet to discover the optimal balance between muscular tension and breath pressure required to play with a consistent tone quality and reliable intonation. Until that balance is found, the common tendency of the inexperienced player is to play a little *under* pitch. This may perhaps explain Rainer Weber's lower pitch readings as reported in 1975.

Another parameter that can have a marked effect on cornett pitch is the choice of mouthpiece—the crucial interface between player and instrument. Today's cornett players have tended to adopt a relatively narrow variety of mouthpiece types, in comparison to the diversity seen in the small sample of historical mouthpieces that have survived.[19] There are several factors influencing mouthpiece selection for the modern player, not least among which are the demands of the recording industry (e.g., a mouthpiece that sounds like Mersenne's "ray of sunshine" in the expansive acoustic of a large church or cathedral may sound quite unacceptably harsh in close proximity to a microphone). But perhaps the single most important factor is the necessity to choose mouthpieces that allow us to play Monk and descendant-of-Monk cornetts in tune at a^1=440. I have lost count of the number of otherwise excellent mouthpieces that I discarded during my formative years as a player because they yielded a performing pitch that was unacceptably higher or lower than a^1=440.

In recognition of this issue, I decided to commission precise copies of a range of historical mouthpieces to use for pitch comparison. A problem with hand-copying cornett mouthpieces is that the tolerances involved are very small; a fraction of a millimeter can make the difference between an excellent mouthpiece and one that is essentially useless. Having had some experience of making mouthpieces myself using a model maker's lathe, I knew the difficulties of making truly precise copies relying on hand and eye alone. I therefore decided to turn to rather more modern methods: CAD modeling and 3D printing. I have written elsewhere about the methods and materials involved, so I will not repeat that information here, but suffice it to say I worked with Guy Schofield at Newcastle University to produce 3D-printed models based on the detailed measurements and engineering drawings produced by Graham Nicholson for Tarr's catalogue.[20]

We selected mouthpieces from museum collections in Lübeck (St. Annen-Museum, 1893.59), Paris (Musée instrumental du Conservatoire, 979.2.18), and Vienna (Sammlung alter Musikinstrumente, 230),[21] with rim diameters varying between 14–16 mm (close enough to the mouthpieces I normally use for professional purposes that I could easily adapt to playing them), but with cup shapes and depths very different from one another.[22] The resulting differences in timbre and articulation were considerable, but the variation in pitch, tested and measured using a modern cornett by John McCann, nominally at A=466 Hz, was greater than I might have imagined. The results are summarized in table 2; and are compared with the pitch measurement taken using my own mouthpiece (JS), and one made for me by Gebhard David (GD), which is typical of the type currently used by many professional players of the "Basel school."

mouthpiece	pitch, mp fully inserted	pitch, mp extended ca. 4mm	pitch, mp fully extended
Vienna	a^1=478	a^1=472	a^1=469 (9mm)
Lübeck	a^1=473	a^1=469	a^1=467 (8mm)
Paris	a^1=467	a^1=464	a^1=460 (8mm)
JS	a^1=469	a^1=466	a^1=463 (8mm)
GD	a^1=470	a^1=466	a^1=464 (8mm)

Table 2: Variation of pitch produced by selected historical and modern mouthpieces with a modern instrument at a^1 =466 Hz.

The difference between the Vienna mouthpiece fully inserted and the Paris mouthpiece fully extended is rather extreme at 18 Hz. In practice, I would expect that most players would position the mouthpiece at a "sweet spot," extended to ca. 4 mm, which brings the difference between the mouthpieces to within a range of approximately 8 Hz, which is still of course quite considerable.

mouthpiece	pitch, mp fully inserted	pitch, mp extended ca. 4mm	pitch, mp fully extended
Vienna	-	a^1=475	a^1=473 (7mm)
Lübeck	-	a^1=473	a^1=471 (5.7mm)
Paris	a^1=470	a^1=467	a^1=465 (6mm)
JS	a^1=473	a^1=471	a^1=466 (7.5mm)
GD	a^1=473	a^1=470	a^1=466 (7.5mm)

Table 3: Variation of pitch produced by selected historical and modern mouthpieces with Verona 13268.

I also tested the effect of the same five mouthpieces on Verona 13268—in my opinion the best (and most stable) instrument in the collection. The results are summarized in table 3.

It was not possible to obtain a consistent reading for the Vienna and Lübeck mouthpieces when fully inserted as this position caused some significant problems of intonation (the upper end was considerably sharper than the lower). Also, I did not want to extend the mouthpieces too far, for fear of putting too much pressure on the instrument's mouthpiece receiver through additional windings of thread on the mouthpiece stem. However, it is clear that the pitch variation between the mouthpieces is again 8 Hz when 4 mm extended. This, incidentally, is also the point at which each mouthpiece seemed to work best with the instrument in terms of internal consistency of intonation. Fortuitously, my own mouthpiece seems to sit in the middle of this range, so I would suggest that my measurements for the treble cornetts can reasonably be understood as representing a mean/median pitch level.

Given the variation demonstrated between different players and different mouthpieces, it is not possible to make any but the broadest of conclusions about the pitch of these instruments. We would ideally need several experienced players to repeat this exercise in order to gather sufficient data for a meaningful statistical analysis—a proposal that would be unlikely to meet with the approval of the curators because of the conservation dangers inherent in too many people blowing moist air into the instruments. A pragmatic solution might involve the use of accurate replicas, in which context 3D printing might again play a role (more on which below).

Intonation issues

Although the above tables ostensibly use the pitch of a^1 as a reference point, the measurements are based on an average reading over the full range of each instrument. Each had its own particularities and idiosyncrasies in terms of intonation. It is beyond the scope of this article to describe every instrument in detail, but I would like to draw attention to some important common features of the treble instruments marked !!, where they differ from most modern reproduction instruments. Similar features are also characteristic of the Christ Church cornetts and Vienna SAM 230 discussed below. My reference temperament for the purposes of this discussion is quarter-comma meantone.[23]

B♭

This note ($b\flat^1$) is consistently under pitch when played with all holes closed, T123456 (the usual fingering on modern reproduction cornetts: see Figure 1). This can be improved by opening the thumb hole, 123456 (as recommended in the second column of Daniel Speer's fingering chart of 1697, Figure 2); on some instruments it can be improved further by closing the thumb and opening the first finger hole, T23456. This latter fingering is not found in any historical chart for cornett, but it is related to historical recorder fingerings for equivalent notes (e.g., E♭ for a recorder in C). Although it does not normally work at all on modern cornetts, it is surprisingly effective on the Verona !! instruments, but results in a very different and rather softer tone quality (the implications of which are discussed further below). The following table summarizes the effects of the three different fingerings, expressed as deviation from a meantone *b♭*[1] in cents (i.e., hundredths of an equally-tempered semitone, so 50 cents = a quarter tone).

acc. no.	*b♭*[1] T123456	*b♭*[1] 123456	*b♭*[1] T23456
13265	-40	-20	Not attempted*
13266	-50	-5	0
13267	-50	-20	-30
13268	-40	-20	-5
13269	-50	-15	-10

[*13265 was leaking air at the mouthpiece end and so I played this instrument only very briefly and did not test every permutation of fingering.]

Table 4: Deviation of *b♭*[1] from meantone in cents.

C♮

This note can be played in both octaves using the forked fingering (T12346) as suggested by Virgiliano (Figure 3). But it can also be played using T1234 as suggested by Speer. The latter fingering yields a note with considerable flexibility in terms of its pitch center (as compared to the relative stability of neighboring notes—*b♮*[1] and *d*[2], for example). On returning to Verona to double-check some of my findings in March 2015, following my work on the Christ Church cornetts and Vienna SAM 230 described below, I discovered that it is also possible to play a good meantone C♯ in both octaves using the same fingering, T1234.[24]

G♯

The fingering chart in Figure 1, above, optimistically suggests the "thumb-only" fingering for *g♯*[1], as found in most of the historical fingering charts. This is often too low on modern cornetts, hence the suggested alternative fingering—12356—which most players use in practice. However, I found it was possible to play a perfectly-tuned *g♯*[1] using the simple historical thumb-only fingering on all the treble cornetts in the Verona collection.

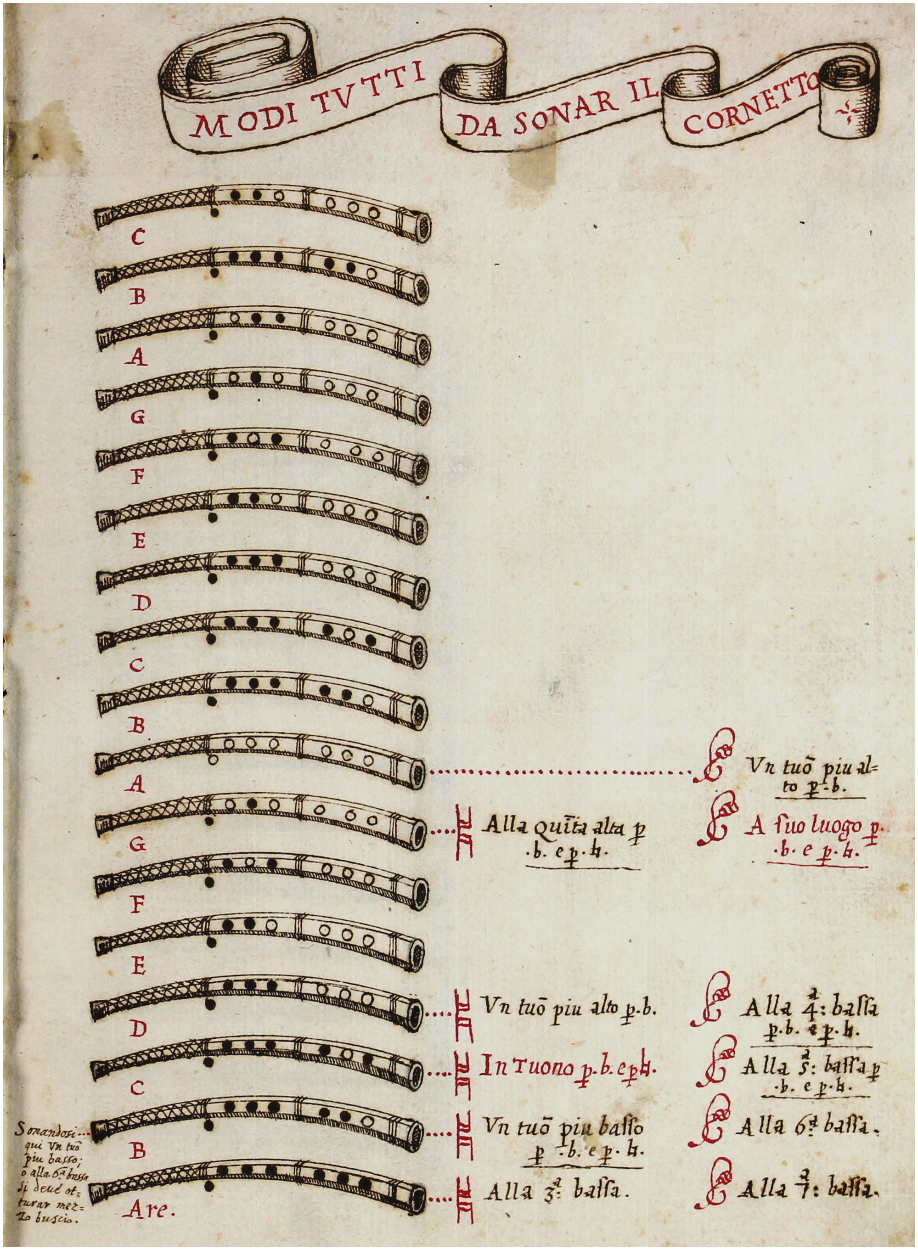

Figure 3: "Modo tutti da sonar il cornetto," from Aurelio Virgiliano, *Il Dolcimelo* (ca. 1600), Museo internazionale e biblioteca della musica di Bologna, MS C.33, f. 53r.[125]

The Christ Church cornetts: finding *fa*

Another famous pair of cornetts bearing the !! mark (type B1)[26] is found in the library of Christ Church, Oxford. According to a plaque attached to the case in which they are currently housed, they were bought as a matched pair for the choir of Christ Church Cathedral "in preparation for the visit of James I and his Queen to the House on 27 August 1605," on which date "the King and Queen heard excellent voices mixt with instruments at a service in the Cathedral."

Access to these instruments is currently rather more restricted than for the Accademia Filarmonica. Players of my teachers' generation (Bruce Dickey, Jeremy West, and others) described to me their experiences of playing these instruments in the late 1970s and 1980s, but stricter conservation policies were put in place in the 1990s, and consequently the instruments have not been played since that time (that is, until 2014, when I was granted special permission to play the instruments for the purposes of this research project, as described below).

As a response to this restricted access, I decided to model one of these instruments using CAD and 3D printing technology—as for the mouthpieces, but on a larger scale—as a means of addressing issues of pitch, fingering, and temperament from a practical perspective. Again, I have described the process of design and manufacture elsewhere so I will not repeat it at any great length here.[27] Suffice it to say that I based the instrument on detailed measurements published by Julian Drake in 1981.[28] Due to the physical constraints of the 3D printers available at Newcastle in 2013, I redesigned the model with a straightened bore and in three jointed sections, in the manner of certain extant instruments of the eighteenth century. So the model looks quite unlike the original in outer form, but the essential parameters for assessment of pitch and intonation are retained: bore dimensions (although averaged out to make a perfectly circular cross section at every point), fingerhole dimensions, and spacing (including undercutting of the fingerholes, which are printed as part of the process, not drilled).

In July 2014 I was thrilled to have the opportunity to compare my 3D printed model with the original Christ Church cornetts, and was able to confirm and corroborate my findings regarding pitch and intonation in front of a small audience.[29] This was important in establishing the efficacy of 3D printing technology for reproducing the essential characteristics of historical wind instruments. Andrew Lamb of Oxford's Bate Collection was present on this occasion, and he suggested I perhaps ought to describe the printed instrument as an "acoustic model" of the original, since it is so very different in other aspects. I will refer to it subsequently as the "Christ Church model."

The model plays at a pitch in the region of a^1 = 448–452 Hz (measured using my own mouthpiece, the variation depending on how far it is inserted into the receiver), whereas Tarr reports a pitch of a^1 = 440 Hz for the Christ Church cornetts in his catalog. This discrepancy in pitch is due to the silver ferrules which are fitted to the mouthpiece end of the Christ Church cornetts; these are both ornamental and functional tuning pieces, since they increase the overall length of the instruments by approximately 8 mm (Drake's measurements are taken with the ferrules removed). To test the effect of the ferrules on pitch we made a second head joint for the 3D-printed model incorporating the additional length; the resulting pitch is in the region of a^1 =440–444 Hz.

I confess that when I received the prototype Christ Church model in July 2013 I was at first disappointed. It played with a reasonable quality of sound that was all but indistinguishable from a wooden instrument, but the internal tuning seemed highly idiosyncratic—at least using the fingering system familiar from the generic modern cornetts that most of us use in performance (Figure 1). The Christ Church model simply does not work using these familiar fingerings. The mains issues are as follows:

- $b\flat^1$ is extremely flat in meantone (like the more extreme of the Verona instruments).
- f^2 with all holes closed is also rather flat (though this is vastly improved with alternative fingerings).
- The T1234 fingering yields not a C♮ but an unequivocal meantone C♯ in both octaves.

$b\flat^1$ **T123456**	$b\flat^1$ **123456**	$b\flat^1$ **T23456**
-50	-20	-5
F **T123456**	*F* **T12456**	*F* **T13**
-35	-10	0

Table 5: Christ Church model, fingerings for $b\flat^1$ and f^2 with deviation of pitch from meantone in cents.

As a result, my first instinct was to "correct" these problem notes by shortening the foot joint, cutting 17mm from the end of the CAD model with a "virtual hacksaw," and slightly resizing (but not repositioning) the bottom two holes to compensate. The revised foot joint makes the instrument play exactly like the generic modern cornetts I have described. It is interesting, too, that the pitch of most other notes was unaffected by shortening the instrument at the bell end (in contrast to shortening at the mouthpiece end); i.e., shortening affected the tuning of a few individual notes (notably $b\flat^1$ and f^2), but did not affect the overall pitch of the instrument.[30]

Of course, this would have been a very simple solution for a seventeenth-century cornettist, too. So why did they not cut the ends of their instruments to solve the intonation and fingering issues? This question prompted me to keep returning to the original foot joint over a period of several months, during which time it gradually began to make more sense, especially in the light of some of the original fingering charts from the seventeenth century.

The earliest known fingering chart for cornett is found in Aurelio Virgiliano's unfinished manuscript treatise of ca. 1600, *Il Dolcimelo* (Figure 3). Virgiliano gives only the diatonic notes of the "hard" and "natural" hexachords here—he does not give fingerings for the chromatic notes in between. Nevertheless, this chart contains a huge amount of information related to transposition practice—the information on the right-hand side gives instructions for transposition in relation to different clef and stave signature combinations.[31] The main difference between the fingerings suggested by Virgiliano and those of the modern system (Figure 1) is that C in both octaves requires a forked fingering (as does F in both octaves). When played using these forked fingerings, the Christ Church model begins to sound much more in tune with itself.

Anne Smith provides a possible key to understanding the relevance of such historical fingerings in her book, *The Performance of 16th-Century Music*. In a thought-provoking chapter on hexachordal solmization—a system fundamental to musical pedagogy in the sixteenth century—Smith draws on a range of historical sources that describe how notes would be sung or played with different timbral characteristics depending on their associated solmization syllable, with a particular distinction between *mi* and *fa* respectively as "hard" and "soft" syllables.[32] Moreover, she observes that "the weaker forked fingerings on wind instruments are often associated with notes that would be sung with a *fa*."[33] Both notes with forked fingerings in Virgiliano's chart—F and C—can be solmized as *fa*, depending on the choice of hexachord. Lest we are in any doubt about the *fa* quality of C here, Virgiliano makes explicit the hexachord we are to use by labeling the bottom A (the lowest note on the cornett) as *re*. It follows that B is therefore *mi* and C is therefore *fa*—to be played with a forked fingering, producing a softer tone quality in accordance with Smith's theory.

B♭ is also solmized as *fa* in the "soft" hexachord on F. Virgiliano does not give a fingering for this note—or indeed for any other chromatic notes—but Speer and all subsequent fingering charts give 123456, with the thumb hole open.[34] This is in contrast to the fingering used by the majority of modern-day cornettists, who tend to play this note with all holes closed—again resulting in a harder sound, at some remove from the "*fa* of exquisite softness" suggested by Smith.[35] The Verona instruments, and especially those in Christ Church, are very interesting in this regard: as we have seen, the *b♭*^{1} produced with all holes closed is far too low in quarter-comma meantone, by up to 50 cents. The pitch can be raised to an acceptable level by opening the thumb hole and "lipping" into tune, and the tone color produced by this means is certainly softer. But an entirely different timbre is produced by fingering *b♭*^{1} with all but the first fingerhole closed, T23456; as noted above, this fingering is not found in any historical charts, but on the Christ Church model and on Verona 13266 (and Vienna SAM 230, discussed below) it produces a perfectly tuned *b♭*^{1} with an exceptionally soft tone quality.

Now, let us consider some of the chromatic notes from outside the *gamut*. Daniel Speer makes no attempt at enharmonic distinction between sharps and flats in his chart. The sharp “spellings” of these notes (*Cis, Dis, Fis, Gis*, etc.) relate to the Germanic system of pedagogy borne out in keyboard tablature, in which the black note between D and E is identified as *Dis*, irrespective of the tonal context.[36] In Speer’s chart, all chromatic notes but F♯ (and G♯ in the lower octave) are cross-fingered, which means they are slightly weaker and softer in tone quality. The cross-fingered notes would seem therefore to accord more closely with Smith’s conception of tone quality for flats rather than sharps. Flats, Smith argues, would normally be solmized as *fa* and sung/played with a sound color appropriate to that syllable; sharps, on the other hand, should be sounded with the intrinsically harder quality of *mi*.[37] Moreover, in my experience, the fingering given by Speer for *Dis* (in both octaves) is more likely to yield a meantone E♭ than a D♯. Similarly, I have never played a modern or historical cornett on which C♯ (in either octave) can be played T1235 without adding 6 as a corrective to lower the pitch to an acceptable level in meantone; Speer’s fingering is likely to result in a perfectly acceptable D♭, however. Indeed, when played on the Christ Church model, Speer’s cross-fingered chromatic notes are all slightly too high to function as sharps in meantone, but they work well in their alternate spellings and tunings as flats.

Virgiliano, as we have seen, does not give an indication of fingerings for chromatic notes in his main fingering chart, but there is some further evidence on an earlier page of his treatise (to which Howard Weiner drew our attention in the 2011 issue of this Journal) thatincludes instructions for transposition for the trombones, and in which the cornett is treated as the soprano member of the trombone consort.[38] What no one seems to have discussed so far is the fingering for cornett in transposition.[39] Let us focus on the transposition up one tone in *chiavi naturali* (or normal clefs): Figure 4.

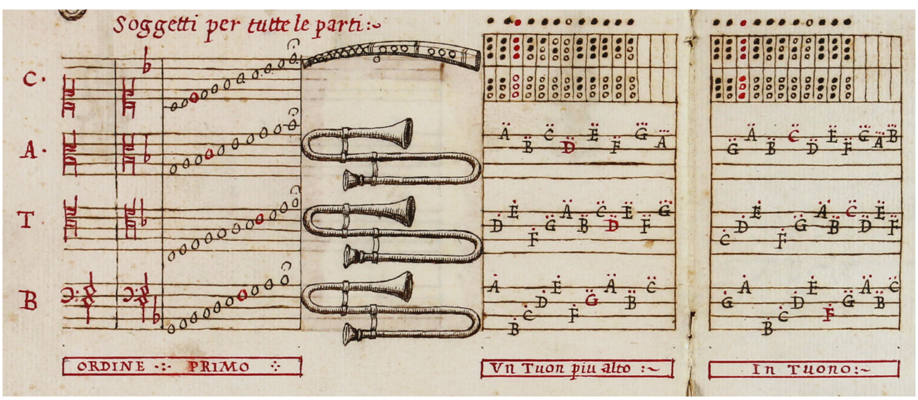

Figure 4: detail from Virgiliano, *Il Dolcimelo*, Museo internazionale e biblioteca della musica di Bologna, MS C.33, f. 51v–52r.

Here we have fingerings for an aeolian scale, *un tuon piu alto* (one tone higher) and *in tuono* (at pitch). If we transpose the aeolian mode up one tone we will need to play C♯s and F♯—but note here there is no cross fingering indicated for the former. So in fact Virgiliano seems to be suggesting here that C♯ (in both octaves) can be played T1234, which is exactly how the Christ Church model behaves; and indeed, this seems to be the corollary of Virgiliano's forked C♮. Moreover, on the Christ Church model, *g♯*[1] works perfectly with the thumb-only fingering suggested by Speer, so it is therefore possible to play a scale of A major over two octaves with no cross fingerings at all—which is much easier than the cross-fingered version familiar from the "modern" instruments (compare Figures 5a and 5b). In fact, this instrument seems to favor sharp keys, because that flat *b♭*[1] with all holes closed becomes an excellent *a♯*[1]

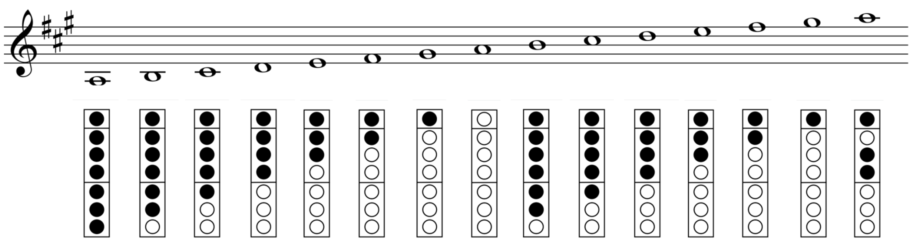

Figure 5a: A major (Christ Church fingering).

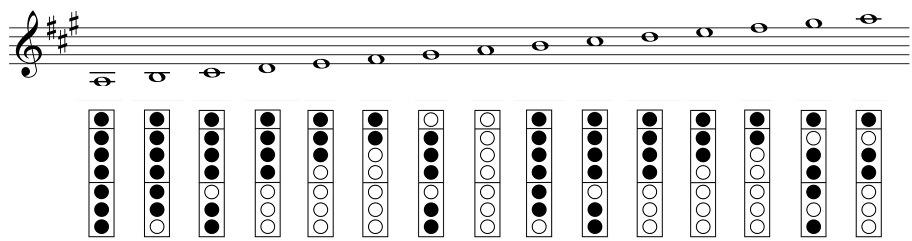

Figure 5b: A major (generic modern fingering).

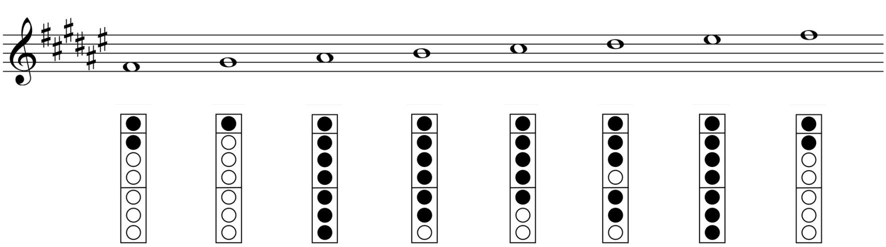

Figure 5c: F♯ major (Christ Church fingering).

in the context of F♯ major—a scale that is all-but-unplayable on a modern cornett (in part because of unwieldy cross-fingerings, but mainly because there is no alternative fingering on the modern instrument that will yield a satisfactory *a♯*^{1} without "lipping" down substantially). The flat all-closed *f*^{2} also becomes a quite satisfactory *e♯*^{2} in this context (another note that is not easily obtainable on the modern cornett).

F♯ is, of course, a rather extreme key in late sixteenth or early seventeenth century music; we hardly ever find written music from that period that strays into such tonal realms, and it is easy to overlook the practical application of facility in sharp keys. However, as Virgiliano shows us, the cornettist was expected to be able to transpose routinely. And of course F♯ major is just E major rendered one tone higher, in which our troublesome all-closed *b♭*^{1}/*a♯*^{1} becomes a beautifully tuned meantone *g♯*^{1}. Or another valid transposition in *chiavi naturali*, according to Virgiliano, is downward by a minor third, in which our open-fingered F♯ major scale becomes A major (and *b♭*^{1}/*a♯*^{1} becomes *c♯*^{2} in this context). Transposition by a minor third would also provide a pragmatic means of reconciling opposing pitch standards (e.g., between the prevailing pitch of many north Italian organs in the region of a^{1}=466 and Roman pitch of a^{1}=392; or, in the English context, between Quire and Consort pitch, presumed to be in the region of a^{1}=473 and a^{1}=400, respectively).[40] The *Cavaliere del Cornetto*, Luigi Zenobi, tells us in a letter of ca. 1600 that cornett players were to be judged "by their ability to play semitones and in transposition when necessary."[41] I take this to mean that cornettists were expected to observe the enharmonic diesis and to differentiate between enharmonic spellings of notes when transposing. The Christ Church cornetts seem to have been built with transposition in mind, because the fingering system is such that there are many more possibilities for enharmonic distinction between sharps and flats than we tend to find with generic modern system instruments. The more-or-less complete enharmonic scheme is given in Figure 6**.** In many ways this resembles the split-key arrangement of certain surviving organs and other keyboard instruments of this period, but actually exceeding them in its range of enharmonic possibilities.[42]

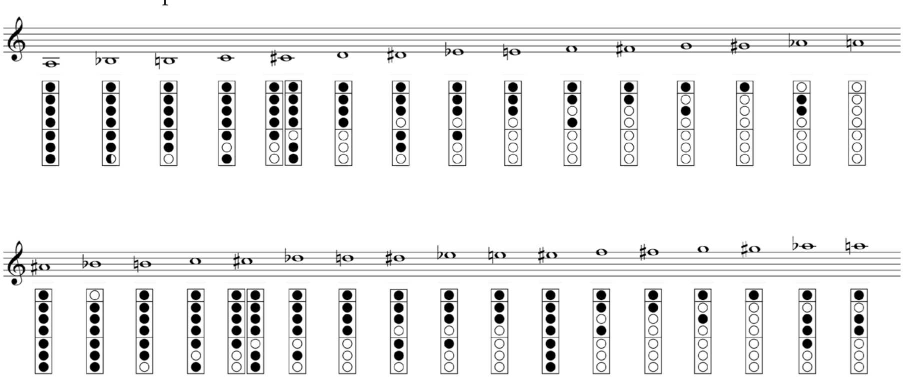

Figure 6: Christ Church model: enharmonic fingering scheme.

If we consider the specific context for which the Christ Church instruments were originally made, the practical value of such a system becomes clearer. The instruments were made to play with the cathedral choir—which means they must have been made with reference to the pitch of the cathedral organ in 1605. Unfortunately no part of that organ survives, but we know it was pitched rather high: Bruce Haynes cites a memorandum from Dr. Woodward, Warden of New College, Oxford, referring to the commission of a new organ at New College in 1661, which was requested to be built "half a note lower than Christ Church organ, but Mr. [Robert] Dalham [the organ builder] supposed that a quarter of a note would be sufficient." It so happens that some of the pipes from the 1661 organ survive, which allow for a calculation of pitch at around a^1=470 Hz, from which Haynes deduces that the "older Christ Church organ (presumably ¼-step above Dallam's organ) would have been at about 484."[43] Haynes's estimate of pitch is very nearly a whole tone above a^1=440 Hz (a whole tone would be a^1=492 Hz in quarter-comma meantone temperament), and so it seems likely that the pitch of the Christ Church cornetts (as corrected by the silver ferrules) could have been reconciled with that of the organ by means of upward transposition by one tone.

Vienna, Sammlung alter Musikinstrumente 230

The third project on which I would like to draw for this essay included another use of modern technology: in this case some very detailed CT-scan measurements of the cornetts in the Sammlung alter Musikinstrumente at the Kunsthistorisches Museum in Vienna.[44] These extremely precise measurements provided in the new SAM catalogue (2011) provide a level of detail and accuracy that had not previously been available. John McCann was the first maker to take advantage of the data to make accurate copies of the cornetts in the collection, and exhibited a beautiful copy of SAM 230 at the Second International Symposium of the Historic Brass Society in New York City, July 2012. A year after that event McCann sent me a second copy of the same instrument, in the hope that I might be able to "unlock the mysteries of its design and tuning."

SAM 230 is one of seven curved treble cornetts in the collection that bear the !! makers' mark. This particular instrument is one of a pair with the "type C" mark, originally from the collection of Archduke Ferdinand of Tyrol (1521–95) at Schloss Ambras.[45] I have been fortunate indeed to have this beautiful facsimile instrument as a reference point for the past two years. It shares many of the features of intonation with the Verona and Christ Church instruments described above. It plays comfortably at a^1=466 (and functions well in a range between a^1=464 and 470). Deviation of meantone $b\flat^1$ in cents is similar to that demonstrated in the Verona and Christ Church instruments, which means the all-closed fingering therefore yields a good mean-tone $a\sharp^1$.

f^2 is playable using alternate fingerings T13 (as suggested by Virgiliano), or all closed (as suggested by Monk). The timbral qualities are very clearly differentiated between these fingerings, while the pitch remains fairly constant.[46]

	$b\flat^1$ **T123456**	$b\flat^1$ **123456**	$b\flat^1$ **T23456**
SAM 230	-50	-20	0

Table 6: SAM 230, deviation of $b\flat^1$ from meantone in cents.

In common with the Verona cornetts, the Virgiliano forked T12346 fingering produces a stable and focused C in both octaves, with a relatively soft tone quality. The open T1234 fingering yields a "flexible" C. That is to say, the tonal quality remains clear and bright, but there is considerable flexibility with the pitch center: it is *possible* to play C♮ in tune with this fingering, but it is also possible to play rather higher. My first instinct was to "correct" this feature by slightly closing hole 5 with wax, as I imagined a player might have done in the sixteenth century. This improved the stability of pitch, but as my work and thinking on the Christ Church model progressed in parallel, I began to wonder if there might be an inherent advantage in the flexibility of the original tuning of SAM 230. On removing the wax I discovered that, with practice, T1234 can be played as high as C♯ in meantone, at exactly the same pitch level as the usual cross-fingered T12356. So that means we have options of a soft (forked) C♮ appropriate for *fa*, or a brighter (open, unforked) option which may be more appropriate for *ut* or *sol*. Similarly, C♮ can be played with an open, harder fingering appropriate to *mi*, or with a softer cross-fingered option depending on the context. This also means that it is possible to play A major with no cross-fingerings (as on the Christ Church model, and—as I later discovered—the !! cornetts in Verona).

It is possible to play up to high d^3 with at least the ease of any modern instrument I have tried, and on a good day I have been able to play as high as f^3 and g^3, as described by Praetorius.[47] Unlike most modern instruments, though, this instrument really seems to favor the low register: the bottom fifth is playable with a full-bodied sound and clear articulation.

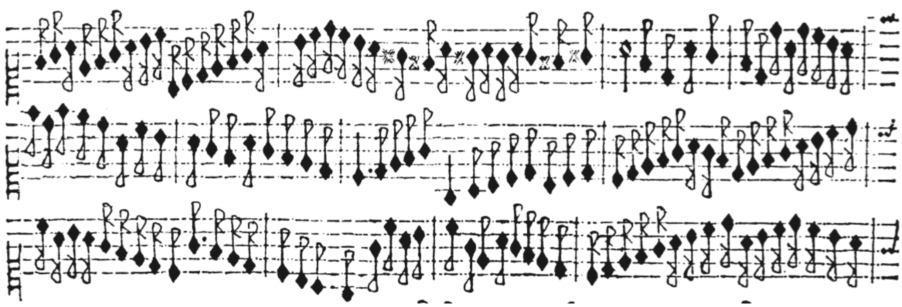

Figure 7: Extract from Giovanni Bassano, *Ricercata quarta*, from *Ricercate, passaggi e cadentie* (Venice, 1585).

Moreover, it is possible to lip down to *g* with comparative ease, which makes sense of some of the very first articulation exercises in Dalla Casa's treatise *Il vero modo* (1584), which incorporate this low *g* (and which are useful exercises in learning to control this note).

In recent months I have spent some considerable time practicing Giovanni Bassano's eight *Ricercate* (1585) as a means of developing fluency in what I believe we can now call the Venetian fingering system. The third and fourth of these pieces are written in C1 clef and descend to *g* with some frequency. With practice I found that both pieces are playable at the written pitch, or one tone higher using "open" fingerings. The advantage of an instrument with the characteristics of SAM 230 becomes very clear if we consider the example from the fourth Ricercar (Figure 7), either at written pitch (facilitation of low *g*), or transposed a tone higher (simplification of fingering and facilitation of $a\sharp^1$ in the cadential ornament).

Conclusions

Among the world's musical instrument collections there are some thirty-four extant treble cornetts bearing the !! mark, of which eight have been examined in the course of this research.[48] The evidence of these instruments suggests very strongly that Venetian/Bassano cornetts of the later sixteenth and early seventeenth centuries were conceptualized as instruments "in A," in contrast to the modern cornett which we tend to think of as an instrument "in G" (and starting on the second degree of the scale).

It is a commonplace that one of the most prized attributes of the cornett was its ability to imitate the human voice. In the most obvious sense, the comparison is one of sound quality; Luigi Zenobi, for example, tells us that a good player should be able to imitate a boy's voice, whereas Roger North famously likened the sound of the cornett to that of a "choice eunuch."[49] But Girolamo Dalla Casa goes a little further in describing two specific aspects in which the cornett excelled above other instruments in imitating the voice:

> De gli Stromenti di fiato il piu eccellente è il Cornetto per imitar la voce humana piu de gli altri stromenti. Questo stromento si adopera piano, & forte, & in ogni sorte di Tuono, si come fa la voce.[50]
>
> Of the wind instruments the most excellent is the cornett, for it imitates the human voice more than the other instruments. This instrument is played *piano* and *forte* and in every sort of key [*tuono*], just as the voice.

First, in light of the foregoing discussion, I suggest that we might understand the familiar Italian terms *piano* and *forte* not just in terms of binary dynamic contrast, but also as descriptors of tone quality (i.e., "soft" and "hard"), which could therefore extend to differentiation of solmization syllables in the hexachord.

Second, playing *in ogni sorte di Tuono*, or "in every sort of key," strongly implies that facility in transposition was integral to the practice of imitating the human voice (and therefore integral to vocal practice itself). The importance attached to transposition makes sense in an era when vocal notation (and, indeed, the pedagogy of hexachordal solmization) was conceived as a system of relative, rather than absolute pitch.

We have seen that transposition and solmization practices are encoded within Virgiliano's fingering chart for the cornett. Moreover, the surviving Venetian cornetts embody tangible evidence of these practices, with implications for all musicians interested in rediscovering the sound of sixteenth- and seventeenth-century music.

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Notes

[1] "More/better to imitate the human voice": Girolamo Dalla Casa, *Il vero modo di diminuir* (Venice, 1584). Extracts from earlier versions of this paper were given at the RMA Research Colloquium at Glasgow University on 5 November 2014 and at the Galpin Society Conference at the University of Cambridge on 27 September 2015. I would like to thank Magnus Williamson and Faye Newton for kindly reading drafts of the article at various stages in its preparation.

[2] John McCann, email to the author, 5 March 2013.

[3] David Lasocki, *The Bassanos: Venetian Musicians and Instrument Makers in England, 1531–1665* (Aldershot: Ashgate, 1995), 223–27; Maggie Lyndon-Jones, "A Checklist of Woodwind Instruments marked !!," *Galpin Society Journal* 52 (1999): 243–80.

[4] The Bassanos' instrument-making business was a truly international affair: see David Lasocki, "The Anglo-Venetian Bassano Family as Instrument Makers and Repairers," *Galpin Society Journal* 38 (1985): 112–32; Beryl Kenyon de Pascual, "Bassano Instruments in Spain?" *Galpin Society Journal* 40 (1987): 74–75.

[5] Monk filed a patent for his molded resin cornett (and cornettino) under "Improvements Relating to Cornetts," on 8 March 1968; patent granted on 21 October 1970 (GB1209817). Patent record accessed on 17 August 2015 via worldwide.espacenet.com.

[6] My pitch measurement, taken on 20 November 2015 at the kind invitation of Arnold Myers and Jenny Nex. I was also able to ascertain that the fingering system of this instrument is much closer to those of the Venetian cornetts described in this article than that of Monk's design for the resin cornetts.

[7] Monk, "Improvements," 1.

[8] For example, the excellent French maker Serge Delmas openly acknowledged the Monk instrument as his initial reference point during the Symposium International de Cuivres Anciens,

Toulouse, 22 April 2006 (live radio interview for *France Musique*). There are of course some notable exceptions to this trend, e.g., Roland Wilson, who has always based his own instruments directly on historical originals, and who was among the first to adopt the pitch standard of a^1=466 Hz with his ensemble Musica Fiata.

9 This chart is based on that provided by Christopher Monk Instruments, but revised to reflect more accurately the fingerings that, in my experience, most professional players tend to use in practice. I acknowledge that this is probably an over-generalization and that there will be variations between individual instruments, and the personal preferences of individual players may result in some alternative fingerings to those presented here.

10 It is likely that many of the surviving cornetts are those listed in the inventories of the Accademia compiled in 1569 and 1585, reproduced in Giuseppe Turrini, *L'Accademia Filarmonica di Verona dalle Fondazione (Maggio 1543) al 1600 e il suo Patrimonio musicale antico* (Verona: La Tipografica Veronese, 1941), 179–81 and 185–90; there is a "Cornetto un tuono più basso del corista" listed in 1585, which most likely refers to cornett 13266 (or 13257). A further inventory, from 1580, is reproduced in Marco di Pasquale, "Gli strumenti musicali dell'Accademia filarmonica di Verona: un approccio documentario," *Il Flauto dolce* 17/18 (1987–88): 3–17, here 13. See also Marcello Castellani, "A 1593 Veronese Inventory," *Galpin Society Journal* 26 (1973): 15–24.

11 Edward H. Tarr, "Ein Katalog erhaltener Zinken," *Basler Jahrbuch für Historische Musikpraxis* 5 (1981): 11–262.

12 I would also like to register here my thanks to the generosity of Michele Magnabosco, librarian and curator of the musical instrument collection at the *Accademia Filarmonica di Verona*, for allowing me access to the instruments, and for his assistance with a number of subsequent bibliographical queries.

13 Edited recordings are available via the project website: www.venetiancornett.wordpress.com.

14 See Tarr, "Ein Katalog," 228–47; and Rainer Weber, "Some Researches into Pitch in the 16th Century with Particular Reference to the Instruments in the Accademia Filarmonica of Verona," *Galpin Society Journal* 28 (1975): 7–10.

15 Lyndon-Jones, "A Checklist."

16 Tarr, "Ein Katalog," 228–47, acknowledges this discrepancy, including Weber's alternative measurements in his catalogue within parentheses—although they are sometimes slightly different to the rounded measurements published in Weber's 1975 article.

17 Weber, "Some Researches," 9.

18 Bruce Haynes, *A History of Performing Pitch: The Story of "A"* (Lanham, Maryland: Scarecrow Press, 2002), 40–41.

19 Surviving mouthpieces are documented in Tarr, "Ein Katalog," with detailed measurements and drawings by Graham Nicholson.

20 Jamie Savan and Ricardo Simian, "CAD Modelling and 3D Printing for Musical Instrument Research: The Renaissance Cornett as a Case Study," *Early Music* 42 (2014): 537–44.

21 This mouthpiece is currently stuck fast in cornett SAM 230, suggesting the two objects belong together. However, such an intimate association of mouthpiece and instrument is not necessarily older than the late 1960s, since the mouthpiece is photographed separately from the instrument in Anthony Baines, *Woodwind Instruments and Their History* (London: Faber, 1967), Plate XXII.

22 See Tarr, "Ein Katalog," 153, 204, and 254.

23 For an accessible, entertaining, and illuminating explanation of meantone and other historical temperaments, see Ross W. Duffin, *How Equal Temperament Ruined Harmony: and Why You*

Should Care (New York and London: Norton, 2007).

[24] I am grateful to Bruce Dickey for joining me on that occasion (20 March 2015); he also played the instruments using the same fingerings and was able to confirm my findings.

[25] The manuscript contains two alternative foliations; this article follows the foliation adopted by Veronika Gutmann, "Il Dolcimelo von Aurelio Virgiliano: eine handschriftliche Quelle zur musikalischen Praxis um 1600," in *Basler Studien zur Interpretation der Alten Musik*, ed. Veronika Gutmann, *Forum Musicologicum* 2 (Winterthur: Amadeus, 1980): 107–39.

[26] Lyndon Jones explains in "A Checklist," 247, that "Type B1 instruments are cornetts made in England. The !! mark seems to be identical to type B, but because the tree designs are unlike those on any other cornetts and the instruments are known to be of a later date they have been given a subset of their own." Both Christ Church cornetts have triple !! marks in the leatherwork below the bottom finger hole, and double !! marks on the bell end. Other type B instruments include the Verona tenor cornetts 13293, 13295, and 13296.

[27] Savan and Simian, "CAD Modelling and 3D Printing."

[28] Julian Drake, "The Christ Church Cornetts, and the Ivory Cornett in Royal College of Music, London," *Galpin Society Journal* 34 (1981): 44–50. Drake's measurements are meticulous, although he does not tell us *which* of the two instruments he measured in such detail.

[29] In advance of my visit, the instruments were transferred to a dedicated conservation facility where the relative humidity was raised to 60% for a period of four weeks. I was then allowed to play the instruments for a short time under the close supervision of conservation experts. I would like to record my gratitude to the late Janet McMullin, Assistant Librarian at Christ Church, Oxford, for facilitating this research. Thanks, too, for the conservation advice and supervision of Andrew Lamb of the Bate Collection, and for the advice and encouragement of Jeremy Montagu. I was joined on this occasion by professional colleagues Helen Roberts and Matthew Manchester, who also played the instruments and were able to confirm my findings.

[30] This would therefore seem to contradict Bruce Haynes's suggestion that "sounding length [of cornetts] can be roughly correlated to pitch, offering a cross check on accuracy," in *A History of Performing Pitch*, 6. In his earlier article, "Cornetts and Historical Pitch Standards," *Historic Brass Society Journal* 6 (1994): 84–109, here 89, Haynes suggests that "pitch apparently changes about 6Hz for every centimeter of length," which also becomes problematic in this light.

[31] Andrew Parrott discussed the implications of this chart for transposition practice in "Monteverdi: Onwards and Downwards," *Early Music* 32 (2004): 303–17, here 304–06. See also Parrott's earlier, seminal article, "Transposition in Monteverdi's Vespers of 1610: An 'Aberration' Defended," *Early Music* 12 (1984): 490–516, here 505–07.

[32] Anne Smith, *The Performance of 16th-Century Music: Learning from the Theorists* (Oxford: Oxford University Press, 2011): 20–54.

[33] Ibid., 29.

[34] Chromatic fingering charts are included in the following publications: Joseph Friedrich Bernhard Caspar Majer, *Museum Musicum Theoretico Practicum* (Schwäbisch Hall, 1732); Johann Philipp Eisel, *Musicus autodidactos* (Erfurt, 1738); Johan Daniel Berlin, *Musicaliske Elementer* (Trondheim, 1744); Lorents Nicolaj Berg, *Den første Prøbe for Begundere udi Instrumental-Kunsten* (Christiansand, 1782); J. Verschuere Reynvaan, *Musijkaal Kunst-Woordenboek* (Amsterdam, 1795); and Johann Joseph Klein, *Lehrbuch der theoretischen Musick* (Offenbach, 1801). I am grateful to Bruce Dickey for collating and sharing these charts with current and former students.

[35] Smith, *The Performance of 16th-Century Music,* 52.

[36] For an explanation of German keyboard tablature, see Willi Apel, *The Notation of Polyphonic Music 900-1600*, 5th edn. (Cambridge, MA: The Mediaeval Academy of America, 1953), 21–47.

[37] See Smith, *The Performance of 16th-Century Music*, 28–45, for a detailed explanation of the practical application of solmization syllables and their associated timbral characteristics for *musica ficta* accidentals.
[38] The trombone chart provides important evidence for the practice of transposition in relation to high and low clef combinations. See Howard Weiner, "Aurelio Virgiliano's *Nuova intavolatura di tromboni*," *Historic Brass Society Journal* 23 (2011): 151–59.
[39] These fingerings are not unproblematic, however; some of the more extreme transpositions seem to have notes missing and include some improbable-looking half-hole combinations.
[40] See Haynes, *A History of Performing Pitch*, liii-lv, for a discussion of major-second and minor-third transpositions in practice; 58–75 for discussion of Italian pitch standards, and 86–96 for pitch standards in England. Further evidence for minor-third transposition among cornettists is found in the James Talbot Manuscript (Oxford, Christ Church Library Music MS 1187), which presents the measurements for a straight treble cornett belonging to John Shore (Purcell's trumpet player), together with a tablature (fingering chart) that starts on c^1 as the six-finger note. The dimensions of Shore's cornett are similar to surviving instruments at a^1=466 Hz; the tablature therefore provides a means of reconciling the older high pitch standard with the lower pitch of newer, more fashionable wind instruments from France (at approximately a^1=392 Hz). Significantly, the third degree of the C-major scale is fingered T1234 in Talbot's chart—exactly analogous to the Christ Church fingering for C♯. For a transcription of the MS, see Anthony Baines, "James Talbot's Manuscript. (Christ Church Library Music MS 1187). I Wind Instruments," *Galpin Society Journal* 1 (1948): 9–26. Baines's article does not include a reproduction of the tablature, but I am grateful to Janet McMullin and the staff of Christ Church Library for supplying me with a digital copy of the MS (the cornett tablature is located at Folder 9, page 7).
[40] Bonnie J. Blackburn and Edward E. Lowinsky, "Luigi Zenobi and his Letter on the Perfect Musician," *Studi musicali* 22 (1993), 61–107, here 103. The original Italian is given on 86: "nel sonar mezzo tuono, e fuora di tuono quando bisognasse."
[42] This is not dissimilar to Quantz's fingering system for the Baroque flute (1752), which observes the distinction between sharps and flats and suggests alternative fingerings for F♯ that are analogous to the C♯ of the Christ Church cornetts: Johann Joachim Quantz, *On Playing the Flute*, trans. Edward R. Reilly, 2nd edn. (London: Faber, 1985), 42–43.
[43] Haynes, *A History of Performing Pitch*, 91.
[44] Beatrix Darmstädter, *Die Zinken und der Serpent der Sammlung alter Musikinstrumente*, Sammlungskataloge des Kunsthistorischen Museums 7 (Vienna, 2011).
[45] Lyndon Jones, "A Checklist," 249, explains that "The conifer tree designs found on all these instruments are identical to those found on the type B cornetts. Vienna SAM 230 & 231, which are identically decorated mirror images of each other, were listed in the 1596 Ambras inventory as: '*2 gleiche schwarze krumppe zingen*'." Other instruments bearing the type C mark include the Verona mute cornetts 13261 and 13263.
[46] The all-closed fingering is perhaps a few cents lower (ca. 5–10 cents), but within a manageable range. This contrasts with the all-closed fingering on the Christ Church model which (at -35 cents) is too low for F♮, but produces a useable E♯.
[47] "All cornetts, of whatever kind, have a natural range of a 15th, from *a* to *a''*, although in falsett some players can go up to a good *e'''*, sometimes even *g'''*, in the upper register, and down to bottom *g* or *f*." Michael Praetorius, *Syntagma Musicum II* [1618/19], transl. and ed. David Z. Crookes (Oxford: Oxford University Press, 1986), 46. I find playing to these extremities considerably easier on this historical model than on any of my modern cornetts.

[48] Thirty-four treble cornetts listed in Lyndon-Jones, "A Checklist."
[49] Blackburn and Lowinsky, "Luigi Zenobi and his Letter," 103; John Wilson, ed., *Roger North on Music: Being a Selection from his Essays written during the years c.1695–1728* (London: Novello, 1959), 40.
[50] Girolamo Dalla Casa, *Il vero modo di diminuir* (Venice, 1584). There is, of course, some ambiguity around the word *tuono,* which can be understood to mean either "key" or "mode" in this context.