A History of Performing Pitch

The Story of "A"

Bruce Haynes

The Scarecrow Press, Inc.
Lanham, Maryland, and Oxford
2002

Mechanics

Since the levels of pitches changed with time, original terms can easily be misleading. I therefore use a terminology based on semitones starting with a1=440 (A+0). I explain the system fully in 0-2b.

To indicate a relationship of key and pitch level, I use the symbol "→"; for example, "*Cammerton*→D" means "D-major at *Cammerton*."

Since I often mention the intervals of a major second and minor third, I have adopted the symbols "M2" and "m3" for them.

Frequencies given as numbers are assumed to be for the note a1; "440" is meant therefore to express "a1 = 440 Hz."

I have systematically rounded off Hz values to the nearest integral number, since higher precision is meaningless in the context of this study.

The single letter "c" sometimes stands for "cents," 100 of which make up any semitone in equal temperament.

The spelling of many common pitch standards varies in different sources. For the sake of clarity, I have selected a standard spelling for some of them, as for instance *Cammerton,*[1] *Chorton, Cornet-ton, Mezzo punto, Tuono chorista*, etc.

For this study I adopted a policy that accounts for wood shrinkage and its effect on pitch level (see 1-6c). Cornetts and ivory instruments (as well as a few traversos made of porcelain, crystal, and glass) are considered at their present pitch. Wooden recorders, pitchpipes, and traversos are assumed to have been originally 5 Hz lower, and clarinets 3 Hz higher. That this correction factor reflects historical reality is confirmed in the case of the Laurent traversos in crystal that are at 435, 430/435, and 425/435. These pitches are comparable to the wooden instruments corrected down 5 Hz.[2]

The term "Musick" is used here as it was used from the 17th century to mean pieces performed by a group of instrumentalists. In French and German, the word was "Musique." Thus certain churches had organs and choirs, while others had Musick as well.[3] A related term I have borrowed from German is "*figural*," to indicate orchestral instruments used in church.

"Flute" does not necessarily mean "traverso." It is used that way by some modern musicians because the recorder is a relative newcomer. In the language and thought of the time, however, "flute" could generally mean either recorder or traverso, and sometimes both. "Flûte" is the modern French word for both transverse flute and recorder (one "à bec," the other "traversière"). When a distinction between the instruments is appropriate or necessary, I use the specific terms.

Some of the information used in this study comes from personal communications, which are identified with an asterisk (*).

All translations are mine except those explicitly marked. My general principle in making translations has been to try to communicate accurately the underlying sense of original texts in modern, unadorned language.

Abbreviations used in text:

- The word "bass," sometimes abbreviated as "B," usually means "continuo."
- The letter "*a*" in italic before a date stands for "*ante*" (before); "*p*" stands for "*post*" (after).
- VF: Voice flute (recorder in d1)

The following are abbreviations used in the Bibliography:

- *AfMw* — *Archiv für Musikwissenschaft*
- *AMZ* — *Allgemeine musikalische Zeitung*
- BC — *Bach Compendium*
- BG — *J.S. Bach: Werke, ed. Bach-Gesellschaft*
- *BIOS Journal* — *British Institute of Organ Studies Journal*
- *BJ* — *Bach Jahrbuch*
- *EM* — *Early Music*

- FoMRHIQ — *Fellowship of Makers and Researchers of Historical Instruments Quarterly*
- *GSJ* — *Galpin Society Journal*
- *HBSJ* — *Historic Brass Society Journal*
- *HHA* — *Hallische Händel-Ausgabe*
- *ISO* — *ISO Information*
- *JAMIS* — *Journal of the American Musical Instrument Society*
- *JAMS* — *Journal of the American Musicological Society*
- *MGG2* — *Die Musik in Geschichte und Gegenwart, 2d edition*
- *ML* — *Music and Letters*
- *NBA* — *Neue Bach Ausgabe*
- *NG1* — *The New Grove Dictionary, 1st edition (1980)*
- *NG2* — *The New Grove Dictionary, 2d edition (2001)*
- *NLI* — Waterhouse 1993
- PRMA — *Proceedings of the Royal Musical Association*

Notes

1. Used also by Mendel in 1955 and 1978. I have also distinguished three separate kinds of "*Cammerton*" by spelling them differently: "*CammerThon*" as used by Praetorius, "*Cammerton*" in the early 18th century, and "*Kammerton*" since the late 18th century.

2. Herbert W. Myers (*) writes "I'm a little uncomfortable with a single correction factor for all air-reed instruments—cylindrical, tapering, open, or stopped—all based upon the experience with recorders. (There are reasons to think the changes in bore shape—i.e., taper—might be greater for baroque recorders and baroque traversi than for the other forms.) However, in light of the fact that there is no scientific way to quantify any differences at this point, one should probably just let the single factor stand."

3. The word fell out of use at the end of the 19th century (see Shaw 1980:11:155).

Introduction

The history of pitch standards is actually simpler than it first appears. From the outside, it is a classic case of not being able to "see the forest for the trees:" there are so many seemingly isolated and unrelated bits of information. But by combining material from various fields (history, written texts, and surviving original instruments), patterns emerge, and it becomes clear that there were a limited number of fixed standards that look more complicated than they were because they changed with time. In a long and detailed book on Silbermann's organs, Frank-Harald Greß writes (1989:110),

> It is generally assumed that there were great regional differences among historical pitch levels. . . . Yet in reality, in the various German organ schools of the 18th century the usual pitches differed either not at all, or only slightly.

Pitch standards are not a phenomenon of nature, after all. They are created by musicians, and it is generally in the interests of musicians for pitch levels to agree.

0-1 The Idea of Multiple Pitch Standards

0-1a Sound Frequency, Pitch Frequency, Pitch Standard

A *pitch standard* is a cluster of several notions: *sound frequency*, *note-name*, and *standard*. Sound frequency is expressed in *Hz* (or hertz, also known as *cps* or cycles per second). *Pitch* combines two separate coordinates: not only a frequency value (such as 440 Hz, for instance), but also the name of a note, such as "A." A-440 Hz is a pitch. G-440 Hz is also a pitch. If G is 440 Hz, then A, a tone higher, will be 494 Hz (in equal temperament). But if A is 440 Hz, G will move down to 392 Hz. In this book, we will assume we are speaking of the note A when we discuss pitches, so "440" will mean "a1=440."

Frequencies and pitches, being sounds but not yet music, have no historical dimension by themselves. They become pitch *standards* when they are placed in a musical context. A pitch standard is an agreement among musicians at a given time and place that a particular pitch will be used as a reference for tuning. The statement "*Cammerton* was at A-415," for example, combines two concepts: that of a pitch standard (*Cammerton*), and a pitch frequency (A-415). Written sources often mention pitch standards like *Ton d'Opéra* without giving their frequency, or they describe standards by their relationship to each other (*Cammerton* is a M2 lower than *Chorton*, etc.). Original instruments usually do the reverse, giving historical pitch frequencies that have no obvious name. In its original state, most historical evidence is thus usually separated into one of two types: either names or frequencies. The goal of this book is to try to put these two categories of evidence back together.

An example of this separation is the account by Burney of Handel's famous soloist Faustina Bordoni: "E was a remarkably powerful note in this singer's voice, and we find most of her capital songs in sharp keys."[1] Where was this E, in terms of pitch frequency? It could have been anywhere from a modern D to a modern F. If we knew the pitch standard at which Bordoni sang, however, it would be easy to determine that pitch frequency—and in fact we know that Handel's opera pitch was about A-403, some 3/4 of a tone below 440. So this E would have been between a modern D and E♭.

Something this book is not about (except peripherally) is tuning, or temperament. Temperament and pitch levels are related subjects, but they are distinct. Temperament affects the tuning of a scale within an octave, but (as I will discuss below) the degree of accuracy with which it is possible to determine historical pitches is of another order, and is larger than the variation in pitch between even the most extreme historical temperaments. Although temperament is not an integral element of the study of pitch, it does interface with it on the subject of transposition, clarifying why, for instance, the use of mean-tone temperament makes semitone transpositions impractical (see Sections 0-3 and 5-2e).

0-1b Pitch Variation in the Past

In the course of the last 400 years in Europe, the point that has been considered ideal for a reference pitch has fluctuated by some 5 or 6 semitones. Before the Industrial Revolution it was also considered acceptable (or at least normal) that several standards could exist at the same time and place. Quantz spoke, for instance, of "The diversity of pitches used for tuning . . . [that] produces the inconvenience that singers performing in a place where low tuning is used are hardly able to make use of arias that were written for them in a place where a high pitch was employed, or vice-versa."

Quantz's period was particularly rich in pitch diversity. Rome was a whole-step below Venice, for instance. In northern Germany, whatever *Cammerton* was, *Chorton* would be a whole-tone or more above it. *Chorton* was usually the pitch of organs and brass instruments, while *Cammerton* was associated with the woodwinds and other instruments. There were logical reasons for these differences; instruments that had been developed in one context were suddenly thrown together with others that had worked in another. In every country, it was the confrontation of the traditional local instruments with the vogue for the new import (Lully's music and the new instruments he used with their low pitch) that was the root of the problem. A period of adjustment was necessary that roughly coincided with the lifetime of Bach, about 1685 to 1750.

In the meantime, the obvious interim solution was to transpose some of the parts. Transposing systems, using two or even three different pitches in the same ensemble, were therefore common in the 18th century. And because some instruments sounded better at certain pitches, the discrepancies were never resolved. As a result, we still have instruments at different pitch standards, although we think of them now in a different way.

Earlier, all the instruments were "in C" but their pitches could be different. Nowadays, as heirs of the Industrial Revolution (one of whose principal objects was standardization) we assume a common universal standard. Accordingly, we think of all instruments as tuned to the same pitch (A-440), but describe some of them as "transposing" and others as in "concert pitch." The standard modern clarinet, for instance, is a transposing instrument "in B♭" in relation to 440; as we know, it could just as well be defined as a clarinet in C at 392. The same principle applies to horns in F and saxophones in B♭ and E♭. (The phrase "concert pitch," by the way, comes down to us from the 17^{th} century; it was used in England to mean something similar to "*Cammerton*," a secular instrumental pitch level. "*Kammerton*" is still used in Germany to mean "standard musical pitch." Both "*Concert-* [or *Consort-*] *pitch*" and "*Cammerton*" originally signified other frequencies than they do now. As we will see, the modern Italian word for pitch standard, "*corista*," has had a similar history.)

A pitch standard near A-440 is actually quite old. It is about the same as Beethoven's *Wiener-Ton*, for instance. And because Viennese music was influenced by Italy, *Wiener-Ton* was inherited from *Corista Veneto*, which was itself derived from a standard known as *tutto punto* that had been common in northern Italy since before Monteverdi's time. All these names, used in different periods, referred to a pitch in close proximity to A-440.

Thus pitch fluctuations are at least partly in the mind, a question of semantics, a choice of terminology. Often what really changed were the names musicians gave to the stock of frequency references with which they worked. Praetorius's "*CammerThon*," for instance, was a whole-step higher than Bach's usual "*Cammerton*," and a semitone higher than Strauss's "*Kammerton*."[2] All these frequencies were called by the same name at different times because *Kammerton* did not really refer to a specific frequency, but rather to a musical function (originally it was the pitch of secular music, usually instrumental).

0-1c The Effects of Pitch Differences

If pitch were nothing more than a protocol, an arbitrary convention allowing musicians to perform together, performers reviving early instruments could ignore the discrepancies of the past and play at one standard like A-440 or A-415. But to do this would distort the sound of the music, and seriously alter the performing techniques of voices and instruments.

One of the most important and fundamental objects of reproducing historical pitches is to put voices at the level they were originally conceived. Changing the pitch changes the tessitura of a voice, which affects the generally quality of the sound. Besides that, when pitch is changed the breaks between the registers are shifted, and may fall at awkward places in the vocal line.

An even more basic issue is vocal fatigue caused by excessive vibration of the vocal chords. Throughout this book we will encounter records of singers who complained or refused to sing because the pitch was too high. In most of these cases, the singers involved were sopranos, and there is a physical reason for this. In terms of vibration frequency, the note a0, an octave below a1 at 440, is at 220 Hz. But an octave above 440 is 880 Hz, so the difference in cycles per second is twice as big. An octave above that is 1,760 Hz! Thus higher voices vibrate much faster than lower ones. As Scotto di Carlo wrote,

> For male voices, situated at the lower end of the sound scale, the difference between the two pitches in terms of the number of vibrations of the vocal chords per second is minimal, but it is different for female voices. Thus when the pitch is 445 Hz, for example, the vocal chords of a bass vibrate at an average of 41 times faster over the entire range . . . than when the pitch is 440 Hz; by contrast, a soprano's vocal chords vibrate 160 times faster.[3]

It is clear why sopranos are more sensitive to a higher pitch than basses. The high f3 in the Queen of the Night's aria in *The Magic Flute* (admittedly an extreme case) vibrates 1,376 times per second at Mozart's original pitch (A-435), whereas the high f1 of a bass voice at the same pitch standard vibrates at only about 344 Hz. The Queen of the Night's vocal chords are thus vibrating 1,376 times for each second she holds that note. In a more normal range, the top of Bach's soprano lines was around a2 at A-415, or about 830 Hz; the bass with e1 would have been 311 Hz. Thus pitch can be seen as a feminist issue! (Basses are also concerned in the opposite direction, of course; if the pitch is too low, their lowest notes may go out of range.) We will discuss the effects of transposition on singers in 5-2a.

As for instruments, I have spoken with modern woodwind players for whom the differences between 440, 441, and 442 are vital issues in their orchestras. Distinguishing such nuances is usually beyond the means of a study like this, which normally deals in quarter-steps. But such attitudes give an idea how important these differences can be to musicians.

In 1597 Thomas Morley (166) wrote,

> take an instrument, as a *Lute Orpharion, Pandora*, or such like, being in the naturall pitch, and set it a note or two lower it wil go much heauier and duller, and far from that spirit which it had before.

At the beginning of the 17th century, Praetorius observed that raising or lowering pitch intensified the characters of different instruments. He wrote (1618:14):

> For the higher-pitched an instrument (within its class and type) is made, as with cornetts, shawms, and descant fiddles, the fresher they sound.[4]
>
> And this in spite of the fact that at this [lower] pitch (as every experienced instrument maker knows) harpsichords have a sweeter and more resonant sound than is possible at [the higher] *CammerThon*; but flutes and other instruments are also more beautiful at such a low pitch, and give quite another *timbre* to the listener.[5]

Georg Muffat commented at the end of the 17th century,

> The pitch to which the French usually tune their instruments is a whole-tone lower than our German one (called *Cornet-ton*[6]) and in operas, even one and a half tones lower. They find the German pitch too high, too screechy, and too forced. If it were up to me to choose a pitch, and there were no other considerations, I would choose the former [of the French pitches], called in Germany old *Chorton*, using somewhat thicker strings. This pitch lacks nothing in liveliness along with its sweetness.[7]

In 1752 Quantz (exaggerating misleadingly, in fact) claimed that

> The result of a higher pitch would be that, though the outward shape of the instruments would remain, the traverso would become once more a German cross-pipe, the hautboy a shawm, the violin a *violino piccolo*, and the bassoon a bombard. The wind instruments, which are such a great ornament for an orchestra, would suffer too much. Indeed, their very origin is due to the low pitch.[8]

In 1826, when Rossini began conducting the Paris Opéra, it had recently dropped its pitch a semitone (see 9-2a). Rossini was not pleased with this pitch, which he said was "used nowhere else in the world" and "deprived the instruments of their brilliance and force."

A modern example of the effect of pitch on sonority is the use of different sizes of instruments in the symphony orchestra: French horns in (F and B♭) and clarinets in E♭, C, B♭, and A. To use several differently pitched instruments is obviously impractical; at the very least it requires transposing parts. There must be a good reason for doing so, and it is apparently because differences in pitch of this degree[9] have an effect on tone quality.[10] Roderick Cameron (1986) has commented on traversos,

> Looking at many hundreds of original flutes from the eighteenth century, it is apparent that very few of them played at [exactly] A415 . . . if we wish to be faithful to the sonorities of eighteenth century music for flute, it will not work to play everything at A415. Yes, I know that it is a bother, and it means problems for the harpsichord tuning, etc. Yet if we are going to stick to A415, we should at least be willing to concede that, by choice, the important parameter of sonority is left unexplored.

On string instruments, Ian Harwood writes (1981:470) that they

> can with the help of modern technology [e.g., nylon strings and covered basses] be tuned over a wide range of pitch levels. . . . Tuning any particular lute too high, or a viol too low, is like condemning a tenor singer for ever to alto or bass parts. No one would expect him to be able to do either without strain, but we do it constantly to instruments

with never a raised eyebrow. Yet the pitch of a stringed instrument is perhaps the most important single factor in determining the way it sounds, which in turns affects the sonority of the music it plays.

Fétis (1830:210) tells the story of one of Paganini's secrets that involved pitch:

> It was . . . by means of these varieties of tuning that he produced effects of sound which could not otherwise exist. Thus he played a concerto in E flat minor, in which he multiplied the difficulties of execution, so that it seemed almost supernatural; but the secret of this wonder consisted in making the orchestra really play in E flat minor, whilst the solo violin was tuned half a tone higher, and the performer really played in D minor. The difficulty, therefore, disappears in part, but the effect of the piece was not the less satisfactory.

The orchestra's sound must have been dull and subdued in e♭-minor, while Paganini was playing in one the violin's best keys with its open strings, and naturally sounding more brilliant tuned up a semitone.[11]

While pitch standards affected the way instruments sounded, in some cases the physical nature of the instruments themselves probably acted as an influence on where standards were placed. Herbert W. Myers* draws attention to the ergonomics of wind instruments. Cornetts at around 440, for instance, are more difficult to play than those a semitone higher (which was normal "cornett pitch") because of finger-reach and the wider placement of tone-holes. The same is true of recorders and flutes, which sound rounder and more agreeable at lower pitches, but it is not easy to design a keyless renaissance-type tenor recorder as low as 440 without making the finger-stretches too large for most players. As long as the designs of the smaller members of the cornett and recorder families did not admit the use of extension-keys, this limitation may have been the most important reason that these instruments were normally made at around 466, whereas flutes (on which finger-reach was less critical) were usually pitched lower.

There is another element which may be relevant: the effect the music may have on the listener's psyche at different frequencies. In 1713 Johann Mattheson published his famous description of the *Affects*

he associated with various keys. Since there were different pitch standards in Mattheson's day, if there was some intrinsic property of a tonality that gave it its own particular flavor, would D-major have expressed the same *Affect* in *Chorton* as in *Cammerton*, a M2 or m3 lower?

Mattheson gave us the answer. In introducing his comments on *Affects*, he says: "I am thinking here principally of *Cammerton*, not *Chorton*."[12] From this we can conclude that in Mattheson's mind, *Cammerton* was the primary standard and other pitches were transpositions. In any case, the implications of his idea are startling. Put another way, playing a piece at A-440 when it was first conceived at 466 or 415 could vitiate its ability to move listeners, or alter the intended expression. Whether pitch levels really have such power is a moot point. C.F. Michaelis wrote of a pitch rise in 1814 (774):[13]

> Moreover, it is clear that the different characters inherent in the different keys must have quite disappeared as a result of the rise in pitch. How different, for instance, is the character of E♭-major (which expresses a solemnity and seriousness) from that of E-major (in which is announced cheerfulness and joy)? The higher intonation loses all these distinctions in both vocal and instrumental music.

0-1d Studying Pitch Changes in the Past

The objective of a general study of pitch history is to be able to determine the original pitch of any given piece of music. In order to do this, four kinds of information are relevant: the city where it was played, the period in question, the genre and function of the music, and which instruments were involved. Let us look at these four parameters more closely.

It was Mendel who taught us that conceptions of pitch could change from one generation to the next, or one area to the next. Pitches were often localized, so a standard in one country or city could differ from that of its neighbor, and they tended to change gradually with time.

As we saw in the case of *Kammerton*, the same pitch name can represent quite different frequencies. In any field, it is normal for "buzzwords" or jargon to alter gradually in meaning (as can be seen now with computers, where traditional words like "port" and "mouse" are used to express new ideas). In the past, pitch names were often recycled when their absolute levels moved. *Chorton* was generally about 415 for Praetorius but about 466 for Bach; by the 1730s there were German musicians using the same word to mean a frequency of about 440, and by the late 18th century that had become its value in most of Germany. But in the Habsburg Empire in the 1750s and 60s, *Chorton* still generally meant a pitch at about 415, hence the need for background information on place and time.

Having narrowed a pitch down to a specific period and location, another issue comes into play. For any given period and city, several pitches could be current in different musical domains (chamber pitch could be different from church pitch, for example, or military pitch different from opera pitch). The names of most pitches derived from specific musical functions or (related to that) from the locale where they were used: choirs (*Chorton, corista, Chapell pitch*), chamber music (*Ton de chambre, Cammerton, Consort pitch*), opera (*Ton d'opéra*), ceremonial music out of doors (*Ton d'Écurie, Feld-Ton*), etc.

When pitch names did not relate to a musical functions, they generally referred to instruments ("opra of fluyte toon," "netto Cammer of Houbois-thoon," "Chor- oder Trompetenton," *Cornet-ton*). The instruments usually had associations with particular functions: organs most often with church music, trumpets with the military, etc. Lutes, viols, and harpsichords all had reputations for being lowish chamber instruments, as did the newly invented French woodwinds. Other instruments maintained the older high renaissance pitch right through the baroque period, like the trumpet, and as late as 1716 Bach was still writing for violins at a semitone above modern pitch. In the case of the cornett, a pitch reference emerged that was stable and reliable over most of Europe for almost three centuries, because the instrument did not change in basic design or measurement, and was made for the most part in one place (Venice).[14]

0-2 Appropriate Frequency Tolerance

What tolerance should be considered realistic and appropriate in studying the history of pitch standards? Given a gamut of historic

pitch frequencies from about A-380 to A-500, how close does a particular frequency need to be to a standard in order to be considered as belonging to it? Or put another way, how specific were the frequencies of pitch standards? What, for instance, did Praetorius mean by "The English pitch, however, is a very little lower [than *ChorThon*], as the instruments made in that country show, for instance cornetts or shawms."[15] What is "a very little lower," and does it imply that *ChorThon* was regarded as so specific that even slight deviations were worthy of comment?

While tuning systems of the past were generally more refined and versatile than our present equal temperament, the concept of cycles per second had little relevance to musicians until recently. The smallest unit used in 18th-century pitch discussions was the *comma*, which is the 9th part of a whole-tone. This was just under 22 cents wide, and close to the so-called "syntonic comma" (at 21½ cents).[16] The comma was one of the basic concepts used in tuning and temperament, but it had a limited usefulness for pitch standards. The usual level at which musicians described pitches was the semitone; this is not surprising considering the degree of variation a pitch standard can encompass, and that neither staff notation nor transposition made smaller distinctions than a half-step.

Even at the same place and with the same instruments, pitch must have varied, as indeed it does now. Because it is such a volatile element, it would be unrealistic to expect to find an "exact" pitch correspondence down to the last Hz in historical sources. It could also happen in some cases that a historical pitch was not quite where it was intended to be; nothing guarantees that pitch frequencies that have survived are "in tune" to the exact cycle per second with the pitch standard they represented. Marpurg (1776:66) wrote that "at places where pitchpipes have the same standard, keyboards nevertheless differ from each other in reference to that pitch, and the reasons for this are several."

To take an extreme example, seasonal conditions influence organ pitch in large unheated churches, where theoretically a difference of 18 Hz is possible between winter and summer. Another example is a modern study of pitch dispersion during an opera performance at Paris: the variation was 3 Hz below and 5 above the base A.[17] It seems from this that a range of at least 8 Hz is acceptable as defining a pitch standard.

It is meaningless and confusing to approach pitch variation too specifically; a violinist plays an open string about 5c higher when playing forte than when playing piano,[18] an hautboist playing staccato plays higher than when playing legato, and a modern singer's vibrato has an undulation rate of 5-7 Hz, for instance. If our tolerance is this fine, we will also have to accept the relevance of Ellis's comment (1880:15) that "In point of fact, the exact pitch of an organ cannot be ascertained, for it is so large that various parts of it are constantly at variable temperatures, and hence are constantly liable to be at different pitches, or out of tune with each other." A difference of less than 8c is difficult for a musician to distinguish when heard alone (but becomes clear when the difference is increased to 15-20c).[19]

Another factor that puts the question in perspective is that musicians before the Romantic era distinguished between sharps and their corresponding flats: a D♯ was not the same as an E♭. Quantz gave an example in VXII/vii/9, where a held A♭ on the violin is altered to become a G♯ because the harmony changes. The difference between these notes was a comma. If the voice and some instruments could distinguish an A♭ from a G♯ or an E♭ from a D♯, it means they were able to change the pitch of notes by a comma at will. It is clear, then, that determining pitch standards more specifically than the nearest comma is meaningless. Over the range of a treble instrument, a comma was equivalent to 4-7 Hz. Since weather changes alone could cause pitch to vary as much as a ¼-step, the unit that was sufficiently accurate for most situations was a semitone, consisting of 4 or 5 commas.

There is thus a small range of pitch frequencies that is sufficiently flexible to allow for the inevitable variations that occur in performance but is still specific enough to distinguish the centers of pitch standards. Our modern pitch units, the Hertz and the cent, are usually too specific to be appropriate and meaningful in musical contexts.[20] They have their obvious uses in acoustics, but they are not based on musical concerns like the overtone series; that a simple concept like the comma is expressed as 21.5062896 cents illustrates the point.[21]

Although the Hertz and the cent are often too specific for most musical purposes, our conception of pitch is nevertheless conditioned

by the language we use to describe it. Karp (1989:165) writes "There are no generally accepted units for the designation of pitch, which is a subjective concept that relates to frequency in the same way that loudness relates to amplitude." For lack of anything better, musicians today use the language of acoustics when they say they are playing at "415," but there is something incongruous about the way this term is applied in a generic sense to mean a range of Hz values from, say, A-410 to 420. Musicians know what this means, and they also generally know that this number, or any number of Hz, is only a starting point. As Meeùs asks (1987:27):

> How long do you think a harpsichord remains *exactly* at the pitch and in the temperament one purports to have set it to (especially when it is played)? You may perhaps start playing at A=415 in Werckmeister 3, but where will you be in the middle of the concert? And what about wind instruments raising in pitch as they heat? And, if no instrument of fixed pitch is involved, how fluctuating do you think the pitch of an instrument or an ensemble is as they play?

It is to the credit of Leipp & Castellengo (1977:24ff) that one of the conclusions of their statistical study of pitch variation in Paris in 1965 was that in real performances "it is not possible to identify a pitch with a single number; one needs [to know] the temperature, and the statistical average for [all the] tonic and dominant notes." Their general observation was that "les fluctuations, avec des bons musiciens, sont de ±5 Hz environ" ("with good musicians, the fluctuation is about 5 Hz"). If this is true, then it is the unit used for measuring that is inappropriate.

The well-known instrument restorer Rainer Weber commented (1992:298):

> If we approach [early instruments] with the numerical mindset of the technologist, looking for absolute answers accurate to the last decimal, we will deceive or disillusion ourselves. We should consider if such a literal, mechanical approach belongs to the methods used in the past. While modern physics works with statistical "probabilities" and relative values, at the same time historical instruments are subjected to

measurements to the hundredth of a mm and fractions of Hz or cents. We would do well to look less precisely.

Ellis (who was an eminent scientist but tone-deaf) went to the absurd length of using Hz values reckoned to one decimal point in his well-known pitch study of 1880; the numbers helped him calculate intervals, but they gave an impression of accuracy that did not in fact reflect even Ellis's own perception of the real situation. Many of his pitches were "educated guesses" that could easily have been a comma higher or lower.

In this sense, music and acoustics are based on quite contrasting premises. In acoustics, pitch frequencies are regarded as objective physical phenomena, whereas musicians use pitches in a relative way to create subjective impressions. What is adequate and appropriate for the musician can be hopelessly vague to the acoustician, whose precision often strikes the musician as needless and even occasionally deceptive. The acoustician may reject evidence or measuring techniques as too imprecise that will be perfectly usable by the musician.[22] The following passage appears in an acoustical study, for instance:

> Common sense suggests . . . that good musical performance is characterized at the very least by an accurate rendition of the notes in the written score. In fact, acoustic measurements of performances by well-known artists indicate a high degree of variability, similar to that found in speech. It is only because of the illusion of categorical perception that we are largely unaware of the gross pitch deviations that are the norm in musical performance.[23]

The words "accurate," "variability," and "gross deviations" are value judgments, and are relative to the fineness of the scale being applied. In this case, an acoustic scale is imposed on a musical meaning that depends on perception. One could as well judge an automobile by how well it flies.[24] Neither the musicians nor their audience may even be conscious of the "gross" pitch deviations that are regarded as significant by the acoustician. This difference in viewpoint and goal has been a regular source of confusion in many studies of pitch history,[25] and has often discouraged musicians (one thinks of Mendel) from coming to conclusions because they were not verifiable using yard-

sticks that (had they reconsidered) were anyhow inappropriate for a subject where a certain tolerance in frequency variation is obviously necessary.

Leipp and Castellengo (1977), for instance, show a degree of skepticism and rigor that has led them to the conclusion that "we will never know with certainty how a given organ was originally tuned." By this gauge most, if not all the so-called "historical facts" that go into the received body of musical knowledge known as musicology can be brought into doubt. Intellectual doubts of this order, however well-intended, do not allow information to be used that could lead to conclusions that would be perfectly valid in musical terms. In studying pitch standards, we are looking for parameters that have musical significance and are relevant to musical practice. Leipp and Castellengo's characterization of the pitch information of "scientific researchers" as the "most serious" source of information on pitch history seems from this perspective fatuous; for all its admirable precision, such information can rarely be tied to concrete musical situations (specific musicians or concerts) and is therefore of marginal importance for the subject at hand.

Thus the opinion of La Fage, writing in Paris in 1859, seems relevant: "just as for the weight of bread at the bakers', there are a certain number of grams of 'tolerance,' there will be 'tolerance frequencies' for musicians."

0-2a Fluctuation within a Standard

One of the reasons for tuning at the beginning of rehearsals, and even during concerts, is that the pitch of most instruments varies as a result of changes in humidity, temperature, etc. Although these are differences of pitch, they are not differences of pitch standard. In early sources, that same distinction between adjustments of tuning within a standard and outright differences of pitch standard is not always easy to see. The cornett player Bartolomeo Bismantova wrote in 1677, for instance,

> [One should] also endeavor first to listen to the *tuono chorista* of the organ or other [*strumento acuto*]. In the event that the cornett should be

> higher than the organ, it will be necessary to attach one or more [tuning] joints, and if, on the contrary, it should be lower in pitch, it will be necessary to remove them.
>
> If it should be necessary to attach more tuning joints than usual to the top of the cornett because the organ is quite low, it will first be necessary to place into the bottom end of this cornett a joint of approximately one finger's width or possibly more. This joint must be made of wood, it must be bored with a hole as large as the opening of the cornett, its mouth must fit tightly into the opening of the cornett, and it must be made and turned on a lathe. This lengthening of the cornett above and below is done so that all the notes, especially the high ones, will be in tune, just like that [lengthening] which you do on the recorder, but use good judgment in applying this advice. If, on the other hand, there should be a long and movable silver ligature as an ornament at the bottom end of the cornett, you can lengthen this, which [lengthening] will have the same effect as that of a tuning joint.[26]

If we take this extreme lengthening, that of "a joint of approximately one finger's width or possibly more" to be 2 cm, plus 1 cm at the top of the cornett, the total difference in pitch can be estimated at about 66 cents.[27] Since both here and in what follows, Bismantova counts on being able to tune not only lower but higher, it would seem his instrument was normally tuned at about the midpoint between the extremes. The differences he discusses would therefore be on the order of 33 cents in either direction. If the average pitch of a cornett was A≈470, it could be lowered by these operations to A≈461 or raised to A≈480.[28] The fineness of this tuning, with a range of a third of a semitone in either direction, indicates how specific Bismantova (who was a cornett player himself) considered the instrument's pitch to be.

This would seem to be a case of an adjustment within a single pitch standard. But we cross the line into a different standard in Bismantova's next passage:

> If by chance organs or harpsichords are found which are lower than the *Corista*, and if the cornett can neither be tuned nor accommodated in pitch to the mode in which *Sinfonie* or other [pieces] are being played, it will be necessary to tune the cornett one step higher and then to play one step lower. It is therefore necessary to know how to play in all the clefs in order to be able to transpose, if necessary.

On the face of it, Bismantova's statement is illogical; to "to tune the cornett one step higher and then to play one step lower" would be to arrive where one started. But Bismantova probably means "tune the cornett one step higher *than the Corista* and then play one step lower *than the Corista*," in other words, tune up a semitone and transpose down a whole-tone.[29] This must have been an approximate solution, since (as we have just seen) the player probably had a range of less than a semitone with which to work.

The development of alternate tuning joints on the traverso also demonstrates the distinction between tuning within a single standard and changing to a different standard. The earliest traversos were made in three pieces with a single long center joint. A new model developed in the 1710s divided this center joint into two parts and usually provided a number of alternate lengths or *corps de rechange* for the upper one. Among the earliest traversos that had *corps* were those by Jacob Denner, who began signing his work in 1707. One of his surviving traversos has *corps* showing a relatively large spacing. The highest *corps* is at 413; there are two other *corps* at 403 and 393. According to Konrad Hünteler, who plays the instrument regularly, the highest joint shows the most wear but the one at 393 plays the "best" (i.e., probably has the best internal intonation). Because of the distance between the pitches of these *corps*, they appear to represent different pitch standards. Another Denner traverso, Nürnberg 257, also has multiple *corps* at 393 and 417, a semitone apart.[30]

By the time Quantz wrote his book in 1752, however, the principal purpose of *corps de rechange* seems to have changed: the emphasis is put on the ability of the player to adjust for variations *within* a standard (rather than to switch pitch standards). The total range of a series of *corps* was a large semitone, but the spacing was usually (according to Quantz) in increments of about a comma. Quantz wrote,

> But because in almost every province or city a different pitch for tuning instruments has been introduced and is now more or less dominant, and besides this harpsichords (although they remain in the same place) are tuned sometimes higher or lower due to the negligence of

those who must tune them, about thirty years ago the flute was given more joints; that is, it was provided with *corps de rechange*.[31]

A half-generation earlier, Michel Corrette (c1740:7) described essentially the same principle:

All traversos are at *ton de l'Opéra*. But since in ensembles the harpsichord is occasionally tuned too high or too low, there are usually several *Corps de Rechanges* at different lengths in order to match the harpsichord. It is only the upper *corps* that is changeable. Changes of pitch level are rare except among singers who contract colds, or who like to impose their whims on others; but in such situations the corps are certainly useful.

With a flute having several *corps de rechange*, one or two of the joints (usually somewhere in the middle, but on flutes made by Quantz, usually the longest joint) will have the best internal intonation.[32] Ribock in 1782 criticized flute makers for providing as many as six *corps de rechange*, considering more than three "völlig unnütze Möbeln" ("quite useless furniture"). On page 36 he points out that there are noticeable playing differences even between the two joints on either side of the best one. If a difference of a comma already began to affect the internal tuning of the instrument, changes as far apart as a semitone (4 to 5 commas) would have been used only as emergency expedients. Thus by this time, *corps de rechange* were evidently intended to accommodate smaller variations.[33]

It follows that the *corps de rechange* were not intended for use at different pitch *standards*, since standards themselves did not vary by as little as a comma; they are rather an indication of a pitch problem on a smaller scale: the difficulty of maintaining a consistent level even when a pitch standard is generally recognized. Tromlitz confirmed this when he said, "If one always lives in the same place, where the pitch is uniform, one can make do quite well with a flute with five middle joints . . ."[34] The five joints were evidently intended for adjustments within that pitch level. The *corps de rechange* were thus backups for contingencies when a pitch standard vacillated as a result of factors like temperature, variations between church organs at the

same nominal standard, the negligence of harpsichord tuners, different breath pressures, etc.

The organist and scholar Jakob Adlung wrote in 1758:315, "It is well known that organs are not all the same, so a musician needs always to carry a number of shanks in his pocket, besides his trumpet, if he has to play in different churches. It is the same for the horn. But how can it be made to work with flutes, hautboys, clarinets, and the like?"[35] From this it is not clear what order of pitch variation is meant. Few organs were at *Cammerton* in Adlung's day, however (he mentions the fact when he describes them). So presumably he was thinking of variations within the *Chorton* standard (which, as we will see, could be quite large). Later in his book (p.376) he wrote that organ pitches were "nicht allezeit überein sind in einer Stadt, geschweige in mehrern Städten" ("not always quite the same in one city, not to mention between cities").

0-2b A Terminology for Pitch Levels

With good reason, original terms for pitch standards have not been revived in modern times. A word like "*Chorton*" that stood for different frequencies at different times and places would for this reason be confusing today. That is why we have ended up using numbers like "465"—unsatisfactory as they are—to represent pitch levels.

The growth of the history of pitch will depend on our ability to communicate and develop ideas, and will rely on a language that is specific and yet flexible. I notice a tendency by a number of recent writers talking of pitch levels to use a terminology based on semitone intervals from a given reference pitch. I have used that system here as well. It starts at A-440, since that is the modern reference (and was not uncommon in past centuries either), a ½-step lower is A-1, a whole-step higher is A+2, etc. A-440 itself is A+0. Approximate pitch levels are therefore identified throughout this study as follows:

Pitch name	Hz value for A	Frequency range for A	Commas from 440
A+3	521	509-531	13
A+2	495	480-508	9
A+1	464	453-479	4
A+0	440	428-452	0
A-1	413	409-427	5
A-1½	403	398-408	7
A-2	392	384-397	9
A-3	373	361-383	13

These levels are generally at a distance of 9 commas (a whole-tone) or 13/14 commas (a minor 3d) from their neighbors, so that transpositions would have been practical. Mattheson wrote that "*Chorton* is 9 to 14 commas higher than opera pitch and *Cammerton*."[36] If *Cammerton* was A-1, then *Chorton* would have been A+1 (9 commas higher) or A+2 (14 commas higher).[37]

Considering the tolerances discussed above, by identifying pitch standards by semitones, I am assuming a tolerance half that size (i.e., one-quarter tone, or about two commas). In the table, the column of single Hz values for A is to be understood as the approximate center of pitch frequencies that can vary about four commas from their lowest to highest extremes.

This system is serviceable for most historical pitch standards, but breaks down in certain important cases like French *Ton de Chambre*, for which I have resorted to "A-1½" (A≈403). I also use a different system for English historical pitches (the reference being *Quire-pitch* at A-473; see 2-5a).

The problem with any system like this is that it works as a procrustean bed, compelling a conformity that may not have been there originally. As a way to test how well it conforms to the historical data, let us disregard preestablished levels and consider the pitches of surviving woodwinds in the period 1700-1730 only by Hz value. If we take the total range of pitches, and assume that (at this level) a semitone is about 23-25 Hz, Italy shows two woodwind pitch centers at 418 and 435; France three at 393, 408, and 462; Germany three at 392, 418, and 466; England one at 407; Holland one at 406; and Belgium one at 405:

	Range	1	2	3	4	5
Italy	410-443			418	435	
France	385-416	393	408			
France	456-467					462
Germany	378-431	392		418		
Germany	456-475					466
England	395-418		407			
Holland	392-420		406			
Belgium	395-415		405			

These levels correspond closely to the levels we have postulated, and all the woodwinds of this period fit in these categories, with a margin of, at most, 5 Hz:

Pitch name	Hz	Country
A-2	392	France, Germany
A-1½	403	France, England, Holland, Belgium
A-1	413	Italy, Germany
A+0	440	Italy
A+1	464	France, Germany

We can assume, therefore, that the pitch scheme proposed above accurately represents the centers of historical pitch standards.

0-3 Transposition

Pitch and transposition can be viewed as two sides of the same coin, since transposition is the corrective for an inappropriate pitch. Section 5-2 of this study deals with the practical considerations musicians had to make when transposing.

0-3a Transposition Grids

When musical groups found themselves using different pitches simultaneously, those pitches had to be "transposable;" they had, in other words, to be separated by discrete diatonic intervals. The usual intervals were the M2 and m3. These levels then formed a transposition "system" of pitches at predictable intervals, or what I call a *transposition grid*. Transposition grids were common in most European countries (for instance *Mezzo punto/Corista* in Italy, *Chorton/Cammerton/* tief-*Cammerton* in Germany and Holland, and various derivations of *Quire pitch* in England).

0-3b Transposition and Temperament

While transpositions of a M2 and m3 were common, those of a semitone were rare. That is probably because until the end of the 18th century a semitone transposition would have introduced tuning problems, since in the unequal temperaments then in use, intervals were not all tuned the same. Keyboards with split accidentals allowed both D# and E♭, or A# and B♭, but many keyboards had a single key for the two notes, thus imposing limitations in key choice. For the same reason, mixing instruments pitched a semitone apart would have produced an extremely unsatisfying intonation. Transposing a M2 and m3, however, resulted in parallel intervals that corresponded fairly well, depending on the type of tuning. Where transposition was necessary, pitch standards that functioned together would have been at these intervals, especially the M2.[38]

0-3c The Autonomy of Church Pitches and Secular Pitches

Since a semitone was usually the smallest unit used by 18th century sources for comparing pitch levels, standards tended to be described in terms of diatonic intervals such as a semitone, M2, etc., even when the exact frequency difference between two standards was somewhat more or less.[39] Using such descriptions, it is natural that we begin to assume that all historical pitch standards were related to each other by

transposable intervals: *Cammerton* was lower than *Chorton* by a M2 or m3, etc.

But pitches did not necessarily interact. The levels were associated with different functions, such as instrumental/chamber pitch and choir/church pitch. When the music of these places was separate and never used together, there was no reason for their pitches to have any reference to each other. A pitch standard at 403 (French *Ton de la chambre*) could exist at the same period and in the same city as one at about 392 (French *Ton de Chapelle*), both of which were within a span of two commas or about a quarter tone.

A pitch could operate, in other words, without reference to other musical practices or groups. The Paris *Opéra* in the 18th century, for instance, long maintained a pitch level that had been abandoned everywhere else in France. And in most European countries by the end of the 18th century, church organs seem seldom to have been at the same pitch as other instruments.

Notes

1. Cited in Dean 1980:3:47. Dean noted that half the arias Handel composed for Bordoni were in A or E, major or minor.
2. The distinctions in spelling I make here between Praetorius's 17th-century *CammerThon* and *ChorThon*, the 18th-century *Cammerton* and *Chorton*, and the 19th-century *Kammerton* correspond approximately to the different frequency values associated with them.
3. Scotto di Carlo 1997:24.
4. Tr. Herbert W. Myers*.
5. Praetorius 1618:16.
6. In the German version, Muffat calls it "*Cornett-Thon.*"
7. Muffat 1698, Preface (written in Latin, German, Italian, and French), p.48. In Kolneder 1970:73.
8. Quantz 1752, Ch. XVII/vii/7.
9. Even smaller differences can be heard, as for instance the sound of the oboes in the present Berlin Philharmonic, who are playing at about 446.
10. See also Leeson 1991.

12. Mattheson 1713:236. Mattheson, it should be noted, was not making general rules about the *Affects*, but simply reporting his own personal reactions (See 5-2f).
13. For a further discussion of this question, see Section 5-2f.
14. See 2-2a.
15. Praetorius 1618:15 (Crookes tr.). Original text quoted in 2-5b1.
16. 21.5062896 cents. See Lindley 1980c:4:591 and Sorge 1758. Both these commas were measurements of musical phenomena (the syntonic comma was the difference between the major third in Pythagorean tuning and a pure third).
17. Leipp and Castellengo 1977:24.
18. This is the conclusion of the author and the baroque violinist Michael Sand, in experiments using a Korg tuner. See also Mendel's comments in footnote 103 of 1978:90.
19. Wapnick-Freeman 1980:178.
20. An analogy is the difference between the traditional clock face that can be read at a distance and the digital readout. How often do we really need to know that the time is 5:43, as compared with "a quarter to six?"
21 . Both Sauveur and Ellis, who had important roles in the history of acoustics, were said to be tone-deaf.
22. "Tonie" is a word used in the field of psychoacoustics to represent the perception of pitch change caused by changes in timbre when frequency remains constant. The existence of psychoacoustics alone emphasizes the difference between external quantitative measurement and internal perception of physical phenomena. What appears significant to humans contemplating sound as a physical phenomenon is not always important to humans making and listening to music.
23. Siegel & Siegel 1977:406.
24. Siegel & Siegel, in all fairness, are making an interesting and valid observation here about musical perception.
25. The two disciplines have always had a natural mistrust of each other. Berlioz wrote on page 287 of his *Traité d'instrumentation* (1856), "se conformant ainsi à la doctrine des acousticiens, doctrine, entièrement contraire à la pratique des musiciens" (cited in Burgess 1994:25).
26. Tr. based on that in Dickey et al. 1978:164.
27. This is based on the general relation between length and pitch discussed in Haynes 1994c, section 3.
28. This is almost exactly the range of the middle cluster of curved cornett pitches (see Graph 1d).
29. This interpretation was suggested by Bruce Dickey*, who added "In any case I think it must be a whole step transposition, because half step transpositions (especially in 1677 with cornetts playing mainly in D major . . . and C major) would just be too impractical."

30. In this case, however, there is documentation that the instrument possessed two other *corps* that are now missing (Kirnbauer 1994:92); these may have "filled in" the semitone interval.
31. Quantz 1752:Ch.I/9.
32. According to Cary Karp*, former curator of the Stockholm Musikhistoriska Museet, "On all the transverse flutes I've seen with lots of joints for multiple pitch use, only one of the alternate joints ever shows any real signs of wear."
33. Another element in the use of alternate middle joints is the use of a tuning slide in the head joint, as described in §15 of Quantz's chapter 1. The slide can be used to bridge the pitch gap between each *corps*. On a surviving flute by Kirst with a slide, see Weber 1993.
34. Tromlitz 1791: 1§26, trans. Powell. See also 1§17.
35. Original text quoted in 5-4c.
36. Original text quoted in 5-4c.
37. Mattheson's statement is ambiguous, however, as he may not have meant that opera pitch and *Cammerton* were the same. We will discuss this question later.
38. A semitone transposition is much less practical than a whole-tone in a regular temperament like 1/6-comma meantone (which Mozart prescribed for Lindley: see Chesnut 1977). This is because an organ tuned to play the keys E♭ B♭ F C G D at A-440 would only be capable of playing the keys E B F♯ C♯ G♯ D♯ in tune at 415. If the keys E♭ B♭ F C G D were available at 415, switching to 440 would produce D A E B F♯ D♯.
39. Cf. Nivers in 3-1b, or the ambiguity about the relation between Venice and Rome described in 2-2c.