Rehearsal Break

Jennifer Rodgers, editor

Chasing Perfection: Better Harmonic Tuning for Choirs

by Ross W. Duffin

Column Editor's Note: *This Rehearsal Break article is the second in a three-part series on intonation from three different authors. Their approaches span from tuning practices and exercises in harmonic context to the detailed management of alternative tuning systems. Read part one, "Choral Singing in Tune" by Jameson Marvin, Choral Journal (May 2026).*

The sound of a choir can be affected by many elements such as blend, vowel treatment, and balance, but I suspect there are many choral directors who would like to learn more about tuning in particular and how best to achieve a good tuning result with their groups—perhaps not perfect, but better. This article is for those people. Some aspects of tuning may seem daunting, with unfamiliar numbers and terminology; but don't be discouraged—the basic message is pretty simple:

1. sharped notes low; flatted notes high
2. major intervals narrow; minor intervals wide
3. diatonic semitones wide; chromatic semitones narrow

Surprising as it may seem, these three precepts are all you really you need to know, and the pages that follow explain why. After the basics of tuning theory, I address Just Intonation, a term known to most choral directors as an ideal for Renaissance music, and then tuning for music from more recent periods—not Just Intonation, but a system sharing some of the same characteristics.

I have been writing about historical tuning and temperament for a long time, as may be seen in the list of resources linked in the notes.[1] In this article, I will explain how to make the tuning of your choir sound better in virtually any repertoire that uses some form of modal or tonal harmony. That encompasses a lot of music, from the late Middle Ages to the present day, but the precepts recommended here are offered to help make your choir sound better in tune, and thus simply better overall. The good news is that, in spite of all the complicated-sounding explanations, conductors and singers don't need to be experts in these historical tuning systems, and they don't even have to adhere to one specific historical system to make a difference. Simply keeping a few things in mind will help singers begin to find purer harmonic intervals and, eventually, sing better in tune more intuitively.

Being "In tune"

The concept of what constitutes being in tune has changed over the centuries. One constant is that unisons that are "out of tune" have noticeable "beats"—pulsations caused by interference between the vibrations of the notes, equal to the speed of their difference in frequency. The faster the beating, the more disagreeable and out of tune the sound appears to us. Notes that are in tune have no such beats, making the sound stable and tranquil. Nobody is going to argue for unisons that are not in tune, and everyone would want to hear them corrected in a vocal ensemble, but the predominant tuning system in use today, Equal Temperament (12-ET), features intervals with beats that many musicians don't notice or don't consider offensive, even though some of them beat quite a lot. But why do we have to suffer beats at all? Why can't we just have pure, beatless intervals everywhere? One reason is that, contrary to what you see on a piano keyboard, twelve acoustically pure fifths do not equal seven pure octaves, and three pure major thirds (M3rds) do not equal a pure octave. As a result, compromises are necessary in order to make the tuning systems work within our musical system.

In the case of Just Intonation, where the goal is pure, beatless intervals everywhere, the compromise is a complicated juggling of intervals sizes depending on the context (as will be explained below). The compromise that 12-ET makes is a slightly altered 5th and a drastically altered M3rd. Other tuning systems throughout history used alternative compromises as a way of making the tuning work with the music based on what sounded best to them. Some of the intervals of those systems may sound out of tune to us merely because they're different from 12-ET, even though they're in tune within their system. We're used to 12-ET and how it sounds, and it's undeniably efficient even though its biggest compromises are with intervals that make up the triads and simple chords that are central to both modal and tonal music. Why you might want to explore non-ET solutions as a path to better harmonic tuning is the subject of this article. As the historical tuning police might say (if there were such a thing): "Put down the piano, and slowly back away."

First Principles

The first thing to understand is that the pure M3rd is narrower than the 12-ET M3rd. Some people say "flatter" (as in the common expression, "flat thirds") but I do not find that helpful because sometimes the root must rise to narrow the interval, rather than the third coming down. It is true that the third of a major triad must often be sung lower than in 12-ET, however. One useful signpost for such notes in an individual voice part is an accidental sign altering the note, such as a G♯ when there's a G♮ in the signature, or B♮ when there's a B♭ in the signature. In those cases, the G♯ would need to be lower against a E root, and the B♮ would need to be lower against the G. But in the case of a B♭–D M3rd, the D is a more stable note, and it is the B♭ that needs to rise in order to narrow the M3rd and make it pure—or if not pure, at least better than in 12-ET. The basic message for good harmonic tuning (as given in the first precept above), is that sharped notes need to be sung lower, and flatted notes higher.

The narrower M3rd ought to mean, conversely, that the minor 3rd (m3rd) should be wider in order to fill out the pure 5th in a triad, and so it is: the pure m3rd is wider than in 12-ET. So, the tendency of singers to make m3rds narrower in order to make them more "mournful" in "sad" music goes against the requirements of purer tuning—besides having a tendency to make the ensemble go flat. A note like B♭, for example, is likely to be a m3rd in a G-minor triad, and therefore should be sung higher than in 12-ET. This also helps to narrow the M3rd between B♭ and D in that triad, so the harmony is better. Note that this applies also to notes like C and F as m3rds in A-minor and D-minor triads, respectively. Having the score—an innovation that singers in the past did not often enjoy—is useful for seeing the notes in the chord, and making adjustments as necessary.

There are melodic implications to all of this that are helpful even when a singer is concentrating on a single voice part. Obviously, melodic M3rds need to be sung narrow and melodic m3rds need to be sung wide. But just as important, the diatonic semitone—F♯ to G, B to C, A to B♭, etc.—needs to be wide. If the G is descending to an F♯ which is the low M3rd of a D-major chord, or if the A is rising to a B♭, which is the high m3rd of

a G-minor chord, the semitone must be wider than in 12-ET. (And it goes both ways: if your progression is G–F♯–G, for example, make sure you get all the way back up to the initial G again!) That is a common mistake when first starting to use narrow major 3rds and wide diatonic semitones.

On the other hand, the chromatic semitone (within one note name) should always be narrow. If you sing from F up to F♯ and the F♯ is low, or from B down to B♭ and the B♭ is high, then the semitone must be narrow. In strings of chromatic notes, furthermore, you will usually find large and small semitones occurring in alternation—a much more energizing and directional melodic progression than perfunctory and directionless successive semitones in 12-ET. Exemplifying the third precept, above, Figure 1 is an exercise for singing large (diatonic) and small (chromatic) semitones in each voice part, with opportunities for hearing and adjusting thirds.

Making distinctions in semitone size, I've found, means that singers are more aware of where they are in the scale, and are less likely to drift sharp or flat—an added benefit to the improved quality of the harmony. Significantly, all those chromatic distinctions remain true, though with different sizes of enharmonic intervals, whether you're attempting to use Just Intonation or Harmonic Intonation. (In other words, they always foster better harmonic tuning.) So, what's the difference between those systems, and how do you choose between them?

Just Intonation

We know from theorists that singers of the Renaissance endeavored to perform in Just Intonation, with harmonic intervals tuned pure according to the ratios of the notes in the harmonic series (2:1 octave, 3:2 fifth, 4:3 fourth, 5:4 M3rd, 6:5 m3rd, etc.). The effect of this tuning in performance is extremely gratifying, with chords "locking in" to tune and resonating beautifully, especially in a live acoustic. In 1985, I consulted on historical English Latin pronunciation for the Hilliard Ensemble when they were recording the Tallis *Lamentations of Jeremiah*. It was enjoyable to contribute in that way, but when the recording arrived, what really stunned me was the purity of the tuning! Listen to Part 1 of that recording on YouTube: https://youtu.be/nutZpHpQgbo?si=0sZb779LOUt82Wv5&t=440. I had never heard such extraordinary vocal ensemble tuning before, and when I played it for a class, one student said the tuning was "shocking"; another said it sounded like "the aliens had landed!"

Just Intonation is complicated, however, because it is not a fixed system with twelve notes to the octave (like

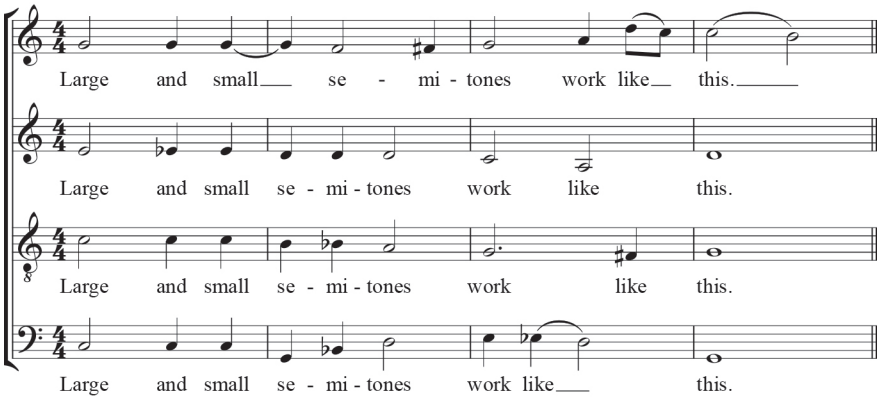

Figure 1. Semitone Exercise.

12-ET), and because it features two sizes of whole tone (9:8 and 10:9) and no less than four sizes of semitone that must be coordinated in performance. My favorite passage for demonstrating the two whole tones is the opening of *Ave Maria* by Josquin des Prez (Figure 2): the notes annotated with 0 are pure to each other as pure 4ths, 5ths, or 8ves, while those with -1, are one comma (about one-fifth of a semitone) lower than they would be using all pure 4ths and 5ths. You can see that this requires a smaller whole tone (10:9) in each voice part between D and E than between C and D (9:8). That stepwise progression makes it possible to arrive at a pure M3rd—10th in this case—above the C (10:8 = 5:4). You can also see in the last two measures that the A in the top part must begin at 0 above the D in the bass, then change to -1 (a comma below) as a pure M6th (5:3) above, then a pure m3rd (6:5) below, the C. That is consistent with major intervals being narrow and minor intervals wide (the second precept above) and also provides a glimpse of how the flexibility of Just Intonation inevitably demands a whole lot more than twelve notes per octave!

Another complication of Just Intonation is that maintaining pure intervals in every instance can lead to "microtonal migration," where the pitch of a piece could rise or fall by tiny increments—comma by comma—depending on the succession of pure harmonies.[2] One famous piece where that danger exists is William Byrd's *Ave verum corpus*: Maintaining pure intervals in the opening phrase would result in the piece rising by a comma, as shown in Figure 3a on the next page. The soprano G in bar 3 needs to be at +1 over the C+1 in the alto and tenor, but then it is trapped there for the remainder of the phrase, and the whole piece has migrated up one comma in the space of a few measures.

Whatever the quality of the harmony, microtonal migration is not a desirable outcome, both for the perceptions of the singers and the listeners and the fact that performance in alternation with a keyboard, for example, could find the singers wandering far off pitch. The solution in this case, I believe, is to compromise the pure intervals in two places in order to maintain the starting pitch, as shown in Figure 3b on the next page. The soprano G in bar 3 does need to begin at +1 over the C in the alto and tenor, but it then uses a very wide descending semitone to F♯ at -1. (This is one of the four sizes of semitone in Just Intonation.) The other small compromise in the example is that the E♭ in the bass is allowed to be at +1 for melodic reasons, rather than at +2 against the C+1. Those are brief compromises, but they enable a resolution to G at 0 and allow the piece to maintain its original pitch.

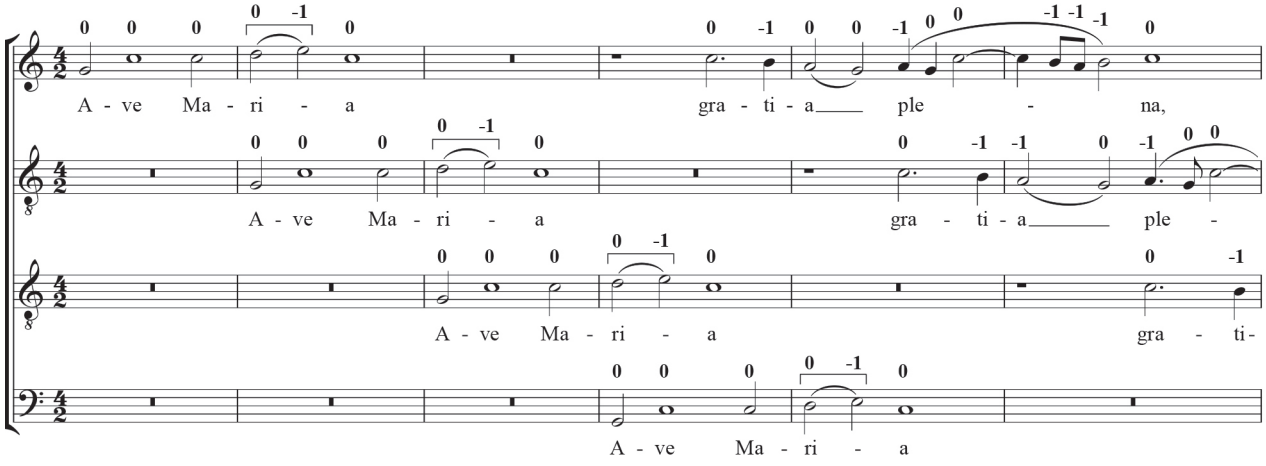

Figure 2. Josquin des Prez, *Ave Maria*, Opening.

With such momentary adjustments, Just Intonation can work beautifully in any repertoire based on triadic harmony, but it is not designed for music with an abundance of diminished triads and seventh chords—like much later tonal music. That is because two stacked pure m3rds (6:5 x 6:5 = 36:25) do not make a pure tritone or diminished 5th (45:32 and 64:45, according to the ratios given by historical theorists), and those intervals are the essential driving force of functional harmony. So, the simple ratios of Just Intonation don't work as a system in music with complex harmonies (like Bach, for example). For those intent on using Just Intonation extensively for the purity of its harmony, the resources listed at the end of this article may be helpful.

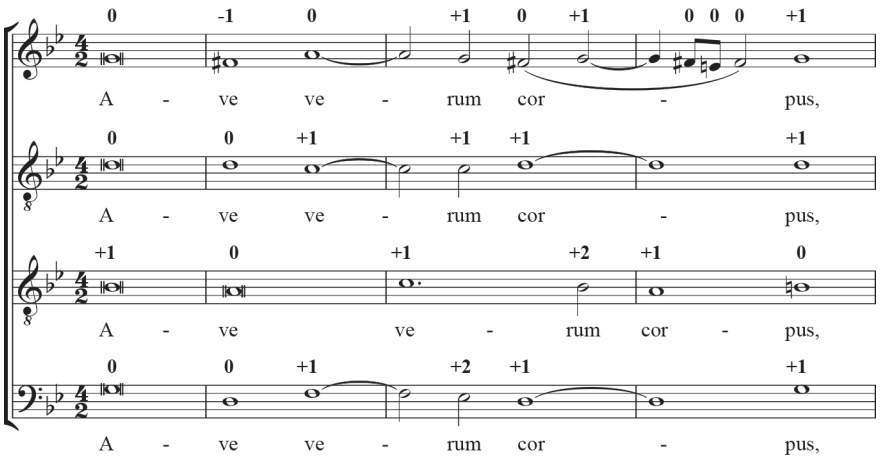

Figure 3a. William Byrd, *Ave Verum Corpus*, Opening.
with comma ascent

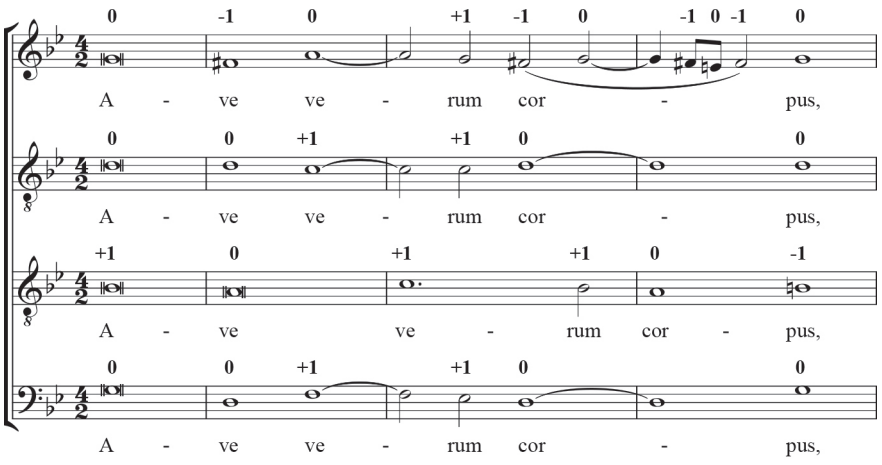

Figure 3b. William Byrd, *Ave Verum Corpus*, Opening.
justified

Indeed, there are progressions, passages—even whole pieces—of later tonal music where the intervals of Just Intonation can help clarify the tuning. The opening of Herbert Howell's *A Spotless Rose* in Figure 4 demonstrates how Just Intonation might be applied to a more modern piece.

A Just Intonation approach generally works well here, with frequent wide m3rds and diatonic semitones. Sharped notes, including those in the key signature, are almost always low, as we might predict, although F♯ needs to be somewhat flexible because of its varying harmonic context. Also, unlike the Josquin example, the stepwise motion above the tonic, E–F♯–G♯, usually has the minor tone as the first whole step, and the major tone above it (the reverse of C–D–E in the Josquin). There are complications from complex chords like the dominant ninth in the final cadence (last bar, second chord). For example, the altos' C♯ is low above the A (and melodically below the E tonic), and it needs to match the F♯ in the top voice; but that F♯ doesn't match the bass there. The interval is just passing, and in a complex dissonant harmony, so it would not be very noticeable.

What singers might do to avoid such conundrums in repertoires with more complex harmonies and modulations is to use a system that irons out some of the complications—one based on a mild form of meantone temperament. This raises the question: what is meantone?

Meantone

Quarter-comma meantone temperament originated in the Renaissance as a way for keyboards to approximate Just Intonation, understanding that tuning four pure 5ths creates a major 3rd that is much too wide. In order to make pure major 3rds—that sweet and desirable sonority in so much Renaissance music—what keyboard players did was to narrow (temper) each one of the pure 5ths so that four of them in series (like C–G–D–A–E) created a pure M3rd above the starting note, narrowing each 5th by one-quarter of the discrepancy—the comma—between a pure M3rd and the wide M3rd created by four pure 5ths. Meantone has the advantage that it eliminates the major and minor whole tones that complicate Just Intonation. In 2008, I was explaining Just Intonation to a class at Juilliard, when one student, trying to take it all in, astutely asked,

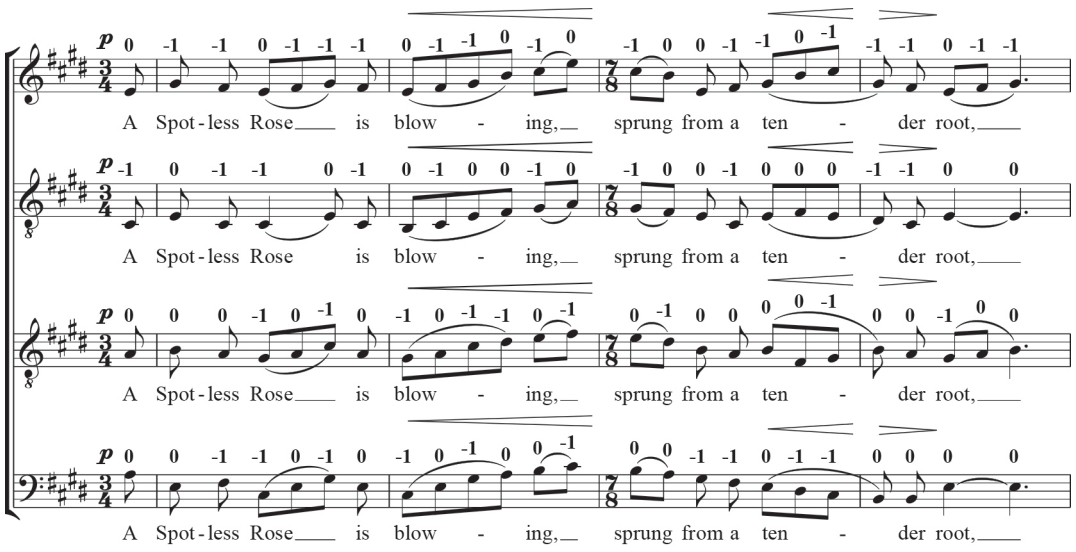

Figure 4. Herbert Howells, *A Spotless Rose*, Opening.

"Why can't we have pure M3rds but simply average the size of the whole tone?" "We can and we do," I replied, "It's called meantone." Indeed, meantone means "averaged tone," where the whole tone is an average between the two sizes in Just Intonation. That is a huge advantage for meantone over Just Intonation in terms of ease of performance, although it compromises the purity of the tuning for some intervals. For example, singing the Josquin *Ave Maria* (Figure 2) in meantone would be easier from the standpoint of regular interval sizes, and the M3rds on the second beat of measures 2–4 would indeed be pure; but all the open 5ths on the downbeat of measures 2–5 would sound quite harsh—uncomfortably narrow. Although singers occasionally perform with keyboard, I strongly suspect that unaccompanied vocal ensembles would have preferred Just Intonation in repertoire that allowed it.

Extended Meantone

Quarter-comma meantone worked well for keyboards in the Renaissance and early Baroque, creating acoustically pure M3rds in the most common keys, but there were significant musical costs:

- an unusable and extremely wide "wolf 5th"
- uncomfortably narrow quarter-comma 5ths around the rest of the circle (which were mostly tolerated because of the sweetness of the M3rds)
- several chords that sound excruciatingly out of tune—not because the tuning is bad, but because a note tuned as G♯, for example, cannot also serve as A♭.

So, keyboardists have the problem that if they tune their meantone keyboard to have a good E-major chord, they will have terrible A♭-major and F-minor chords. But here's an important point: Non-keyboard musicians—both singers and instrumentalists—are not limited by twelve notes per octave: they can extend meantone to work with any harmony by performing the notes as spelled—effectively extending the series of narrowed 5ths in each direction until they ultimately meet back at the starting point, thus making every enharmonic available, no matter how notated. One way to visualize extended meantone is through the graphic in Figure 5, not a circle of 5ths, but a spiral, with the narrowed 5ths extending off in each direction to create additional chromatic notes, and M3rds always four places away in the line. What that chain of narrowed fifths means is that the flats get progressively higher and the sharps get progressively lower, but the system of consistent interval sizes is universally maintained: A♭ to C is exactly the same size as G♯ to B♯, for example, although those apparent enharmonics are slightly different pitches (with the sharped notes lower, of course). The benefit is that every chord in every key sounds equally good—a huge advantage over keyboard temperaments (including 12-ET, where, in spite of its uniformity, as H. W. Poole pointed out in 1850, "all the chords are *equally out of tune*" [italics original]).

Harmonic Intonation

The feature of consistent interval sizes remained true in extended meantone even as musicians began

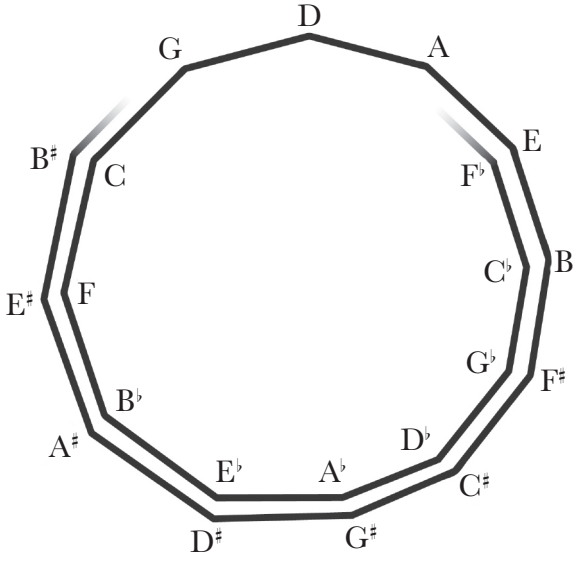

Figure 5. Extended meantone 5th-Spiral

to use less narrowing of the 5ths, so that the resulting M3rds are not as narrow as pure but still somewhat narrower (and therefore more euphonious) than in 12-ET, and the whole steps, again, divide the M3rd in half. The advantage of this milder, smoother form of meantone (in my book I make the case for extended sixth-comma meantone as a standard) is that complex harmonies sound fantastic; and, in fact, Alexander Ellis in 1885 called sixth-comma meantone the "True Tritonic" system because it features the acoustically pure forms of both the tritone (45:32) and diminished 5th (64:45)—not the same interval! What could be better for functional harmony than pure tritones and diminished 5ths resolving to euphonious triads? And if singers or non-keyboard instrumentalists want to mix in an occasional pure 5th or 3rd, why not? After all, unlike keyboards, they have that flexibility.

I have come to refer to this hybrid approach as "Harmonic Intonation."[3] In contrast to "Expressive Intonation" which advocates for high leading notes, Harmonic Intonation employs higher flats and lower sharps, occasional pure intervals, and a general goal of more euphonious harmonies.

The Payoff

Here, once again, are the basic points from the beginning of the article (perhaps useful as banners in the rehearsal hall):

1. sharped notes low; flatted notes high
2. major intervals narrow; minor intervals wide
3. diatonic semitones wide; chromatic semitones narrow

Hopefully, the reasons and justification for them are clearer now, but some may still seem counter-intuitive following decades of striving for "high leading notes" (raising sharps and lowering flats). Most modern singers, furthermore, are not accustomed to narrow M3rds and wide m3rds, for example, or to a distinction between wide diatonic semitones (like F♯–G or D–E♭), and narrow chromatic semitones (like F–F♯ or B♭–B). I guarantee, however, that whether your goal is Just Intonation or Harmonic Intonation or simply improved harmonic tuning along those lines, following these three precepts will enhance the quality of the music making, regardless of the repertoire. It may not be perfect—if such a thing is even possible—but it will be better.

That principle was brought home to me through an experience with a student string quartet in 2015. String quartets are famous among instrumentalists for obsessing about tuning, and this fine young group was having trouble with a late-Beethoven quartet—a challenging repertoire, to be sure. The first violinist had studied historical tuning with me and suggested they try extended sixth-comma meantone, narrowing their open strings slightly more than for 12-ET, and observing the low-sharps/high-flats principle. They did, and it worked magnificently, even though three of the players didn't understand why they were doing it; but in order to avoid a wholesale retuning mid-concert, they had to use Harmonic Intonation for their entire program, which also included Shostakovich and Webern! To everyone's surprise, including the players, it sounded wonderful, and they actually placed highly in a national quartet competition while performing that way!

Important Note

Implementing these tuning precepts in choirs means that the music should ideally be sung unaccompanied from the start, not using the equal-tempered piano in rehearsal, even for the starting pitches (unless, of course, the piece is meant to have piano in performance). The interval sizes in 12-ET, quite simply, will draw the singers away from better harmonic tuning, and once they learn the music that way, it will be difficult to relearn it with a more harmonic approach. If help is needed at first to learn the notes, having the bass line played alone is a reasonable compromise for rehearsals. In that case, it is preferable to use some melodic bass instrument, like cello, bassoon, or trombone, observing the same tuning precepts as the singers.

Final Thoughts

When *How Equal Temperament Ruined Harmony* was published in 2007, there was a lot of pushback. Over the years since then, however, many musicians have come to realize that a more harmonic approach to tuning works beautifully for the repertoires they perform, far surpassing the equal-tempered default of recent times. At the very least, I hope you consider following the advice of my late friend, performer, instrument-maker, scholar, and philosopher, Bruce Haynes. He was writing to me about tuning in Mozart, but it is applicable to tuning in composers from all eras of modal and tonal music. Citing the "Serendipity Principle" (where accidental discoveries lead to new insights), he observed that if the composer "expected it that way, there was probably a good reason (which may not be evident to us until we give it a good try)." A "good try" is all I can ask. CJ

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[1] For further reading and listening suggestions from the author, visit: https://acda-publications.s3.us-east-2.amazonaws.com/CJ/JuneJuly2026/SupplementalMaterials.pdf.

[2] For more, see "Just Intonation in Renaissance Theory and Practice," *Music Theory Online* 12.3 (2006): http://www.mtosmt.org/issues/mto.06.12.3/mto.06.12.3.duffin.html.

[3] I coined this term in *How Equal Temperament Ruined Harmony (and Why You Should Care)* (W. W. Norton & Company, 2007).