

It's Just Intonation

Beth Bronk

It is faulty intonation that creeps in and spoils what would otherwise be a fine performance . . . good intonation is the indispensable of the mechanics of music. —William Revelli, 1938

The foundation of all good intonation is to have strong inner hearing, a clear plan or desire for the exact coming pitch. (Joukamo-Ampuja and Wekre, 1999, p. 47).

We Already Teach Fundamental Skills – Intonation is Fundamental, Too!

As band directors, we recognize the importance of taking a fundamental approach to performance. We would all probably agree that the fastest way to make an ensemble sound better is to teach each student to perform with good characteristic tone quality. Next to good tone quality, improving intonation is probably the next fastest way to make our ensembles sound better. While we often choose to use visual tuning skills in rehearsal, aural tuning skills for use in performance situations must be better developed.

“Good intonation” has been defined “as the ability to adjust performed pitches to minimize or eliminate perceived discrepancies” (Morrison, 2000). Adjusting pitch to eliminate discrepancies is as fundamental a skill as articulation, flexibility, or technique. According to Latten (2005), three pre- and co-requisites for the development of intonation control exist.

1. It is important that students use good quality instruments

that most closely match Equal Temperament tuning. This adjusts the instruments to factory settings and allows all the members of the ensemble to start from A=440.

2. Students and teachers must strive constantly for excellence in tone quality.

3. Performers must develop the ability to audiate.

“Audiation”, or inner hearing, is a term originally coined by Ed Gordon. “...When you are listening to music, you are giving meaning to what you just heard by recalling what you have heard on earlier occasions. At the same time, you are anticipating or predicting what you are hearing next, based on your musical achievement (Gordon, 1997, p. 5-6). The value of audiation is that musicians anticipate where to place the next note in order for it to be correctly interpreted, in time, and in tune. “The foundation of all good intonation is to have strong inner hearing, a clear plan or desire for the exact coming pitch” (Joukamo-Ampuja and Wekre, 1999, p. 47). Anticipating exactly where notes must be placed to be in tune is the foundation of ensemble

training for better intonation.

Performers and teachers must have some very practical knowledge and skills in order to successfully teach intonation. These include:

- The ability to produce (or teach our students to produce) a vibrant, centered, characteristic tone quality
- Knowledge about the intonation tendencies of specific notes on instruments
- The ability to correctly adjust the length of the instrument
- The ability to manipulate pitch up and down (note-bending)
- Knowledge of alternate fingerings when their use is necessary

A Brief History of Tuning Temperaments

Historically, many tuning systems have been devised in an effort to allow music to be played in tune in all keys. Pythagoras (530 B.C.) built a tuning system based on the first two pure or natural intervals of the harmonic series: the octave (ratio of 2:1) and the fifth (ratio of 3:2). Using a succession of fifths and octaves, he devised

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all of the notes in the diatonic & chromatic scale. It is important to note that the Pythagorean fifth is two cents sharper than the Equal Tempered fifth. Circling through this spiral of perfect fifths, Pythagoras thought he would end up at the same harmonious “do”—instead he ended up 23 cents sharp of the unison. This is called the “Pythagorean Comma” or the “wolf tone” (Duffin, 2007). Taking this into consideration, what Pythagoras found is that B-sharp did NOT equal C. Though string players tune using Pythagorean fifths, this tuning system works best in music that is not very harmonically adventurous and does not change keys often.

Equal Temperament tuning, first documented in 16th century Western music, is the division of the octave into 12 equal half-steps, with a distance of 100 cents between each half-step. This is the tuning system used today on the piano and pitched percussion. This system made compromises so that enharmonic tones such as G-sharp and A-flat would sound the same frequency, regardless of the key. In Equal Temperament, all intervals (except for the octave) are altered slightly so that they are perceived of as slightly out of tune. Intonation is the same in all keys; however, one might also perceive Equal Temperament as equally out-of-tune in all keys.

Just Intonation uses pure intervals derived from the natural harmonic series. Every interval used in Just Intonation can be found somewhere in the harmonic series: 1 to 1 = unison, 2 to 1 = octave, 3 to 2 = P5, 4 to 3 = P4, 5 to 4 = M3, 4 to 3 = P4, 5 to 4 = M3, 6 to 5 = m3, and 9 to 8 = M2. The advantage of using these simple-integer ratios is the consonance of the sound they produce. Unlike intervals in Equal Temperament, intervals based on just intonation sound beatless, without waves of dissonance. Long (2008) began his research into intonation preference with the idea of ‘Coincidence Theory’, which states that when the

components of harmony are in enhanced alignment, the sound will be more consonant to the human auditory system. Performing in Just Intonation may create greater consonances than Equal Temperament (i.e., more resonant chords and better sound projection) and has the potential to provide more varied and powerful dissonances. The most important point may be that, with good instruction and thoughtful practice, ensembles using Just Intonation may be perceived as performing equally in-tune in all keys (though, admittedly, it is more difficult in some keys than others!).

The table below the adjustments performers must make from equal temperament to reach Just Intonation. There are adjustments for every half step as well, but these scale degree adjustments are adequate for starting out.

Adjustments from Equal Temperament to Just Intonation

MAJOR KEYS:								
Scale Degree	1	2	3	4	5	6	7	8
Adjustment	0	+3.9	-13.7	-2.0	+2.0	-15.6	-11.7	0
	Bb	C	D	Eb	F	G	A	Bb
MINOR KEYS:								
Scale Degree	1	2	3	4	5	6	7	8
Adjustment	0	+3.9	+15.6	-2.0	+2.0	+13.7	+17.6	0
	Bb	C	Db	Eb	F	Gb	Ab	Bb

This chart shows that a performer must manipulate the pitch up or down as indicated to perform each of these intervals in tune, with no beats or waves, when sounding against the root of the chord, or scale degree one. The same skill applies to performing chords in Just Intonation. It is crucial that the idea of adjusting the third of chords becomes second nature to both teachers and performers. As the chart indicates, in a major key, scale degree three must be lowered -13.7 cents to be perceived of as in tune.

Certainly there are some disadvantages in using Just Intonation. Wind instruments still play better in

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tune in some keys than in others. For example, in the key of B-flat, the tonic chord is a B-flat major chord, spelled B \flat - D - F B \flat , the root of the chord, is the fundamental of the harmonic series for most brass. D, if written in the fifth harmonic, is usually flat, which may help to lower the third of the chord appropriately. The fifth of the chord is F, which must be raised +2 cents to be in tune within the chord. F is sharp in certain registers on many instruments, which may bring it closer to in tune within the chord. It will not be very difficult to teach students to play a B-flat major chord in tune, but you will have to pay close attention to placing the third of the chord (D concert) nearly 14 cents low.

Now consider a more difficult key, D-flat major. In the key of D-flat, the tonic chord will be D \flat - F - A \flat . D \flat is the root of the chord. F is often sharp on many brass instruments and certainly very sharp on alto saxophone, and now must be lowered nearly 14 cents to be in tune within the chord. A-flat will need to be played +2 cents in order to be a true perfect fifth. The biggest challenge will be for performers to play F concert much lower than usually required, especially since many of us spend a great deal of time on F concert. The same problem occurs in the key of G-flat, where B-flat concert becomes the third of the chord, and must be performed much lower than usual to be in tune. These considerations may answer the question of why bands play better in tune in certain keys and less in tune in others. My experiences working with Just Intonation in the past couple of years have shown me that my band can play in tune in more difficult keys when I improve their listening skills and increase their awareness and understanding of what they need to do in specific keys and on specific scale degrees to play in tune.

Admittedly, Just Intonation is not appropriate for all types of music. Atonal, twentieth-century, and some

polytonal compositions may work better in Equal Temperament, although I sometimes find myself using Just Intonation to improve the way certain intervals tune, even in non-common practice styles. We also have to make decisions about when to adjust to the pitched percussion or to the piano. For example, if the winds are playing in Just Intonation and a solo chime sounds that must be matched in Equal Temperament, the players will need to do so. Their well-developed ability to manipulate pitch up or down as needed should allow them to do this fairly easily. Soloists playing with piano accompaniment will have to tune to the piano. Time and practice will help you make choices about when to use one tuning system over another.

Tools and Skills Equal to the Task

We have many tools available to help us when tuning our bands: twelve-window tuners, hand-held tuners, the applications on our Smart Phones, Smart Music, and my number one rehearsal tool, the Yamaha Harmony Director 200 Keyboard. Additionally, there are books, CD's, and DVD's that can help us as well. Choosing how to use these tools is the key to accurate intonation in performance. Making a decided effort to use these tools to improve our student's ear-training skills is the long-term solution to solving intonation problems. Students who learn to hear better in tune and understand how to manipulate pitch will play better in tune.

Twelve-window tuners are great for seeing the intonation of multiple pitches at once, but they will not produce in-tune chords if all performers successfully "stop the dial". Only by raising the fifth +2 cents and lowering the third -13.7 cents will the major chord be truly in tune. A knowledgeable director may be able to use the 12-window tuner to get close to that and their well-trained ears to make final adjustments.

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I look forward to learning more about the Peterson Strobe Center 5000 II, which advertises the following preprogrammed temperaments: Equal temperament, Pythagorean Tuning, Just Intonation-Major Mode, Just Intonation-Minor Mode, Quarter Comma Mean-Tone, Werckmeister-111, Kimberger-111, and Young Temperaments.

Hand-held tuners are wonderful for adjusting the length of the instrument (correctly placing the tuning notes) and helping students to see whether the pitch they are playing is above or below Equal Temperament. "iStrobosoft" is an application for the iPhone made by Peterson that allows your phone to become a convenient, accurate, hand-held tuner. I use mine in some rehearsals to set the length of instruments individually, especially if my Harmony Director is not available. (Note to Harmony Director users: when adjusting tuning notes using the Harmony Director, it is important to make those adjustments using the Equal Temperament setting.)

A hand-held tuner can be valuable when used with a tuning clip to help oboe and bassoon players that may be playing consistently sharp make a visual connection to their pitch and hopefully make an overall adjustment. However, like most 12-window tuners, using a hand-held tuner will not produce an in-tune chord without the knowledge of how much above or below equal-temperament notes must be placed. I would strongly advise not using a hand-held tuner and tuning clip for every member of the ensemble. I think when students use their eyes rather than their ears they may distort tone to manipulate pitch. Again, the result of all students "centering the needle" on hand-held tuners will not be an in-tune chord, so their use is limited to the knowledge and understanding of the user. The Smart Music program has a built-in chromatic tuner and the capability to sound a drone. These capabilities are helpful in

adjusting the length of the instrument, tempering specific pitches, and learning to eliminate beats when playing intervals against a drone.

Many books and publications contain great information about the tuning tendencies of individual instruments. James Jurrens' book, *Tuning the Band and Raising Pitch Consciousness*, provides information about each instrument regarding intonation tendencies, suggests tuning notes, discusses the effects of hard and soft reeds and dynamic changes on intonation, and offers suggestions for alternate fingerings for specific notes on each instrument. This 48-page book is available through RBC Music Publishers (www.rbcmusic.com/RBCpubtexts.htm).

Tuning CD's that provide drones, perfect fifths, or chords in every key can be very helpful in band rehearsal or in individual practice. Examples of these include The Tuning CD, from Richard Schwartz (www.thetuningcd.com) and Steve Colley's Tune-Up System (www.tuneupsystems.com). These can be used by individual performers to improve pitch sensitivity and in band rehearsal as a reference for the entire ensemble. Players may be able to copy the files to their mp3 players, put on earphones, select the drone or fifth in the key in which they intend to warm up or practice, and learn to eliminate interference beats as they play.

The DVD, "Harmony Training for the Ensemble" (available from Bravo Music) is an incredible tool, demonstrating how to use the Harmony Director 200 as an ear-training tool in rehearsal. Noted Japanese bandmasters demonstrate harmony training exercises with both Japanese and American student performers in great detail, using the Harmony Director 200 Keyboard. The Yamaha Harmony Director 200 (HD 200) Keyboard has the ability to sound drones, perfect fifths, intervals, or chords in Just Intonation, modeling correctly adjusted chords for students to hear and

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imitate. It can be used to demonstrate different attacks and releases and has settings for ten different instrumental timbres. The volume of individual notes can be altered to demonstrate chord balance and the pitch of individual notes can be altered to demonstrate the difference correctly adjusting one note can make in a chord. It can also play in Equal Temperament (as well as several other temperaments), and it has a good metronome, including subdivision capabilities. Students can use it easily because it can be set in any common transposition – C, B-flat, E-flat, and F. One does not have to be a very skilled keyboard player to successfully use the HD 200. It is, in many ways, a complete rehearsal tool.

What Can You Do Today?

If you have a Harmony Director sitting in your band hall unused, I encourage you to start using it immediately. You have the ability to demonstrate intervals that are out-of-tune, help students recognize the beats of interference, and adjust the notes individually to make the interval perfectly in tune, and to model perfectly adjusted chords. If you do not own one and cannot buy one, you can start doing many of these exercises by using a reference pitch on a keyboard or a tuning CD. Soon you will be able to hear that the fifth on a regular keyboard is not quite in tune, but it is close enough to begin working with your ensemble.

You may find that a sequence of instruction that moves from singing, to mouthpiece vibrations, to playing, works well in these exercises. Mouthpiece vibrations are good only if the teacher is able to monitor the quality and accuracy of the vibrations to make sure they are free, relaxed, and full, without excess pressure or tightness created elsewhere in the physical system. If you are not sure about your ability to do that, or if you have younger, less-experienced players that have difficulty producing the correct vibration, focus on

developing their ears through singing and playing, and add mouthpiece later.

Singing for at least a minute or so at the beginning of rehearsal really awakens the ears of the ensemble. Be sensitive to the fact that some students are shy about singing aloud. You can ask everyone to hum, place their hand at the top of their chest to feel the vibrations, and to open their mouths when they feel comfortable doing so. If individuals continue to be shy, ask them to keep showing you that they are participating by keeping their hand on their chest. Also, singing too loudly may cause some students to distort pitch, so have them sing at a comfortable volume and avoid “pushing” the sound. Students will sing out more as they gain confidence. Also, remind students to listen and think before they sing, vibrate on mouthpieces, or play – to imagine a beautiful, in-tune sound before they produce it.

Sample Beginning Exercises to Develop Intonation Awareness and Skills

As you begin asking your students to vocalize and hopefully begin to utilize the Yamaha HD 200, you will think of more and more creative exercises on which to work with your students. Much of the feedback will be intrinsic—students will hear and adjust without much teacher feedback, becoming responsible for their own intonation. Bernhard (2003) cited many studies corroborating the benefits of teaching vocalization skills to instrumentalists, so don't be afraid to SING! These may help you to get started.

- If you have a Yamaha HD 200, start by sustaining a chord in Equal Temperament, then in Just Intonation, by changing the setting from “Equal” to “Pure”. Go back and forth several times to help the students hear the difference.
- If you have a Yamaha HD 200, sustain a chord in Equal Temperament. Using the “Individual Pitch”

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button and the dial, adjust the fifth up +2 cents. Then, slowly, adjust the third down, asking students to indicate the speed of the beats they are hearing. The beats should slow down and then stop when you reach -13.7 cents. Repeat this until students are more confident and accurate.

- Sustain B-flat and F on the HD 200, a keyboard, or using a Tuning CD. While sustaining:

- o Have students sing F, bend the note down a half-step and return to F, up a half step and return to F. Repeat for accuracy. Don't allow students to sing too large of an interval, and remind them to listen and match the people around them.

- o Do the same on B-flat.

- o Divide the group in half. Half on B-flat, half on F. Repeat the half-step exercise.

- o Divide into upper and lower instrument voices and do the same.

- o Sing the B-flat concert scale. Know what Just Intonation adjustments need to be made on each scale degree (see previous table). Listen for beats and try to eliminate them. Pay special attention to scale degree 2 (+3.9), and scale degree 3 (-13.7). Focus initially on the first five notes of the scale. As these get better in time and with good repetition, continue up to the ninth and back down. Now focus also on scale degrees 6 (-15.6), 7 (-11.7), and 9 (+3.9).

- o Have students sing root, fifth and third, paying close attention to the lowered third. (If you have a Yamaha HD 200, model this first.)

- o Make sure instruments slides are set in the correct place, than vibrate and/or play these same exercises.

- o Sing the Remington exercises beginning on F, carefully listening to the intervals. Play when you think the students are singing accurately.

- Sustain the root and fifth in different keys, moving around the keyboard. Move fairly sequentially up or

down at first.

- o Have students sing root-fifth-third in each key.

- o Woodwinds sing, brass vibrate on mouthpieces.

- o After student achievement is consistent in this exercise, have students sing root-fifth-third, than bend the note slightly down to find the minor third. Notice from the chart that the major third is performed -13.7, and the minor third is performed +15.6, so the interval between those two notes is reduced.

- o More advanced students can sing root-fifth third in minor keys. You may choose to resolve up to the major third as well.

- o Woodwinds sing, brass vibrate on mouthpieces.

- Chorales are a perfect way to start using these skills in context.

- o Play the first chord of the chorale, than sing it. Have woodwinds play while brass vibrates. Do the same with the first phrase. Add phrases. Eventually singing, vibrating, and playing the entire chorale in tune may be possible.

- o One of the most instructive sections of the "Harmony Training for the Ensemble" DVD shows a horn quartet rehearsing one phrase of a Bach chorale. A student uses the HD 200 to play each part, changing notes just before the horn player changes notes, helping the performer to anticipate where notes need to be placed. After rehearsing each line individually, the quartet plays together. Their performance is stunning.

- Even more advanced understanding involves lowering the seventh in major-minor seventh chords, and slightly reducing the volume of the third and seventh in these chords. You may occasionally make a choice to play the seventh melodically as a leading tone rather than lower it as a part of a chord, depending on how it is presented.

- If young bands would spend time tuning even just the final chords of each musical phrase, the difference

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in the overall performance would be considerable. Every individual chord you improve should have a positive effect on the rest of the musical selection.

- More advanced bands can tune chords in the context of the music in great detail, dealing very specifically with challenges such as the third of the chord being placed on sharp notes in extreme registers. Modeling these chords on the HD 200 and applying the sing-vibrate-play sequence will improve them almost immediately.

Finally, I would like to share that learning to better teach intonation has been very enjoyable for me. My own listening skills and the performance skills of my ensembles have improved noticeably in the past couple of years. Music education students are beginning to learn this information in college, becoming comfortable using the tools available in a more efficient way. It is exciting to see that, with better information and improved instruction, we can help our students master these skills, further improving the performance of our ensembles.

Please feel free to e-mail or call with comments, questions or suggestions: bbronk@tlu.edu or (830) 372-6028.

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After 18 years of public school education and administration, Beth Bronk accepted a position as an Assistant Professor of Music at Texas Lutheran University in Seguin. Currently in her fifth year at TLU, she teaches conducting, instrumental music education classes, supervises student teachers, and conducts the TLU bands. She is pursuing her doctorate at Teachers College, Columbia University in New York and is currently researching intonation instruction for ensembles. She holds memberships in TMAA, TBA, Phi Beta Mu, MENC, CBDNA, TMAA, and ITG, and currently serves as president of TMEA Region 12. Professor Bronk is an active clinician, adjudicator, and performer.