INTONATION OF BRASS INSTRUMENTS
Ten Factors

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Teaching brass players to play with good intonation is a vital process, but it need not be confusing. The effective teacher recognizes that there are overall concepts that should be taught to brass players.

Overall Concepts

Teach students what "in tune" sounds like. Two instruments playing a pitch in tune will have no waves occurring between their sounds. Alternatively, a player matching a drone with no waves between the two sounds has demonstrated good intonation.

A teacher can demonstrate what "in tune" sounds like easily with two students playing, but it may be done more efficiently with one good student and the teacher: the teacher makes slight changes in intonation until there are no waves between the two instruments. Have the rest of the students raise their hands when the waves disappear—they can hear that!

Another technique is to use a drone and have a student (tuning has to be one-at-a-time) play and adjust until the waves disappear.

Some teachers use two trombonists to demonstrate good intonation, because the slide is so easily manipulated while sustaining the tone.

Teacher: "Trombonist A, play and sustain your third-position E-flat. Trombonist B, start with your slide in fourth position and move it slowly into third position until the waves disappear. Class, listen closely and raise your hands when you hear the waves disappear."

Ten factors all brass players should learn:

1. All wind instruments pull out to flatten and push in to sharpen pitch.
2. Temperature affects pitch: cold=flat, hot=sharp.
3. Brass players usually face sharpness when playing in upper range.
4. All wind instruments can lip down (flatten) pitch to a greater degree than they can lip up (sharpen) and still maintain an acceptable tone.
5. The embouchure and the shape of the oral cavity can influence intonation as well. A tight embouchure usually plays sharper and a flabby one plays flat. Opening up the oral cavity (taller) will lower pitch.
6. Mutes alter pitch. Straight and Harmon mutes usually sharpen pitch a little, and some players feel cup mutes flatten pitch a little. The amount of intonation discrepancy can vary. With all mutes, corks should be adjusted to favor better intonation.
7. Shallow cup mouthpieces play sharper and deep cup mouthpieces play flatter.
8. Dynamics and changes in dynamics affect the intonation of a brass player. Studies show that ff and crescendo will result in sharpness while pp and diminuendo causes flatness. This effect was researched and measured by the educator/author Ralph Pottle and addressed in his writings.

Valve Combination Issues

Each of the valves, individually and in combination, lowers the pitch of the open brass tube by successive half steps.

Combination	Interval from open tube
(Open)	(Unison)
2	Minor 2nd lower
1	Major 2nd lower
1, 2, (3 as alternative)	Minor 3rd lower
2, 3	Major 3rd lower
1, 3	Perfect 4th lower
1, 2, 3	Augmented 4th lower

The problem arises when valves are used in combination. Whereas 2nd valve and 1st valve produce a pretty accurate half step and whole step respectively, the use of valves in combination results

in intervals that are not accurate distances lower than the open tube.

9. The valve combinations tend to show these tendencies:

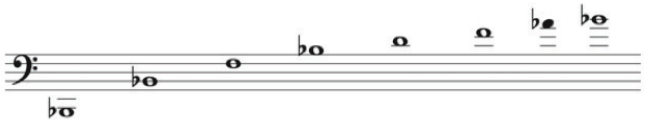
Combination	Intonation issue	Notes
Open	In tune	
2	In tune	
1	In tune	
1, 2	Little sharp	Trumpets lengthen 1st valve slide; 3rd valve can be alternate
2, 3	Little flat	In tune or flat
1,3	Sharp	Trumpets kick on their Low D; 4–valve instruments use 4
1, 2, 3	Very sharp	Trumpets kick on their Low C#; 4–valve instruments use 2, 4

Trombone positions are "equal" to each combination: 1st position is equal to open valves, 2nd position is equal to 2nd valve, and so on, by succeeding half steps. However, since trombonists can be taught to adjust the location of each position, this particular factor should not affect their intonation.

Overtone Series Issues

Everything that vibrates in our world is governed by the overtone series. It is a series of intervals above a fundamental tone, and those intervals grow increasingly smaller as one ascends. Certain acoustical properties may enhance, negate, or favor certain partials of the series, such as happens on the clarinet, but all brass instruments produce all of the partials. The lowest pitch in any given series is known as the fundamental. All brass can produce the fundamentals (sometimes called pedal tones by players) on each valve combination/position, though this is considered an advanced technique on trumpet.

Here is an example of the first eight partials using Bb1 as the fundamental:



These are the first eight partials available on trombone (1st position) and euphonium (open). The seventh partial is indicated differently for reasons to be explained in the chart below.

Brass playing depends upon manipulation of the embouchure, air and/or oral cavity to "zero in" on a given partial above any fundamental produced by each valve combination/position. Though this is the natural vibration that occurs in any vibrating column of air, the use of equal temperament in the music of western civilization creates some problems both teachers and students should know.

Short Side-step: History of Equal Temperament

Equal temperament is a system in which the octave is divided into twelve equal semitones. As early as 1581, in Florence, China and France, visionaries began to experiment with equally tuned intervals. Versions of this were used by makers of organs, harpsichords, and lutes. Fully realized equal temperament allowed for modulation among all twelve major and minor tonalities, something not possible using meantone or just intonation systems. Equal temperament had a great champion in J. S. Bach: his publication in 1722 of *The Well-Tempered Clavier,* Book I, was practical proof of the theory of equal temperament.

Since that time, music of the western hemisphere has been composed and performed using equal temperament, in every style and genre of music.

How Does This Affect Modern Brass Players?

Brass players are playing on an instrument that produces pure intervals (just intonation) to perform music that has been composed using equal temperament. Thus, brass players exist in a constant state of reconciling natural vibrations with the strictures of equal temperament. Since the music we play using equal temperament needs to have chordal function and the ability to modulate, we tend to think of (and to speak of) these differences in terms of how the natural vibration varies from equal temperament.

10. These are the specific overtone series problems that face the brass player:

Partial	Intonation (compared to equal temp.)	Notes
1 (fundamental)	In tune	Vibration of the original length of tube.
2	In tune	Simply 2X vibrations of fundamental.
3	Slightly sharp	Can lip down.
4	In tune	4X vibrations of fundamental: if this is out of tune, it's NOT the partial causing the problem.
5	Flat (noticeably)	Can lip up, though C trumpets will use alternate fingerings, tubas learn to the use 1st valve slide, etc.
6	Sharp	Not upper range for horn, they easily can lip down: for other brass, range exacerbates the sharpness.
7	Very flat	Used by trombone for G4 and Gb4, but usually avoided by all other brass on all combinations (positions) for traditional fingerings due to flatness.
8	In Tune (however..)	Theoretically, should be perfect as it is simply 8X the vibrations of the fundamental. On a string, this WOULD be perfect, because string players are not burdened with an embouchure. This is mid-high range for horn, but it is definitely upper range for other brass. Therefore, this tessitura usually tends sharp, but because of range, not partial.

Of course, there are partials that exist beyond the 8th, but most of the music performed by public school brass players deals with these partials.

A hornist performing on a double horn has two sets of fundamentals and their related partials. However, hornists can shade notes effectively using the right hand in the bell, in the same manner trombonists can adjust the slide to match partials to qual temperament.

An effective director can easily memorize the 5th and 6th partials encountered in the traditional chromatic scale of each brass instrument, thus predicting the problem players will encounter. Ultimately, however, it rests with players to listen and adjust (and to always play with good tone!).

The ten factors enumerated in this article may be helpful as a resource for both player and teacher, but eventually it comes down to getting rid of the waves, on any given note, between a player and any other sound.

Fred J. Allen is a music teacher, conductor, arranger, composer, and author. He is Director of Bands Emeritus at Stephen F. Austin State University. Prior to that he taught at Abilene Christian University and in two public school districts. At the university level, he taught numerous courses in the music education and wind conducting curricula, including conducting lessons, wind literature, rehearsal techniques, instrumental methods and orchestration in addition to conducting duties with the wind ensemble. His teaching was recognized in 2012 with the Meritorious Achievement Award by the Texas Bandmasters Association. He is a 2020 inductee into the Texas Bandmasters Hall of Fame, sponsored by the Alpha Chapter of Phi Beta Mu Honorary Bandmasters Fraternity. Allen has conducted All-Region and All-State Bands throughout Texas and the United States, where he is also an active concert clinician and adjudicator. He has often served as guest conductor for bands playing at the Midwest Clinic and the Texas Music Educators Association Convention, and has also conducted in Korea, Taiwan, Hong Kong and Australia. As an arranger and composer, Allen has published several pieces for band, orchestra and flute choir that have drawn upon his experience in teaching in the public schools. His music is noted in The Heritage Encyclopedia of Band Music (Rehrig), Teaching Music Through Performance in Band (Miles, et al) and other band music reference books. He has presented clinics and workshops at conventions of the Midwest Clinic, Texas Music Educators Association, Texas Bandmasters Association, at the Conservatorium of Music in Hobart, Tasmania, and in several public-school districts for faculty development. He is an elected member of the American Bandmasters Association, Phi Beta Mu International Bandmasters Fraternity, College Band Directors National Association and ASCAP. He lives in Arlington, Texas.