Trumpet Enrichment

One of the main reasons given in the introduction for the natural trumpet's growing popularity since its comeback in the middle of the 20th century is that of its sonority/timbre in comparison to modern valve trumpets. After all, if playing Handel's "The Trumpet Shall Sound" on the piccolo trumpet sounded the same as playing it on a natural trumpet (aside from the aesthetics of the instrument's appearance on stage) there would be no need to bother with a natural trumpet. Furthermore, most trumpeters would agree that playing the natural trumpet is more cumbersome and error-prone due to the notes being so close together in the upper register (and most orchestras don't offer hazard pay for risk taking). But there is something special about the sound of the natural trumpet which cannot be reproduced by its modern counterparts. It exhibits a rich, brassy timbre in the lower to middle registers (even at lower dynamic levels), and a silvery yet supple sound when playing passagework in the upper register. For the discerning music lover having heard a world class performance of Baroque repertoire played on a natural trumpet, hearing it then played on the modern piccolo trumpet can sound piercing, overbearing, and somewhat out of place.

Why does the natural trumpet sound different from a modern valve trumpet? Some think that the extensive series of playable notes of a "long" instrument like the natural trumpet brings out more overtones in the sound of any particular note, but this is not quite accurate.[1] Technically speaking, while many notes of the natural trumpet are reinforced by the air column's resonances above it (a phenomenon described as a "co-operative regime" by music acousticians), when the piccolo trumpet or the natural trumpet play the same note, they produce a sound spectrum with the same set of frequencies, or harmonics.[2] That is, the sounding pitch becomes the fundamental, and a series of frequencies following integer multiples of the fundamental frequency appear above it.[3] That being said, even the casual observer would notice a marked difference in the timbre of the two instruments.

Period performers, historic brass enthusiasts, and instrument makers often point to variables such as mouthpiece dimensions, bell profile, gauge (thickness) of the metal wall, choice of alloy, or type of seam in the tubing and bell, as the critical factors that give the natural trumpet its characteristic sound. Although these variables all contribute to a greater or lesser extent, you might be surprised to learn that acousticians attribute the timbre of the natural trumpet mainly to a phenomenon called "spectral enrichment," which is a distortion of the sound wave as it travels down the tube length.[4] It turns out that the more cylindrical the tube, and the longer the instrument, the more spectral enrichment can occur.[5] So, while all the variables mentioned above contribute in some way to the timbre of the natural trumpet, it appears that the overall length and relative cylindricity of the bore are the factors with the greatest impact.

A natural trumpet in Bb is roughly twice the length of a modern Bb trumpet, and four times the length of a piccolo trumpet pitched in the same key. All of these being categorized as "cylindrical" instruments, with similar bore sizes, it is therefore the relative length that explains the bulk of the difference in timbre between them.[6] It turns out that as the trumpet gets longer its timbre changes gradually. To see how this

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[1] The term "overtones" is more accurately described as the "frequency spectrum" or "spectral components" of a played note. Murray Campbell, Joël Gilbert, and Arnold Myers, *The Science of Brass Instruments* (Switzerland: ASA Press, 2021), 53.

[2] See "co-operative regime" in Trevor Herbert and John Wallace, eds., *The Cambridge Companion to Brass Instruments* (Cambridge: Cambridge University Press, 1997), 21; See "Bouasse-Benade prescription" in Campbell et al., 53-54.

[3] See "Cor Values" on pg. 7.

[4] See "non-linear propagation" in Campbell et al., 271, 274.

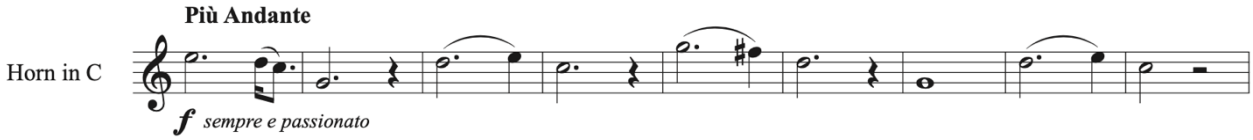
[5] Bore size also effects spectral enrichment. Narrower diameter = more capacity for enrichment. Ibid., 283.

[6] No modern brass instrument is entirely cylindrical or conical. All have expanding sections towards the bell, and all have cylindrical sections of tubing around valves and slides.

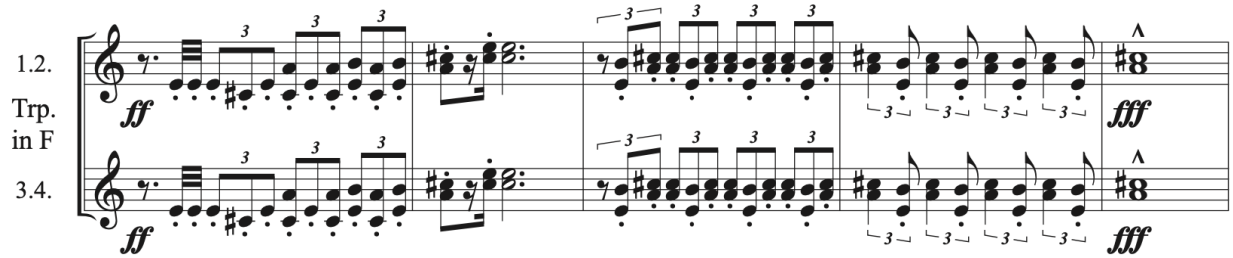
works on a much smaller scale, consider that orchestral players sometimes choose alternate fingerings for reasons of pitch manipulation, facility, and timbre. For trumpeters, playing E above the staff with the first two valves depressed not only brings the pitch up, but results in a richer, more brassy sound than the open fingering, especially when playing softly. That is spectral enrichment!

Spectral enrichment is perceived in a more dramatic way when brass instruments, especially those with a high proportion of cylindrical tubing, play at higher dynamic levels. As loudness increases, so does the amplitude of higher harmonics in the frequency spectrum, eventually resulting in what acousticians call a shock wave.[7] The resulting sound is commonly described as "blaring/brassy," "cuivré" (French), or "schmetternd" (German). Instruments that have a higher proportion of conical tubing such as bugles, flugelhorns, and euphoniums have a significantly lower capacity for spectral enrichment.

Of the modern brass instruments, the French horn has the most capacity for spectral enrichment due to its length and relatively large proportion of cylindrical tubing.[8] A musical example in which the enrichment effect is often exploited to its fullest is the famous solo in Brahms Symphony No. 1, based on an alphorn call:



It is important to note that some of the best-known Romantic period repertoire was written for valve trumpets in F (Romantic F trumpet), which have more capacity for spectral enrichment than trumpets in Bb or C. Take for example the fanfare from the first movement of Mahler's Symphony No. 1, which happens to be entirely playable on natural trumpets pitched in D.



Why should this matter to the modern trumpeter?

In comparison to their 19th century counterparts, modern orchestral brass instruments all have larger bores and bells, which requires playing at somewhat higher dynamic levels to get an equivalent level of spectral enrichment. Modern valved trumpets however are not only larger in bore but are much shorter—sometimes half the length of the natural trumpets for which much of the 19th century repertoire was written—giving them a disadvantage when it comes to matching the timbre of modern French horns and trombones.

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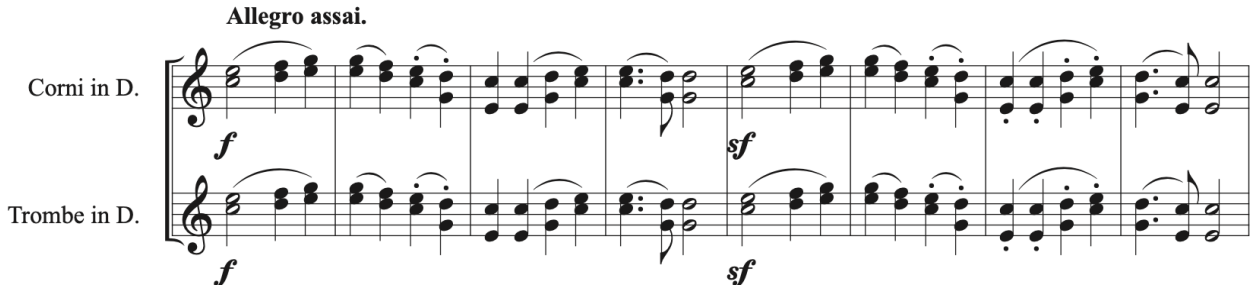
[7] Campbell et al., 55, 272, 274.
[8] Another factor is the significant length of very narrow tubing in the leadpipe.

Trumpeters playing classical period repertoire are often faced with a dilemma: to get the brassy fortissimo sound called for in the score on a modern valve trumpet, it is necessary to play at very high dynamic levels, often resulting in "the hand" from the conductor. So, while French horns and trombones are providing a rich brassy sound, the trumpets sometimes end up playing with a relatively dull tone. Playing 19th century repertoire on the natural trumpet facilitates the appropriate timbre, even at lower dynamic levels, which melds with the rest of the brass section and provides the appropriate color without overbalancing the orchestra.

There is another major musical benefit to playing classical period repertoire on the natural trumpet. When playing in a section on natural instruments of the same length, players will experience a sympathetic resonance, including the production of resultant tones, which is much rarer when playing on valved instruments of constantly changing length. The result is a sort of "super spectral enrichment," where 2 + 2 = 5, especially coming from the French horns and trumpets in octave displacement. It is a truly spectacular sound that is simply not possible with modern instruments. This famous excerpt from Beethoven's 9th Symphony presents the typical formula:



It may not be possible for the largest symphony orchestras to use natural trumpets and horns when performing classical period literature due to the need to balance massive string sections, but in many cases, when orchestras play classical period literature, numbers are reduced to achieve a more lean, transparent, and colorful orchestration. In this case, the use of natural trumpets and horns is increasingly common. Regardless, having had the opportunity to learn 19th century repertoire on the natural trumpet, the modern trumpeter will have developed a deeper understanding of the appropriate sound aesthetic for both classical and romantic period repertoire, undoubtedly adding a higher level of artistry to their modern trumpet playing.