Problems of Muted Brass Instrument Intonation, a Novel Solution

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https://s-mute.com/pages/research

1. Introduction and Background

Brass instrument mutes trace part of their ancestry to the innovations of eighteenth-century hornist A.J. Hampel. Hampel's non-transposing horn mute was a leap forward in a time when mutes would alter the instrument's pitch by a half step *or more* [1]. His mute constituted a redesign from the thick wooden "plug" that dominated the Baroque period to a conical and hollow form, fashioned from brass sheet metal and covered in leather [2]. This new design improved the acoustic properties of muted horns, solving the issue of pitch alteration, and would later influence the development of modern brass instrument mutes. Although most modern mutes no longer alter pitch to the point of requiring transposition, the finer challenges of mute tuning continue to plague brass players some 270 years after Hampel's refinement.

Literature concerning the acoustic effects of brass instrument mutes is plentiful. Campbell et al., 2021 [3] provide spectrogram comparisons of the muted and unmuted baroque trumpet and modern trombone, the latter showing a rise in frequency (pitch) when muted. Sluchin and Caussé, 1991 [4] thoroughly investigate the acoustic properties of muted brass instruments, explicitly addressing the Helmholtz resonance, its effects, and possible mediation. This investigation shows the parasitic Helmholtz resonance can be modified by changing the depth of the mute in the bell, which also alters the frequency of the surrounding harmonics. Yoshikawa, 2017 [5] provides some brief insight, highlighting changes in frequency spectra when a French horn straight mute is moved 28mm closer to the bell flare. The precise acoustic mechanism behind these findings is not within the realm of this paper; however, research does point to empirical evidence that the playability of a mute, as well as its effects on the pitch of the instrument, is detectibly influenced by its depth in the bell.

Bell geometries vary widely from one trumpet model to the next and between types of instruments within the trumpet family (cornets, rotary trumpets, etc.) [6], with their respective taper speed and resulting throat size directly impacting the depth a mute fits within the bell [7]. A faster taper results in a wider throat at the bell end, which causes a deeper mute position, while a slower taper would result in a mute position further out.

Mute corks (Figure 1) are permanently affixed (glued) to the body of the mute and provide a gripping surface between the mute body and the instrument's bell throat. Cork (or similar synthetic material) is chosen because it will firmly grip the instrument's bell while also allowing easy removal. The cork thickness determines the depth of the mute in the bell and is, therefore, the gateway to tuning a mute to a given bell flare.

Figure 1.

2. Extant Solutions

As laid out in the previous section, trumpet players have an objective basis for understanding that mutes can noticeably alter the pitch of their instrument. Players must adjust the main tuning slide to compensate or “file the corks,” i.e., reduce their thickness, causing the mute to sit further into the bell, or glue cork strips to the cork surface, causing it to sit further out [8]. This has been the general experience of trumpet players throughout their education (including this author) and reinforced through practical application and experience. Many trumpet players choose a third option, ignoring the problem entirely and instead suffering through the experience of using an out-of-tune mute-instrument arrangement.

These historical solutions are cumbersome, with the latter not at all a solution despite its apparent prevalence. In the case of moving the main tuning slide to compensate, quick mute changes, like those present in Valerie Colment's work *UMOJA* (there are countless others in the repertoire), prevent the player from adjusting and later re-positioning the tuning slide once unmuted. Filing or otherwise altering the corks has a degree of permanence. Once altered for a specific trumpet, the mute may be unsatisfactory for a different trumpet, a cornet, a rotary trumpet, or any other trumpet with a differing bell geometry [9]. The modern orchestral trumpet player may employ 5 (or more!) distinctly different instruments throughout a given season, each requiring a mute to be tuned to it (corks permanently altered) lest the player suffers the inherent difficulties of using a muted instrument that is not aligned with the ensemble pitch center. Suppose one also considers the trumpet player's need for mutes of the same general type (straight mute) but made in different shapes and/or from different materials (copper, brass, plastic, fiber, etc.) for tone color variety. The high monetary cost for the conscientious trumpet player becomes apparent.

A casual review of commercially available mutes (apart from the author's designs) would reveal little observable innovation related to cork thickness. A horn mute designed by hornist Phillip Farkas attempted to solve the problem by way of a variably sliding cork mechanism, however, Sluchin and Caussé describe in their investigation that poor coupling between the corks and the mute body causes an undesirable alteration of the sound. Other commercially available mutes tend to have thick, permanently attached corks, leaving the player to make the necessary adjustments. This exposes a disconnect between the needs of the brass player outlined earlier, and currently available commercial offerings. Given the current mute design philosophy, the reader may conclude that historic industry offerings cannot efficiently solve the problems outlined herein.

Figure 3.

3. A Novel Solution

The novel solution proposed here is a device whereby the player selectively installs corks of varying thickness onto the mute to suit the instrument. Such a device is shown in Figure 3 (patent pending) and installed on a commercially available, commonly used aluminum straight mute. The device consists of a thin collar with three dovetail rails formed on its surface, evenly spaced around the circumference, and is glued to the surface of the mute. A tray with a corresponding recess can slide and lock onto the dovetail rail. A cork or other gripping material is affixed to the tray, creating a cork assembly. Trays of varying thickness alter the overall thickness of the cork assembly and, ultimately, the depth of the mute in the bell. (Figures 4 and 5)

Each cork size differs in thickness by a half millimeter, introducing a one-millimeter change in cork-bell contact point diameter with each subsequent size. The range of adjustment is pictured in Figure 6.

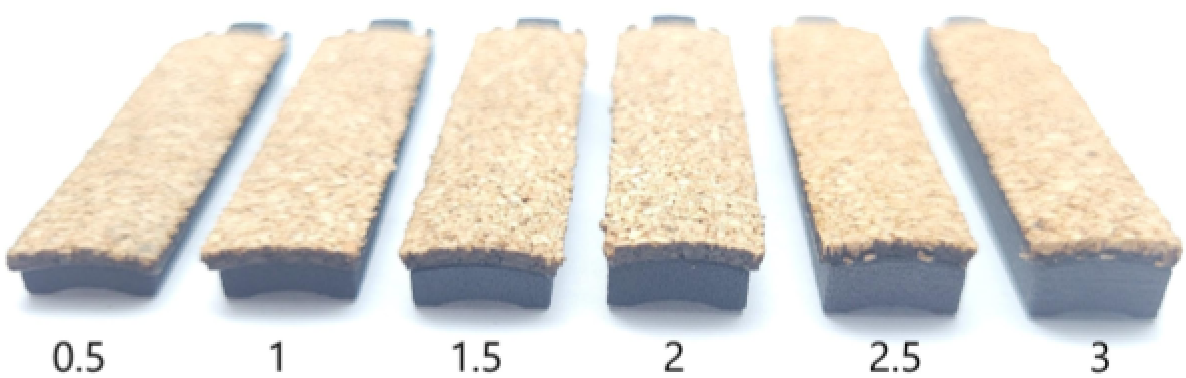

Figure 4.

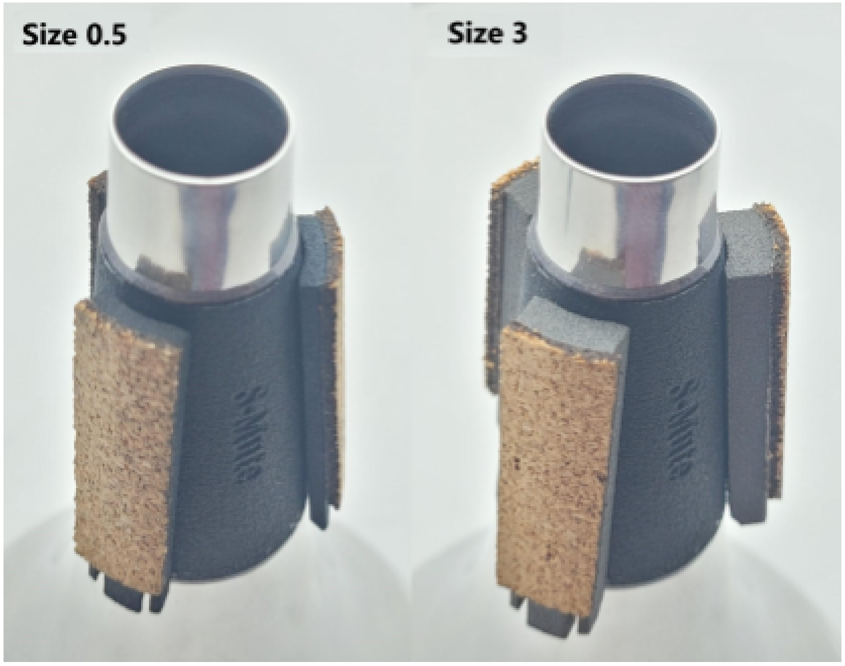

Figure 5.

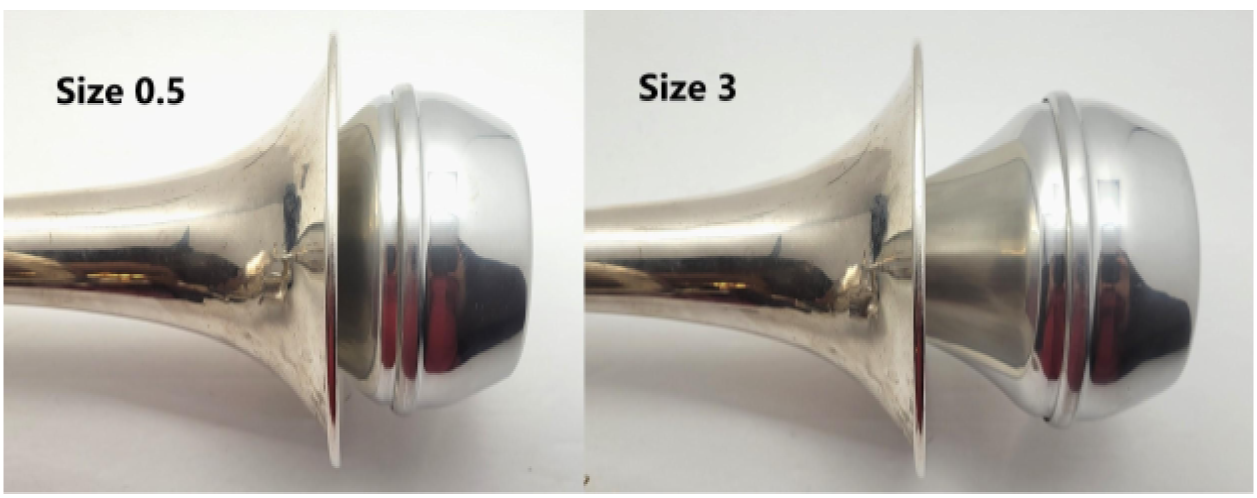

Figure 6.

4. Experimentation

The following experiment involves testing the mute with six cork sets of varying thicknesses. Ten successive pitch readings (F4 concert pitch, 8 seconds duration) are taken for each thickness, then averaged and compared against an unmuted pitch average in Tables 2 and 4. Unaveraged raw data is shown in Tables 1 and 3. Pitch measurements are taken using a commonly available tuning application. Cork sizes are randomly selected and installed by a third party who observes and logs the results.

Tables one and two show the result of this test using a Bach 180S37 Bb trumpet. This table shows a 20.6-cent pitch distortion range (approximately 4hz) between the thinnest corks and the thickest, with size 1.5 or 2 thicknesses closely matching the unmuted pitch center. The player would select size 1.5 or 2 corks in this use case. Original factory-installed corks are closest to size 1, within .25mm, and result in a +3.6 cent average deviation from the pitch center. This is not severe, though also not surprising, given the ubiquitous nature of the Bach 180S37 trumpet and its numerous copies; its bell geometry may have influenced factory cork thickness choice.

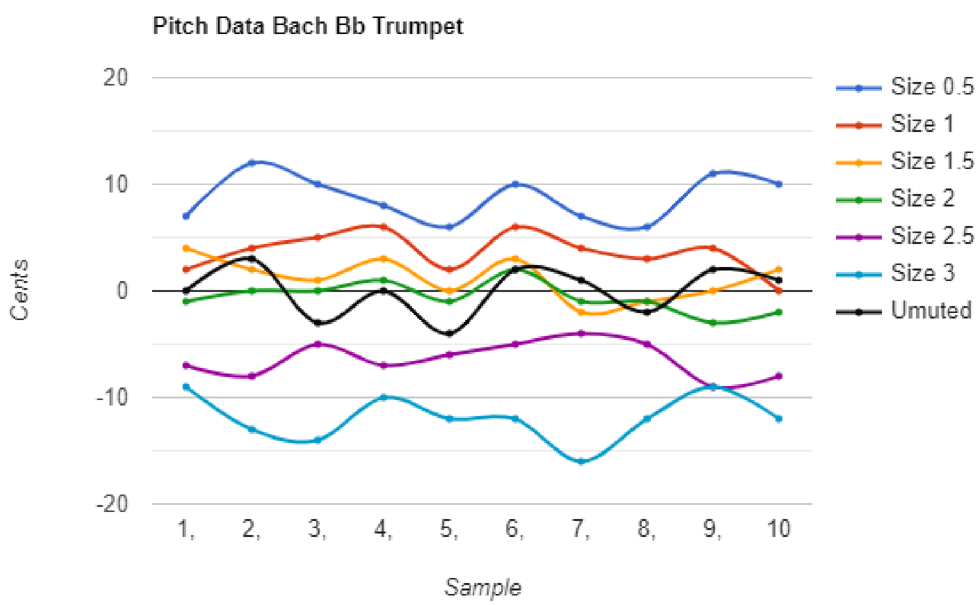

Table 1.

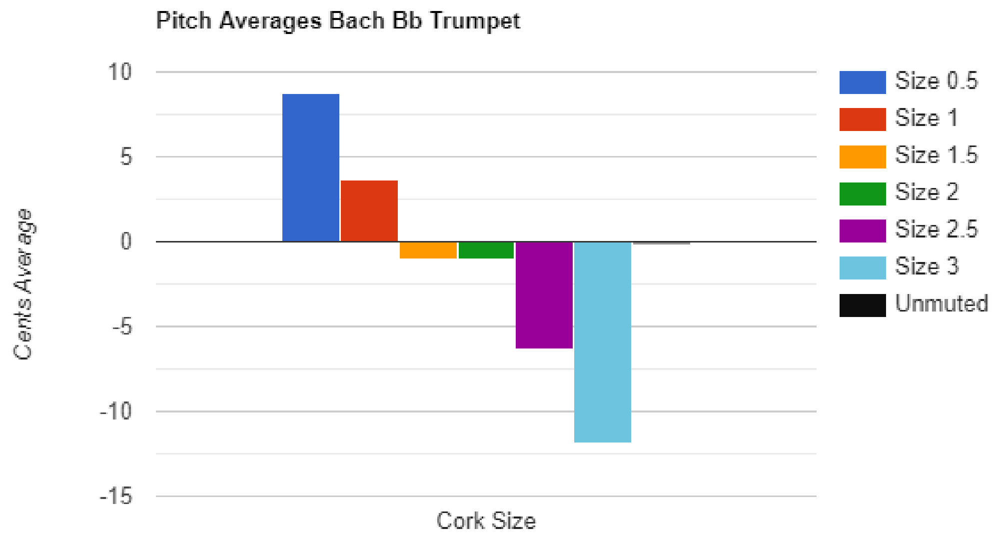

Table 2.

Tables 3-4 show the result of testing with a Yamaha YTR-9445CHS Gen I C trumpet. Data shows a 19-cent pitch range between the thinnest and thickest corks, with size 2 most closely aligning with the unmuted pitch. Factory-installed corks produce an average +9.7 cents deviation from the unmuted average. This is more significant than the deviation with the Bach Bb trumpet. The player would elect for size 2.

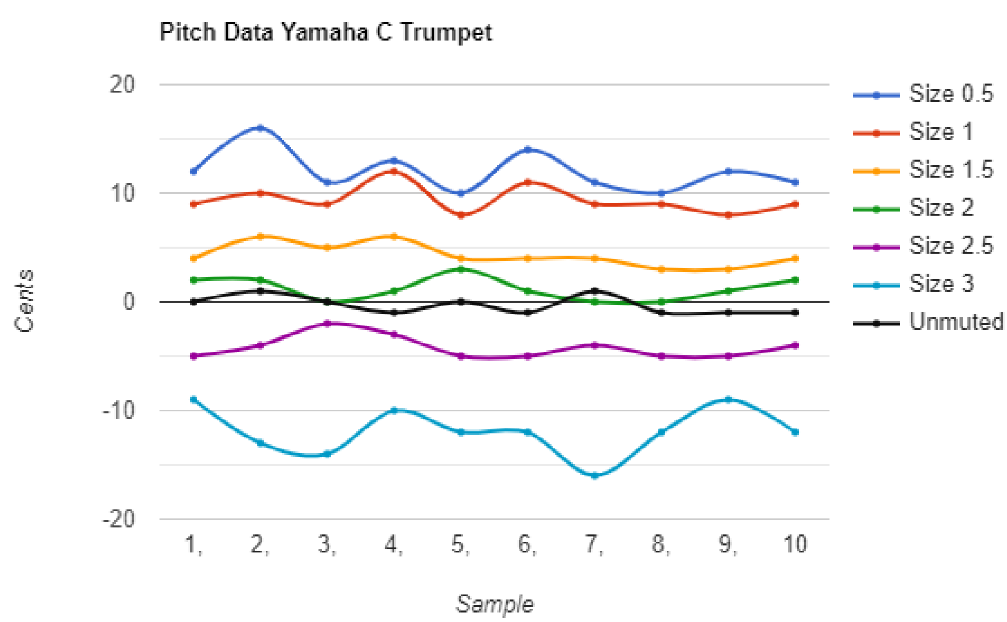

Table 3.

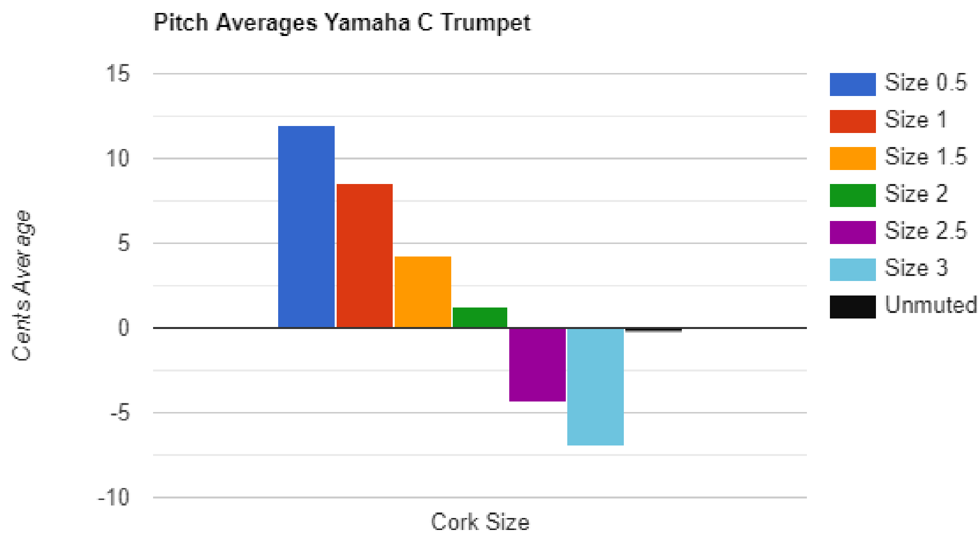

Table 4.

5. Concluding Remarks

This investigation demonstrates a clear need for improvement of the brass instrument mute, related explicitly to cork thickness, and illustrates the utility of the author's proposed patent pending solution. Once installed onto the mute, this cork/rail arrangement allows the instrumentalist to adjust the depth of the mute within the bell and, consequently, the tuning of the muted instrument. This solution also provides for adjusting the mute to various bell geometries, potentially saving the conscientious player hundreds of dollars in duplicate mutes.

References

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