Physical and Perceptual Effects of Heavy Mass Neck Screws for Saxophones

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Introduction

The saxophone is physically separated into three parts: the body, the neck, and the mouthpiece. The mouthpiece is connected to the neck by means of a cork, while the neck fits into the body of the instrument and is held in place by a screw that tightens the body of the instrument around the neck. This is somewhat unique among woodwind instruments, and thus has not properly been considered as a factor that could possibly affect the sound of the instrument. However, a company called Meridian Winds develops heavy mass, ergonomic neck screws, which are advertised as being much easier to twist into the instrument, as well as with the claim that they “may also provide tonal character & colour according to some discerning artists”. This claim was seemingly untested, and so the goal of this pilot study is to determine whether the claim could have any basis in reality that would warrant further testing.

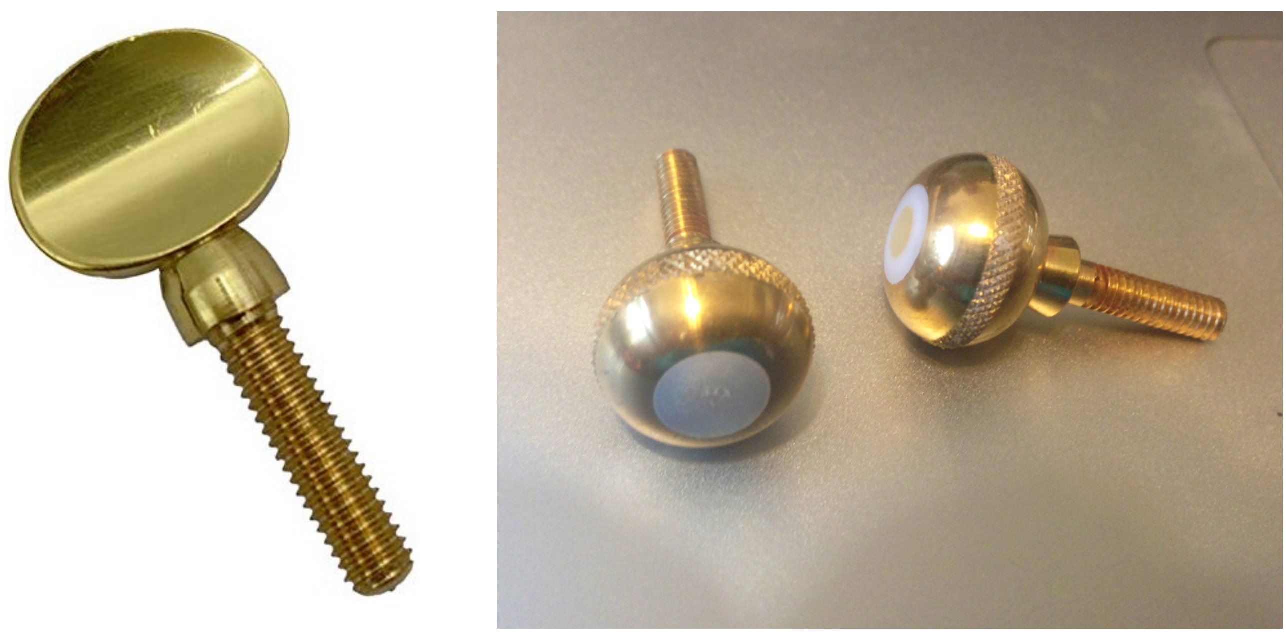

Image: Regular saxophone neck screws (left) compared to ergonomic heavy mass neck screws (right)

At first glance, it may not seem like the screw should have any more than a negligible effect on the tone of the instrument; the screw would probably be at the bottom of most lists of which parts of the saxophone affect the sound most profoundly. However, the screw itself could be argued to have some influence the way the instrument vibrates; the mass of the screw may change any number of things, such as the energy required to form an equivalent vibration. To evaluate the influence that the neck screw may have, measurements of the input impedance of a single saxophone were taken on nine notes of the written B-flat arpeggio, from the bottom of the range of the instrument to the top of the non-altissimo range. These measurements were taken both with the screws that came with the instrument and the heavy mass screws. The same instrument was then used for a perceptual study with four musicians.

Measuring input impedance

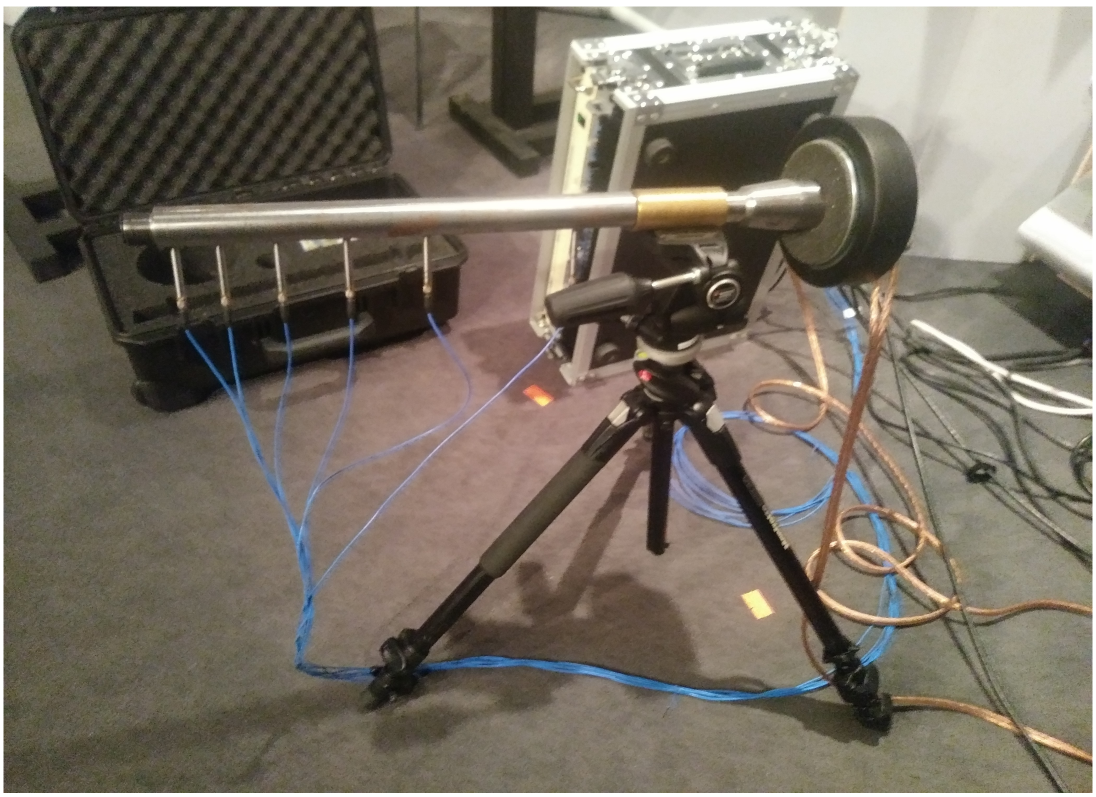

Figure 1: Microphones connected to the impedance measurement device.

Input impedance measurements were taken using a multi-microphone system based on a least-mean-square signal processing technique, as detailed by Lefebvre and Scavone (2011). The setup uses a system of six PCB Piezotronics condenser microphones mounted in an impedance tube at distances of 30mm, 60mm, 100mm, 150mm, 210mm, and 330mm from the input plane, which are then connected to a computer through a signal conditioner and an audio interface, as can be seen in Figure 1. Sampling at 48kHz, the system is excited with a looping logarithmic swept sine tone with a period length equal to the length of the Fourier transform. Responses are averaged together after dropping the first response, using a spectral analysis with 38768 points, resulting in a frequency resolution of 1.46Hz. Any harmonic distortion is removed using the method given by Farina (2000). The pressure spectra at each microphone is used for solving an algorithm using the Moore-Penrose Pseudo Inverse for forward and backward travelling waves (Jang & Ih, 1998), effectively measuring reflectance, which can be converted to impedance.

Figure 2: 2-meter pipe used to simulate a pipe of infinite length.

The device is calibrated with three non-resonant loads with the procedure described by Dickens, Smith, and Wolfe (2007) but the pipe of infinite length is replaced by a 2 meter long pipe, seen in Figure 2, and an additional procedure to time-window the first impulse from the reflections; this simulates an infinitely long pipe, as described by Kemp, Walstijn, Campbell, Chick, and Smith (2010). The instrument is connected to the device by the neck for consistent measurements without the influence of a mouthpiece.

Figure 3: Device connected to Selmer Super Action 80 Series II saxophone.

Saxophone measurements

A single Selmer Super Action 80 Series II was used for this study, as the screws are specifically made to fit the instruments of different instrument-makers, so using different instruments would require much more preparation with the participants ahead of time, and there was not enough time for these preparations to be made. The input impedance of the instrument was first measured with the fingering of an open written C-sharp, and then with the fingerings of each of the 9 notes of the written B-flat arpeggio. The measurements were first recorded for the normal neck screw, then for the heavy mass screw, and then again for the normal neck screw, as it was suspected that a change in temperature had occurred by the time the second set of measurements was taken. Because the accuracy of the measurement gets lower at higher frequencies, the measurements above 5kHz are not being considered.

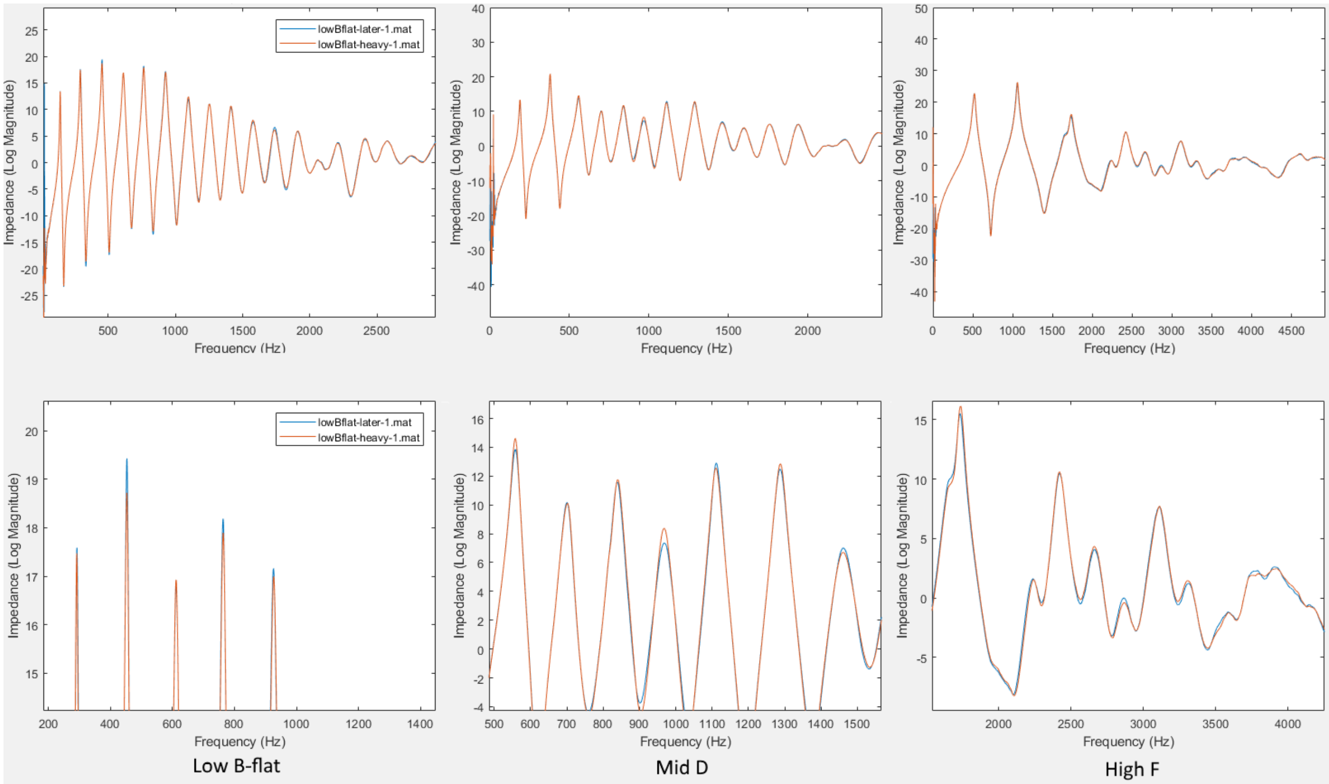

Figure 4:Impedance differences between the two measurements for a low written B-flat, a mid written D, and a high written F. Blue always represents the normal screw, and red always represents the heavy.

Figure 4 shows some comparisons between the later measurements done with the normal screws and the measurements done with the heavy screws. The results of the measurements are not conclusive on whether a difference exists. There are slight differences in input impedance at the peaks and valleys of the measurements, but all of these differences fall within 1dB, and as such could be explained by measurement error, because the method used has a range of error of at least 1dB. Therefore, the difference, if it exists, is small. As well, because all of the fingerings tested have differences that fall within the range of measurement error, it is impossible to say whether different notes are affected more, so despite the fact that input impedance was measured for many different fingerings, there is no usable difference in results between the fingerings recorded. Therefore, it can be concluded that any such difference that might exist is mostly insignificant.

Perceptual study

Four skilled saxophonists took part in this study (all having at least part of a university-level of training). Two normally played Yamaha instruments, one normally played Selmer instruments, and one normally played P. Mauriat instruments. The experimental session lasted between 15-20 minutes, with the experimenter either present in the room to facilitate the procedure or just outside the room to change the screws. The participants were first presented with the saxophone with its regular neck screws, and were made aware of the fact that its regular screws were in. They were asked to play the instrument using their own mouthpiece and reeds until they were comfortable rating three different aspects of the instrument compared to their normal setup, those being brightness, ease of play, and evenness of tone across the registers. The rating was fixed on a scale of -5 to 5, with 0 being their setup, although the degree of change was left for the participants to infer for themselves. After they completed their ratings, they were asked to put on a pair of sunglasses, and the lights were dimmed so that they could not see the screws in future tests. The saxophone was removed from the room, and the experimenter either replaced the screws with the heavy mass screws or waited for a length of time sufficient to give the impression that the screws were changed, so that the participants would not know whether the screws had been changed. The participants were then asked to play the instrument again for long enough to determine whether they noticed a difference in any of the three previously-mentioned qualities compared to the previous trial, and if so, to re-rate the qualities, but setting the qualities of the first trial as the 0 reference point. This process was repeated for two more trials, for a total of two trials with the normal screws and two trials with the heavy mass screws.

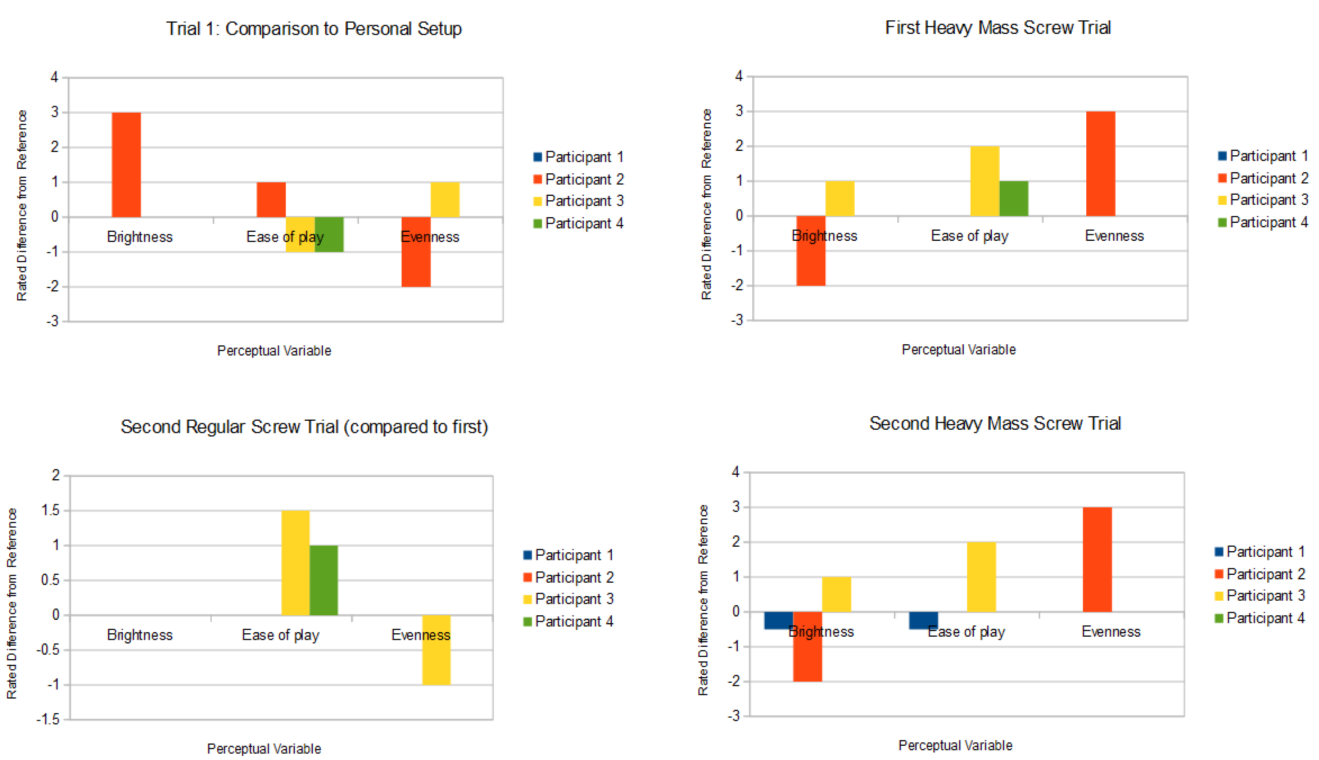

Figure 5: Results of perceptual test. All trials other than trial 1 were rated in comparison to trial 1, while trial 1 was rated in comparison to the player's own setup.

Figure 5 shows the results of the perceptual test. The results were somewhat scattered. Two participants noticed drastic differences between the tests with regular screws and the tests with the heavy mass screws, while the other two noticed little to no difference. Additionally, the two participants who noticed larger differences noticed the differences as being almost entirely opposite to one another; one participant noticed an increase in brightness and ease of play, while the other noticed a decrease in brightness and an increase in evenness of tone. The other two participants only noticed very slightly changes in brightness and ease of play, and these changes were not consistent.

One possible explanation for these inconsistent results is that the two players who noticed the most difference were also the two players who rated the initial setup most different from their normal setup. This could imply that their perception of the effect of the screws was already skewed because they were in unfamiliar setup territory. Because of the inconsistent results, it cannot be concluded for certain whether the heavy mass screws have a noticeable perceptual effect on the brightness, ease of play, or evenness of tone. One possible follow-up would be to work with saxophonists ahead of time to acquire screws for their particular instrument and make sure they fit properly, then perform the trials with them on their own setup to increase consistency.

Conclusion

Due to measurement error, it cannot be conclusively determined whether the heavy mass neck screws have a measurable effect on the acoustical qualities of the saxophone. Because of this, even if there is a difference in the input impedance, it is likely that such a difference is insignificant.

A perceptual study performed with 4 musicians generates widely varied results, with two musicians finding very little perceived difference between the test cases, while the other two found partially opposing perceived differences between the test cases. These differences could have been due to some form of skewed perception, as the two musicians who reported significant differences also reported the most difference between the test setup and their personal setup. More testing would be required in order to reach a conclusion on whether the screws have any effect.

References

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