



Brass Instruments

Physics of Brass Instruments

Trevor

How much of the sound is down to the player and how much of it is down to the instrument that he or she is blowing through.

Murray

The fact that the sound is basically generated by the lips of the player and that's where it all starts is the really crucial thing here I think because the player's lips, in my view, play a much more important role in the co operation with the instrument than say the reed of an oboe does in the co-operation with the air column of the oboe. The player can really control and change the sound very much just by what the player does with their lips. And in fact some players can make almost any kind of instrument sound with their characteristic sound, however good or bad the instrument is. However it's obvious that a really good player is trying to constantly push the bounds of possibilities on the instrument and develop new techniques and so on and for that purpose a really good player needs a really good instrument.

Trevor

If I was a very rich man and I could give you lots of money to go out and buy a brand new instrument lets say a B flat trumpet what would you do to test whether that instrument is the instrument that you would be buying? What is it that you look for in a good instrument?

Sandy

There are two things that I think are most important when we are choosing an instrument. Intonation the tuning of the notes of the harmonic series um and the second is the response. It's basically how sensitive that instrument is to the way that I am playing. So if I aim for a particular note I feel that the note is speaking easily with the least amount of effort.

Trevor

What is it that affects the timbre of an instrument apart from any qualities an individual player has why is it that two instruments of the same pitch sound different.

Murray

When you buzz your lips into a mouthpiece you're generating quite a complex disturbance of the air in the mouthpiece. It's a periodic vibration, a periodic variation of the air pressure which is rising and falling regularly but it's not a simple sinusoidal variation, it's got quite a lot of harmonics in it and so each of these harmonics is sent down the tube and has the possibility of interacting with the resonance of the air column. In a well-designed brass instrument these resonances are members of a harmonic series and so each of the harmonics you send in from the lips can find a partner in the air column and sort of interact with that and build up a strong rich standing wave. But if the instrument is not very well designed some of these might be out of tune and then the interaction will not be as successful, the sound will not be as rich. However the shape of the air column also affects the strength of the resonances and so for example in a widely flaring tube the lower resonances are particularly strong and therefore the lower frequency harmonics you put into from the lips are preferentially amplified and give a very mellow sound.

On a tubing which is much more narrow for a lot of its length like the traditional natural trumpet for example which is cylindrical over more than half the length, the upper harmonics are relatively strong and the lower harmonics are relatively weak and that means that the sound is much more brilliant but lacking in some of the mellowness you get from the wider flaring tubes.

Trevor

There's an interesting question about whether or not the materials a brass instrument is made of actually matter.

Murray

For many years scientists have been trying to find out whether the materials of the walls of the instrument affect the sound and many interesting experiments have been done. And what these have shown is that there is a small measurable interaction between the pressure variations in the air column inside the instrument and the vibrations of the walls. But the amount of sound energy, which is radiated by the walls, is very tiny in comparison to the sound which comes out through the end of the instrument - through the bell.

And as a result it's very dubious whether that tiny amount of extra sound energy is actually audible by a listener. So many tests have been done to try to establish this and the scientific jury is still out on that question.

Trevor

Why brass instruments then, because brass has been used for centuries as the basic material.

Murray

The fact that brass instruments are made of brass I think is down to several very straightforward reasons. One is it's an easily available material. It's cheap and it's malleable, it's easy to push it into the rather complicated flaring shapes, which you need for a well-designed brass instruments. But instruments have been made from other materials of course, from copper and silver and players often think that a different material such as silver or copper makes a big difference to the sound. But scientific tests have been struggling to actually demonstrate a measurable difference.

Trevor

How do players control whether the music they're playing is loud or quiet?

Murray

This is an interesting question that we've been investigating with some of our experiments with artificial lips and what we have found is of course what players know, that the basic control that you have is the pressure that you exert - the pressure which comes from the lungs and is in the mouth. If you start by blowing very, very gently with your lips in a fixed position, at first you don't make a sound, you only hear a gentle hissing noise as the air goes between your lips. But then at a certain critical pressure threshold the lips spontaneously start to vibrate, opening and closing and generating a quiet sound in the instrument. And then as you increase the pressure, the amplitude of the opening and closing of the lips gets bigger and bigger and the amplitude of the sound gets louder and louder.

The main reason why I'm doing research into brass instruments is that I am both an acoustician and a brass instrument player and therefore my innate scientific curiosity about the things that I do, led me into research into brass instruments. But there's a more general point, that the interaction between the lips of a brass player and the instrument, is a very interesting interaction from the scientific, as well as the musical point of view.

It falls into a class of scientific studies, which we describe technically as non-linear dynamics and that's an area in which there's a lot of current research interest.

The way in which the player can control the sound of a brass instrument with the lips is fascinatingly complex and not scientifically understood fully.