Well Tuned Brass 2020

Interview with Robin Hayward, joined by Paul Schwingenschlögl at the end.

Conducted by Thomas Glaesser

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Thomas:

Let's start with the microtonal tuba, how does it actually work, how does is produce sound?

Robin:

Independently of it being a microtonal tuba, the way all brass instruments work is that you blow in one end and the sound...

(laughter, Robin plays a pitch)

Robin:

The slightly more technical description is that there's actually a standing wave formed within the instrument, that's the case not just with the microtonal tuba but with every brass instrument.

Thomas:

Its formed because something is vibrating...

Robin:

Exactly, what's actually happening is that the lips are buzzing...

(demonstrates lip buzz)

…and they are the oscillator of the system, and what is actually resonating is not the lips but the standing wave within the instrument. What we hear is actually a very small percentage of the intensity of that standing wave, what we actually hear is the inefficiency. If it were completely efficient, every time I go...

(buzzes)

…I am sending little pules of air through the instrument, very fast. What happens is that those pulses go to the open end of the instrument. If I have a tennis ball and I bounce it against a wall, it bounces back. This is essentially like a wall except that its an open wall. What's happening is that the pressure impulse goes to the end of the tuba and it also bounces back. It bounces back phase inverted, in the oppostie phase direction. It comes back and it hits the lips, which act as the hard wall, and then the next impulse goes out. This forms a feedback loop, this forms the standing wave. What we hear s about five percent of the intensity of what's actually in the instrument. So its due to the inefficiency of what goes into the room, what doesn't go back into the tuba. I don't want to get too technical about this but it maybe a good thing to have some idea of how brass instruments work. What's actually happening is that because my lips are a hard wall, you've got maximum pressure fluctuation at the mouthpiece end. The technical term for that is called "input impedance", because its the input of the instrument. If you imagine that you're pressing up against a wall, what's happening is that the molecules of air get stuck because they can't go through the wall, they can't go anywhere and therefore the molecules are not moving but the pressure intensity is changing. At the other end of the tuba its completely the opposite because its the soft wall, you have minimum pressure fluctuation and maximum velocity fluctuation. This is actually why we hear the sound, because its what makes the air vibrate within the room.

Thomas:

What about the tonal organisation of the tuba?

Robin:

Yes what I just played is called the fundamental pitch. There are different standing waves which can be formed within the tuba or within any brass instrument, according to how fast the osciallator is moving.

(demonstrates buzzing with different pitches)

This produces different pitches. The fundamental pitch of the F tuba with no valves pressed is this.

(plays pedal F)

That's the bottom F on the piano, but if I change the lip pressure I can then play the octave above.

(plays an F one octave higher)

What's happening here is that there's a maximum velocity here and also maximum velocity half way along the tube of the instrument, of course we can't see it. Putting it very simply – there are two standing waves within the instrument which are now each half the length of the full standing wave which was before. Its not quite as simple as that because actually only half a wave fits within the instrument, the actual wave continues to twice the length of the instrument.

Let's pretend that this pedal F is 100 herz, so its vibrating 100 times per second, its actually not but I'm pretending it is because it makes the maths much more simple to understand. If this was 100 herz:

(plays pedal F)

And I multiply that frequency by two, so think of the standing wave – I now have two standing waves – I get double the frequency.

(plays F one octave higher)

You can probably hear that that's an octave above the fundamental frequency. If multiply the fundamental frequency by 3, I get to the third harmonic, partial:

(plays a C)

So you can hear the first:

(plays pedal F)

The second:

(plays F one octave higher)

The third:

(plays C)

If I multiply the fundamenal by four, I get the fourth:

(plays F another octave higher)

By five:

(plays the fifth partial A)

By six:

(plays the C one octave higher than the previous C)

By seven:

(plays the 7th Eb)

By eight:

(plays F another octave higher)

So if you think of the wave in the instrument, you've now got 8 standing waves all vibrating within the instrument, pressure nodes and anti nodes within the instrument.

Thomas:

We could quickly try to hum the first four partials together.

(audience hums them while Robin plays tuba)

Robin:

What we actually just sung and played is the beginning of what's called an overtone row, or a harmonic series.

Thomas:

So that's the basis of how a brass instrument is tonally organised.

Robin:

Yes.

Thomas:

The natural tone series, how it unfolds through the overtone series.

Robin:

Exactly.

Thomas:

But then you also have valves...

Robin:

Yes. This is an invention of the early nineteenth century, actually 1814, actually in Germany. A horn player called Stölzel wanted to find a way of changing between different crooks quickly. Natural horns which were the only horns available before then could only play the harmonic series, and the horn player could change the tuning by altering the position of the hand within the bell. You could have a horn with a different crook, a crook is a slide, so its essentially like a valve slide, like this:

(shows valve slide)

Which goes on the main slide and you could have crooks for different lengths, so you change the horn from being an F horn into a Bb horn into a C horn etcetera.

Thomas (to audience):

Maybe you realised when you were humming that the distances between the natural tones get smaller as you go along the partials, so when you don't have valves and you want to have a differentiated melodic use of brass instruments you have to play in a very high register.

Robin:

Yeah. This is why in the "Christmas Oratorio" which Bach did, the high trumpet thing is very very high because they couldn't have played those melodies lower on the trumpet.

Stölzel invented the valves initially as a way of changing crooks quickly, so rather than having to take out the crook and put it back in, you can simply press the valve and convert it to being, in this case an Eb tuba:

(plays F pedal, then Eb)

I was pressing the first valve, or an E tuba:

(plays pedal E)

by pressing the second valve.
Thomas:

So basically the valves are extending...

Robin:

They're adding lengths of tubing, so you see here's the first valve and if I don't press it the air goes striaght through here, and if I press it – the air is diverted and goes through this tube, and it goes back through here and that makes the fundamental tone lower.

Thomas:

Its basically filling out the spaces betweeen the partials

Robin:

Yeah.

Question from the audience (Jasper Stadhouders):

A regular tuba has four valves – right?

Robin:

Different tubas have different numbers of valves. This is actually a standard German tuba and they do often come with six valves, just like this one. Its five or six usually. The English tuba usually has four, that's a different system.

(technical question from Thomas)

The function of the valves until people started using them for microtonality has always been to approximate the twelve chromatic pitches of the piano.

The tuba was actually invented here in Berlin in 1835. The patent is for the "Chomatisches Bass Tuba". After the valve was invented there was a whole spate where they built different instruments, the tuba was just one of them. The patent is actually still here in Berlin in the Geheim Archiv (the secret archive) and its very clear that that's his aim. There's actually a contradiction in trying to do that, because when you combine valves you get this thing called the subharmonic series, which is the inverted harmonic series. Another name for it is the "undertone row". What I played at the beginning, going up, was the overtone row. Now I'm going to play an undertone row. It's the same thing, its just turned on its head. So rather than starting low and multiplying by one by two by three by four, I'm starting high and I'm dividing by one which is where it starts, by two which is the octave below that, by three which is the fifth below that.

(plays a subharmonic series, dividing by 1 to 8 to land on the fundamental)

The reason that the valves, actually on any brass instrument, most brass players don't know this, they'll always play the subharmonic series – because if I then press the first valve, I can then create the ninth subharmonic, that's actually what it does, so I've gone to the eighth subharmonic:
(plays eighth subharmonic)

I divide by nine, the first valve.

(plays ninth subharmonic)

Divide by ten, this wouldn't work on a normal tuba. What I've done is lengthened the third valve length, so the third valve is now divided by ten:

(plays tenth subharmonic)

I combine the first and the third valve and divide by eleven:

(plays eleventh subharmonic)

The fourth valve, which I've also elongated – it goes to twelve:

(plays twelth subharmonic)

The first and the fourth go to thirteen:

(plays thirteenth subharmonic)

The third and the fourth go to fourteen:

(plays fourteenth subharmonic)

The first, the third and the fourth go to fifteen:

(plays fifteenth subharmonic)

All six plus the trigger on the microtonal tuba go to sixteen:

(plays sixteench subharmonic)

This is actually the lowest note on the instrument, officially – you can lip a bit lower than that. That's the F below the lowest pitch on the piano.

(request from audience to play the low F again, plays low F)

Its actually even clearer if I play it with the tongue, you can really hear, this is actually 21 herz, its just between where you can hear pitch and where you start to hear noise, so if I use the tongue instead of the lips to be the oscillator:

(demonstrates tongue oscillator)

You can really hear each pulse of air. As I said at the beginning, its sending pressure waves which go to the bell and are inversely reflected back. You can very clearly hear the pulses:

(demonstrates tongue oscillator again)

Which are becoming a rhythm.

That's why valves which are on all brass instruments actually create a subharmonic series. For two hundred years its been seen as a terrible problem, because it means that the instruments are not tuned according to the piano. Because the piano has become so dominant in Western musical thinking and because the nineteenth century was the century of Western imperialism, it became the dominant thinking throughout the world almost, the piano has become extremely dominant in the way we think about tuning. When I studied classical music – "in-tune" – was always in-tune with the piano. Therefore because the valve combinations of brass instruments create a subharmonic series which is out of tune with the piano, there's lots of different devices invented to try to get the valves to behave themselves and get in-tune with the piano. All the microtonal tuba does is take the valve combinations to their logical conclusion, which is to create a subharmonic series. When I first discovered this, it wasn't just the prospect of being able to play microtonally, it was the beauty of the fact that brass instruments are based on the overtone row, then you add valves and you create the undertone row, so there's symmetry there, and there's something very elegant about that. That's the reason why I dug into this idea. I was very frustrated about playing tuba normally!

Thomas:

You had to make some adjustments though?

Robin:

Oh yes. I mentioned that the third and fourth valves are elongated, so the third valve usually lowers the pitch by a minor third, which is almost equivalent because its a slightly larger minor third than the first and second valves. I'll play a little higher to its clearer:

(plays a descending minor third)

The third valve of the microtonal tuba is elongated so it becomes a major third:

(plays a descending major third)

The fourth valve on a normal tuba lowers the pitch by a perfect fourth:

(plays a descending perfect fourth)

On the microtonal tuba, you can see there's a loop here, its adding extra tubing, it lowers it by a fifth:

(plays a descending fifth)

That's why when I was playing just now, I could play each of the steps of the subharmonic series. But that was only using three valves, until the very lowest one. By adding the smaller valves you can essentially start from an ever higher F, so rather than starting from:

(plays a high F)

I start from:

(plays another F, an octave higher)

That's one of the highest pitches of the instrument. I can then... actually I'll see if I can play it:

(plays subharmonic series from the highest F)

That's the first sixteen tones of the subharmonic series, when I press the second valve, I get the seventeenth:

(plays seventeenth)

Eighteenth:

(plays eighteenth, then nineteenth)

Nineteenth etcetera...And I start from the F an octave higher than that, which I can't play on the tuba – this is where the other valve alterations come in because I've now tune the fifth valve, which is usually a long first valves, its usually a large tone valve, it lowers the pitch by a major second – I've now retuned it to lower it by a quarter tone, so half the length of the second valve. So if I'm starting from an even higher F and I get down to my, which will now be the thirty second subharmonic:

(plays thirty second subharmonic)

Thiry third:

(plays thirty third)

I'll play an octave higher, so its easier to hear. Thirty second:

(plays thirty second)

Thiry third:

(plays thirty third)

Thirty fourth:

(plays thirty fourth)

And I keep going down:

(plays going down)

I've gone from the thirty second to the sixty fourth. The next valve adds half a length of tubing...

Thomas (interruption):

Robin, let's er...

(audience laughs, somebody shouts "keep going!")

Thomas:

For those who couldn't follow aurally, there's also a visual opportunity to catch what's going on. I also want to slip in a little "ehrenrettung" for the piano, its not only an imperialist disgrace, its actually also trying to solve a problem, laying out... the natural tuning doesn't quite add up...

Robin:

It does.

(laughter)

Thomas:

…to be put on a keyboard like that.

Robin:

It can, its just that you can't change key, that's the problem. What we know as the equal tempered piano is not the well tempered piano that Bach, well he didn't use piano, the keyboard, there were different temperaments. It was much more interesting in Bach's time than it has become in our time.

Thomas:

And they actually sound better, but all these tunings are grappling with a real world problem that's not so... there's different solutions that attempt to solve this.

Robin:

Yeah.

Thomas:

Of course it adds up in the natural partials.

Robin:

Exactly. Before we move on I'm going to jump ahead to explain the microtonal tuba to the end. I'm not going to go through all the subharmonics, but through the addition of the sixth valve and this slide on the thumb – I can then glissando throughout the whole range:

(demonstrates glissando)

Like a trombone I can reach every pitch, that's what makes it fully microtonal. All that's doing is taking that subharmonic idea to its logical conclusion.

Thomas:

To keep orientation in that maze, Robin actually created this maze here called the Hayward Tuning Vine.

(points to screen with projection of tuning vine software)

Its a software you made. Maybe we can just have a look.

Robin:

Yes.

Thomas:

Also the ensemble is working with that grid which we see there, with a black dot in the middle. What is that?

Robin:

This is, in just intonation its called the one to one, and actually all the tuning vine is, is a visualization of what I've just been talking about. Because it gets very quickly very mathematical, your multiplying and dividing, and you have work out where you're multiplying and dividing from. This was a way of limiting the palette so you can actually see the most harmonically significant relationships.

(Robin then gives a detailed explanatoin of the tuning vine software, demonstating the harmonic and subharmonic series etc)

One of the things I've noticed after dealing with this system is, you then hear a piano and it sounds incredibly out of tune!

(laughter)

(Robin explains further and comes to a 13/11 interval, one of many possible minor thirds of which Robin's piece "Alpha Centauri" is based on)

Thomas:

You call it a third?

Robin:

A minor third...

Thomas:

Its a special minor third?

Robin:

Yes.

(Robin demonstrates more examples also talking about the mean tone system used in the Renaissance organ of Ellen Arkbro's piece "For Organ and Brass", then talks about summation and difference tones, and details about "Alpha Centauri" – a piece which drifts through harmonic space and the name of a binary star system, two stars rotating around each other and a third one – in the piece two instruments play a diad and the third instrument creating different perspectives, moving around the space. Followed by a further demonstration of summation and difference tones after a question from the audience).

Question from the audiece:

How do you use the software?

Robin:

I use it partly as a way of teaching myself because I am actually not very good at maths, I find it very hard to keep these numbers in my head. I developed the microtonal tuba which opens up essentially an infinite harmonic space. I'm not very quick with algebra, but I'm better at geometry, so this is essentially putting the algebraic information into geometric form. Its originally a three dimensional sculpture made with a children's toy called "Zometool", which is for children to model multi-dimensional space like planetary systems or molecules, or DNA. It was actually by accident – the "aha moment" came, I was modeling it with octaves... the octaves were going up and the fifths were going like this and I was thinking – I wanted to make hypercube essentially, and as I was messing around with the sculpture, I was rotating it and I suddenly saw that I could actually align melodically and that's the thing which makes it so intuitive, because the higher you play on the tuning vine, the higher the pitch actually is. So I use it partly to teach myself, I also use it to play along with and we use it when we're rehearsing. I also use it to compose with, "Alpha Centauri" was composed with this software. I could never have done the mathematics which are inherent with all this rotation. If you were to ask me to do this operation:

(plays tuning vine)

If you are to ask me to describe this algebraically, I would have absolutely no idea. Whereas here's its quite simple, I can see that its going from overtone to undertone but what relation is between them, the pitch its hanging from and the pitch it was built on, this enables me to understand it intuitively.

(more technical questions from the audience)

(Robin then demonstrates some different minor thirds with the tuning vine – 13/11 compared to a renaissance minor third – 6/5, then a renaissance major third. The audience then hums a 13/11, and then a 6/5, then back to 13/11, then a blues minor third – a 7/6, then a second – a 9/8, then a blues minor third again, then a 19/16 which is very close to a tempered minor third on the piano, then back to 13/11, then a 6/5, then a 16/13 which is a neutral third between a major and minor third).

Robin:

One of the things that I love about just intonation is that you suddenly don't just have one third to choose from, one minor third, you've got all this palette to choose from.

Thomas:

What's the connection between "Alpha Centauri" and the other piece you're going to play, "Blue Brass"?

Robin:

"Alpha Centauri" wasn't inspired by the blues at all but when we were playing it we noticed that some of the chords sounded really bluesy. This interval does occur, as a result of looking at the potential of the other intervals:

(plays a minor third on the tuning vine)

That's the blues minor third but even the 13/11 is a flattened third. So we wanted to make a collective piece called "Blue Brass" and we then took three of the most bluesy sounding chords within "Alpha Centauri" and used them as a basis for our improvisation, which is actually going to be the premiere of tonight. We've invited Paul to play along with us. Paul is much more a blues musician, I'm not a blues musician at all, but you come from blues and jazz.

Paul:

Yes and the blues plays an important role in jazz. But I listen not only to jazz but also to blues in various musical styles. Actually it started you could say with the blues scale, the minor third, the minor seventh. Stylistically it developed then into many different directions. But already the early blues singers had their special intonation, their scale, and they didn't think about it, it was just by intuition that they came up with this. Often they accompanied themselves with the guitar, a string instrument – rather than with the piano. With the guitar you can bend the strings, its much easier to blend this with the singing. Then later on came brass instruments and also saxophones. Those players often didn't have a classical training, for them it was quite natural and they didn't think about what they played. In the Sixties blues became a big influence in rock music or in singer songwriting. I myself have played in different contexts with blues musicians but also with jazz and bebop musicians who have a very particular approach to blues which is totally different from singers who often stick to the early blues form and stay with it.

Thomas:

If I gather correctly from listening to blues, there's a flexibility in a lot of the intervals.

Paul:

Yes, especially the third. I'll show two ways of playing the C blues scale. If a European classical musician would play it, he would play it like this:

(Paul plays a C minor pentatonic scale in "European" style)

Now I show you how a blues musician, one who had no classical teaching, would play it:

(plays the same scale in a more "bluesy" way!)

Actually its not only the way of playing the instrument. Those musicians thought of themselves as being singers, they didn't think of playing some notes, they just used their instruments as an extension of their voice. The earliest blues recordings are from singers and then the instrumentalists, with whatever instruments, adapted this singing style.

Thomas:

You bring on board a lot of flexibility now in the tuning, into something which seems quite neatly arranged. How does that work out?

Robin:

I remember asking Paul about the blues third, because I've often thought that its not just... I mean if you read... well, I read that this is the blues minor third:

(plays a minor this on the tuning vine)

…but actually I often hear this as well, more of a neutral third:

(plays a neutral third on the tuning vine)

When I was discussing it with Paul – you told me that its quite often that the third is actually raised. Its not only lower, its also raised.

Paul:

Yes, there are both possibilities.

Robin:

There's two differing ways of approaching it. This is a mathematical way of approaching it. There's also a very embodied way, an intuitive way, because our ears have evolved to be able to hear this. Because our ears have evolved to understand speech and spoken vowels are simply filtered overtones. So we can hear all of this intuitively, which is probably why these musicians who weren't brainwashed by the piano tuning, automatically started singing, using the expressive potential within this.

Thomas:

How exactly does the combination of Paul and Zinc & Copper work in "Blue Brass" and how's the piece arranged?

Robin:

Its simply three different chords from "Alpha Centauri", stretched out, each chord is four minutes long and then the first chord comes back at the end, so its fifteen minutes in all. Paul is the soloist. He's got a detuned pentatonic scale, based on the "Alpha Centauri" chords, and we're accompanying Paul essentially. Its actually going to be quite a surprise for us, because we've had a look at it today but its pretty fresh, so we're going to be exploring today.

(final humming exercises with the audience and tuning vine, going between a blues lowered third then a 16/13 – a raised minor third)

Thomas:

Would you object if anyone feels obliged, or compelled to hum along when you're playing?

Robin:

I wouldn't "object"... but try to do it in-tune!

(laughter and applause)