The sound of silence
Recreating sounds

Janice
Alan's told me that instruments sound different, because of the mixture of harmonics that go with the fundamental. I've got a recording of his saxophone here, a sound I want to recreate. So I've come to Anglia polytechnic university, which teaches music theory, to meet **Richard Hoadley**.

Richard Hoadley
Thanks Kevin. Now, I'd like each of you to use your keyboards to try and reconstruct some of the complexities of those sounds.

Janice
Hi Richard, I've come to join your class, I hope you can spare a moment. Here I've got the sound of a real sax that we recorded earlier, and I'm hoping you can show me how to reconstruct the sound.

Richard Hoadley
Aha. Right if you'd like to play it, I'll transfer it into the computer. and here's what it sounds like.

SAX NOTE

Richard Hoadley
In order to understand what the sound is made of, one of the most important things to do, is to look at the frequency analysis of the sound.

Janice
Right so here you've got what amplitude against frequency.

Richard Hoadley
and each of the peaks you see represents the fundamental, and the subsequent harmonics, that together make up the sound of the note.

Janice
and this is showing you how much you've got, you know the fundamental and how much you've got of a different separate harmonics.

Richard Hoadley
That's right.

Janice
So from this is it possible to

actually reproduce the sound?

Richard Hoadley
Yes. Adding harmonics together like this is synthesis, and I've a demonstration of it, which will take a moment for me to set up with my students.

Richard Hoadley
Right, that's all set, and now we can hear the result of putting allthat together.

Janice

Okay.

Richard Hoadley
Right so, this is where we can hear the sound. So this is the fundamental from my work station, this is the second harmonic.

Janice
So it's getting more and more complex.

Richard Hoadley
That's right. and so on, until we have them all. But you don't have to hear the effect like that, you can see it happening.

Janice
Right so on the screen there, that first trace is the fundamental.

Student 1
Yeah. and that's also known as the first harmonic, and that sounds like this. and then you've got the second harmonic just below it, and that sounds like this. and then finally.

Janice
Got both of them together there.

Student 1
Yeah, just at the bottom of the screen. and, that sounds like that, and that should be on the next work station.

Student 2
So the first and second sound like this. and if you add the third, you get this.

Student 4
and the next step is to add the fourth harmonic.

Student 5
What I'm going to do here is add the fifth harmonic. As you can see it's smaller because there's actually less of this harmonic around, and then we'll add it to the other four, and we've got the end result just here.

Student 6
I'm adding the sixth harmonic.

Student 7
We're now adding the seventh harmonic here, and by combining them all together it sounds like this.

Janice
Well it's sounding much better Richard, but there's still a lot missing isn't there.

Richard Hoadley
Yes, a lot of the higher frequencies that you'd normally expect in sounds aren't there.

Janice
So that's a bit like the mobile phone scenario isn't it, there's the higher frequencies are missing there.

Richard Hoadley
Yes.

Janice
Can I just play you some recordings I've got of Alan's voice.

Richard Hoadley
Certainly.

Janice
This is what he sounded like, with his natural voice live.

Alan Graham
Hello **Janice**.

Janice
and then this was the mobile phone voice.

Alan Graham
Hello **Janice**.

Janice
and they sound quite different.

Richard Hoadley
and if you do a frequency analysis of each recording, you can see.

Janice
Right, you can see that they're very different here. Now this is, the natural voice, and this is the mobile phone voice, and here you've got amplitude against frequency, and the bottom frequencies are missing, and the higher frequencies are missing on the mobile phone voice, but you can still get the essential information.

Richard Hoadley
Yes, on a phone you can still hear what the, what the words mean, but it's much more important with music, to experience as wide a range of frequencies as possible.

Janice
So if we put back in the higher frequencies, will we actually get the sound of a real sax note?

Richard Hoadley
We'll get something that increasingly sounds like a real instrument, but you'll still be missing many of the characteristics of a human being playing a live instrument.

Richard Hoadley
You'd be missing what the player does at the beginning of the note or its attack, what they do while they're playing the note, or it’s sustain, and what they do at the end of the note, or its decay.

Janice
Can you actually show me that?

Richard Hoadley
The sax note that you brought over looks like this, and I can play it to you, but it has no attack or decay on it. I could put some very simple attack and decay in it, and it sounds like this.

Janice
So it fades away at the end.

Richard Hoadley
That's right.

Janice
So we are getting much closer to the sound of a real instrument being played.

Richard Hoadley
Yes, but we're still missing some of the spontaneousness of live performance, and also some of the interaction between different instruments. So, if you think of, the sound of a single violin, as opposed to the sound of a section of violins in an orchestra, the sound is not necessarily much louder, but it's much more complex, as parts of each instrument sound cancel, or reinforce parts of the other instrument sound.

Janice
They cancel sounds.

Richard Hoadley
Yes. If, you take a mathematically simple sound like a sign wave, which sounds like this.

Richard Hoadley
and, another one started a moment later, and they sound identical.
TONE

Richard Hoadley
However, the second one starts momentarily after the first, which it's called putting the sign waves out of phase.

Janice
and so when you add them together, I can see that the troughs cancel out the peaks.

Richard Hoadley
That's right.

Janice
and so that gives you silence.

Richard Hoadley
That gives you silence.

Janice
So if we hear you play them. You get nothing. But if you play a real note, you don't get a symmetrical pattern, so surely it won't work then.

Richard Hoadley
That's right. Let me let the computer check that. Here, I've got two saxophone tones, one started a moment later, which is out of phase, both of them sound exactly the same.
TONES

Richard Hoadley
However, in this case, if you add them together, you get.
TONE

Janice
So you can't actually create the sound of silence.

Richard Hoadley
You can't do it in terms of them being out of phase. However, you can do it, by getting the computer to create the sound's inversion.
So in this case I have, two saxophone tones but, you can see that one is the inversion of the other.

Janice
So by inversion, you mean, that the peak above this read line becomes a trough down here, and the trough up here, becomes a peak below, is that right.

Richard Hoadley

Yes, which is very similar to them being out of phase. So I can make a sound which cancels the first sound out, and the result of that is again.

Janice
You've created silence.

Richard Hoadley
That's correct.

WILDTRACK FOOTSTEPS

Janice
Thanks to Richard, I've got a basic synthesised saxophone sound, I'm going to try it out with the group.