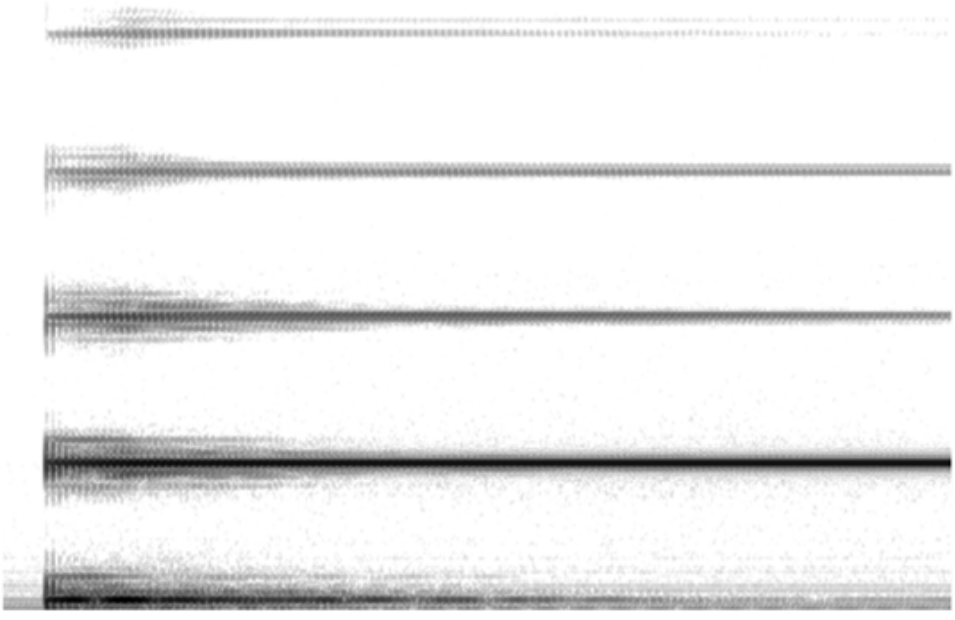
This text is an updated version of my article for the Kybernetes journal in 2005. The current issue and full text archive of this journal is available at www.emeraldinsight.com/0368-492X.htm

Feedback and music: you provide the noise, the order comes by itself(by Knut Aufermann)

A fundamental principle of cybernetics is feedback. Heinz von Foerster was one of the most impressive promoters of this idea. In the various lectures that I saw him give, he convinced me that the idea of circular processes is something special, something that I should keep an eye on, because it seemed to crop up everywhere I looked. This journal is published in memoriam of Heinz von Foerster, however, I do not want to sprinkle this article with his quotes but rather state that his work is a major influence to me, which can be seen throughout this text. Today almost every academic discipline includes the idea of feedback. Some use it as a vague concept in an intuitive manner, other, "harder" sciences struggle with the complex mathematics involved in the non-linear world of feedback. Why is it so difficult to get to grips with the idea of circularity? Why do we struggle to understand the process of feedback? One simple answer to this question might be that there are not enough simple examples of feedback around to play with. Strictly theoretical or philosophical concepts are hard to grasp, especially when the notions of linearity and determinism that we have acquired over the last centuries are challenged. We need to experience a simple example of what feedback means, something at kindergarten or primary/elementary school level, something that can be played with so that the idea of the creative circles (Varela, 1985, pp. 294-309) can be embraced.

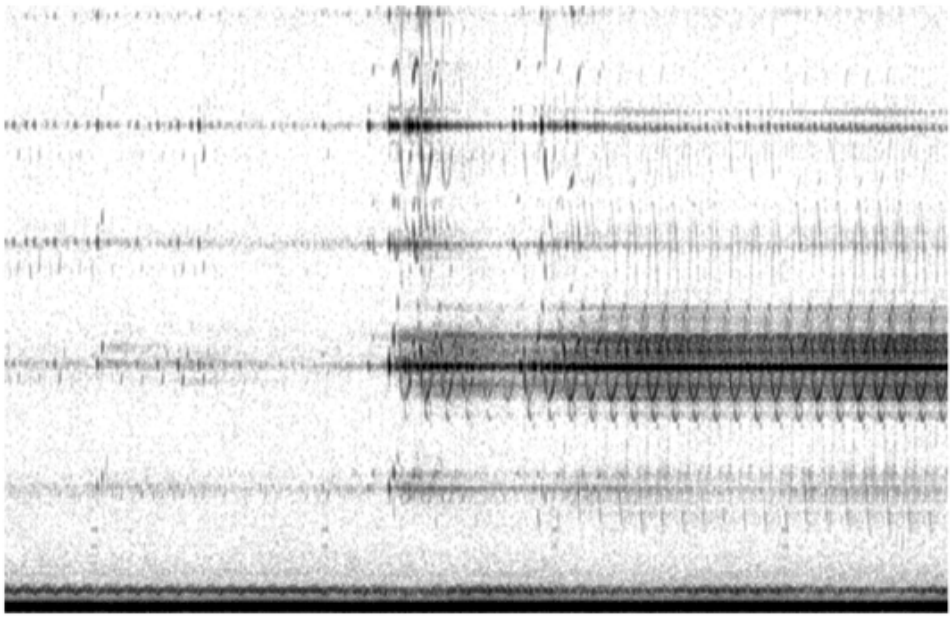


sonogram 1: Δt=3.5s, Δf=13kHz

For me audible feedback offers the best playground to gain understanding of the feedback process itself and before a more detailed discussion of this claim I would like to give a short history of audible feedback and its introduction into music. Since the advent of electronically amplified

instruments in the 1920s feedback or “howl-around” as it is still sometimes called became associated with music performances. A fraction of the output of an amplifier would find its way back to the microphone, which would feed its signal back into the amplifier, and so the loop closes. The screeching noises that emerge through the misalignment of microphones (or other types of pickups) and speakers have ever since been considered a nuisance. It has been top of the agenda for live sound engineers to avoid feedback at all costs and much research has gone into development of electronic amplification that is less prone to howl-around.

It took a few decades before artists started exploring the possibilities of using feedback as a legitimate means of making music, an early example being Karlheinz Stockhausen who used amplifiers[1] made for “Horspiel” (radio play) productions to feedback in his piece “Kontakte” (1959-1960)[2]. When a whole new generation of musicians and composers started to build their own electronic circuits and instruments in the 1960 s feedback music started to take off, producing the first works of pure feedback music (e.g. David Tudor’s “untitled” in 1972). And through guitarists like Jimi Hendrix feedback found its way into the musical mainstream. By then it was clear that not only the sonic quality of the sounds was fascinating but also the unruly process by which they were produced.



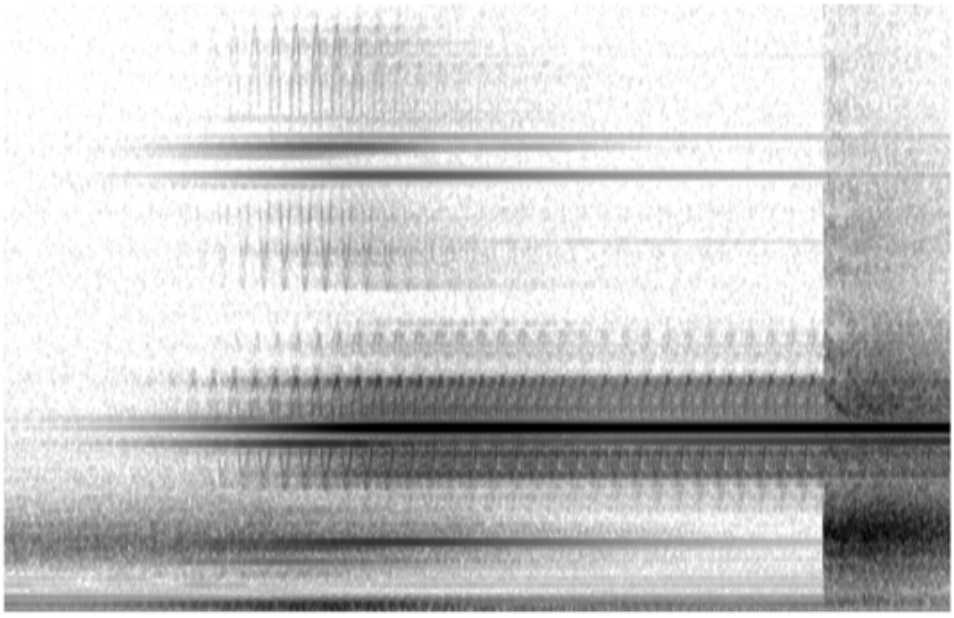
sonogram 5: Δt=6s, Δf=14kHz

One of the seminal music pieces of the 20th century focuses on the process of emerging feedback and presents it in a slow motion style to the listener: Alvin Lucier’s “I am sitting in a room” (1970)[3]. He starts out sitting in a room recording his voice onto a tape recorder. This recording is then played back into the room through a loudspeaker and recorded onto a second tape recorder. This recording in turn is again played back and recorded onto the first tape recorder and so on in an ongoing circular process. In time the original speech input becomes less important and the process takes over. After a certain amount of cycles the intelligibility of Lucier’s voice has been lost to the internal sounds of the circular recording process, which in the case of “I am sitting in a room”

are the resonant frequencies of the room. The architecture of the room (and to a lesser degree a lot of other factors like the frequency responses of the equipment used) shapes the outcome of the piece (Lucier, 1995).

This developmental process that Lucier captured so beautifully happens every time audible feedback emerges, often in such a short time that we cannot hear it.

Currently there are a growing number of sound artists working with feedback across the world[4]. It is interesting to note that they are sometimes known to play feedback, stating the process they are working with, rather than specifying the instruments they are using. Let us go back to the initial proposition that audible feedback is a good study object to learn about circular processes. Circular processes often produce oscillating outputs and this is exactly what the human ear can sense. We do not hear a static environment; we hear the oscillatory changes in our environment, the increase and decrease of the air pressure around us. And it seems that electronic components can not only carry but also produce oscillations very well. In fact the primary component of a synthesizer, the “oscillator”, does exactly what it says by connecting a few simple electronic components in a feedback loop. In a very simple case a circuit contains only a capacitor, a coil and a resistor (LCR circuit).



sonogram 8: Δt=6s, Δf=10kHz

Not only simple electronic circuits have the ability to feed back, audible oscillations can occur in very complex systems. When I was riding on a London bus recently a group of school children started playing around with their mobile phones, calling each other to set off their ring tones. Two of the children then decided to hold together their phones so that the microphone of one phone would come near the loudspeaker of the other phone which produced much to their delight long howling stretches of feedback. This seemingly spontaneous sound emanating from the phones is travelling on a long loop. Oscillations in the air reach a microphone, where they are transduced into analogue electrical signals. They then get converted to digital electrical signals and into

electromagnetic microwave signals, which are transmitted to a microwave dish. From there they are routed to a different mobile phone, reconverted into digital and analogue electronic signals, transduced into physical movement by a speaker which creates oscillations in the air. The whole process begins without any kind of deliberate input, it is not possible to determine a start point in the loop, there is no hierarchy between the different components or stages of the loop, and there is no possibility to control the system in a linear fashion.

The last sentence gives the reasons why it is so much fun to play with feedback. This fascination of playing with feedback seems to interest all ages. Composer and feedback artist Nicolas Collins reports of the fun his children have with a simple cassette recorder and a microphone they can wave in front of it (Collins, 2002). I have experienced a group of 200 adults playing with a deliberate feedback set-up of four microphones and four speakers I installed as part of a presentation at the Profile Intermedia 5 conference in Bremen, Germany in 2002. What are the implications that the use of feedback brings to electronic music?

(1) The abandonment of specific musical instruments in favour of a more modular system of feedback capable equipment. The integral design of traditional acoustic or electronic musical instruments is no longer necessary. Instead any electronic equipment that has an input and an output can be connected into a heterarchical meshwork of devices, often with some kind of routing matrix that allows a player to exert a certain amount of control over the connections made.

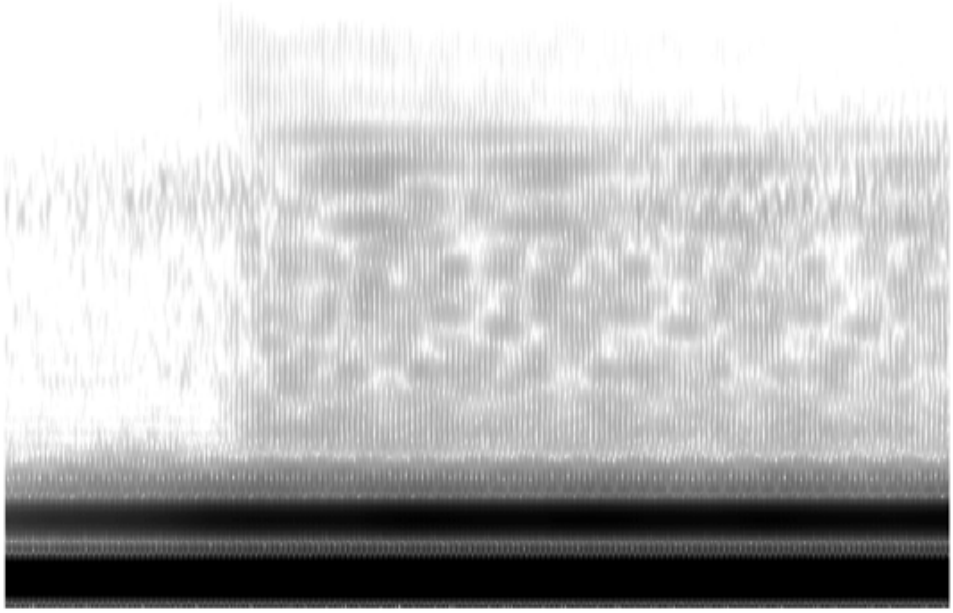
(2) The loss of direct control over the output of the feedback system due to its non-linear behaviour. This has obvious implications on the expectations a player can have towards the "instrument".

Japanese Feedback Artist Toshimaru Nakamura describes this attitude: "You can't be a feedback improviser when you have your brains filled with your big beautiful pictures prior to your performance. If you show up to the venue like that, you won't have any fun. I understand I go onto the stage to get lost" (Nakamura, 2002, p. 5).

The control over the sound is partly given over to the architecture of the feedback system, be it the physical space as in Lucier's "I am sitting in a room" or the programmed algorithm of a reverb unit that is feeding back on itself. The above points do not mean that the behaviour of feedback "instruments" is chaotic and that it is not necessary for the musician to know about their internal workings. On the contrary, a more detailed knowledge of the process of audible feedback is essential for the aesthetic development of a new music language. Ideas taken from cybernetics and chaos theory can form the basis to grasp the non-linear characteristic of any feedback instrument. Tiny adjustments made to the available sound controls can have drastic effects on the output. After some time a player will develop some intuitive understanding of the instrument and will be able to predict roughly how and when the sound will change. It is almost like learning how to communicate with it. One type of input in any electronic feedback system is white noise emitted from the electronic components. White noise is the technical term for hiss that contains every audible frequency in equal measure. Given that this noise floor is enough to develop stable oscillations it can be called an "order from noise" scenario (von Foerster and Bröcker, 2002), feedback music is a prime example of self-organisation.

The Sonograms printed throughout this paper are a graphic representation of a piece of improvised feedback music[5] I performed in 2002. Sonograms are made through the analysis of a sound file with a mathematical process called fast Fourier transform, that splits a complex waveform into its constitutional sine waves. The dark marks on the graphics indicate the amplitude of these sine wave frequencies over time (x-axis: time, y-axis: frequency (linear), with 0 Hz at the

bottom). Many different patterns ranging from highly defined to almost chaotic are visible. As well as being very different to any sonograms that could be produced by analysing recordings of acoustic instruments I find them aesthetically pleasing[6].



sonogram 15: Δt=3.5s, Δf=2kHz

The questions to ask now are: Is the process of audible feedback similar to other forms of feedback? Do all forms of feedback have the same character; do they show the same patterns of behaviour? As far as I can see there are parallels between the feedback processes that produce audible oscillations in electronic circuits, cyclical fluctuations in populations of foxes and rabbits or the rhythmical change of chemical concentrations in the Zsabotinski-Belousov reaction (Prigogine and Stengers, 1985). Maybe all forms of oscillation have the same underlying feedback operation. Rather than making the case for the universal existence of feedback controlled systems, I would like to argue for a pan-disciplinary discussion of the phenomenon. Feedback music can offer an artistic insight into what happens when you allow instruments to show their real character, to develop their own life by getting rid of the traditional idea that the player has to “master” the instrument.

Anybody can experience what a strange kind of animal feedback is and how small changes to the system can have huge results. The control over music of the feedback machines is transferred onto a higher level: You provide the noise, the order comes by itself.

Notes

1. The amplifiers at that time actually worked on the principle of positive feedback, boosting the input by sending it through a feedback loop that would reinforce the signal. At maximum amplification the amplifiers would start to self-oscillate (Stockhausen, 1968).
2. An excerpt from “Kontakte” can be heard here: www.stockhausen.org/kontakte_str_7.mp3
3. Alvin Lucier's “I am sitting in a room” can be heard here: http://ubu.artmob.ca/sound/source/Lucier-Alvin_Sitting.mp3
4. In June of 2004 a group of international feedback musicians (including Alvin Lucier) and a feedback video artist toured the United Kingdom to showcase the astonishing variety and strength of feedback music in a unique concert situation.
5. An excerpt of this piece is published on the accompanying CD to theResonance magazine, Vol. 9 No. 2
6. A selection of these sonograms has been displayed as part of the “Electronic Music Archive” exhibition at Kunsthalle St Gallen, Switzerland in 2003. They can be found online here: http://knut.klingt.org/slideshow.html

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Discography references

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Alvin Lucier, I am sitting in a room. Lovely Music, CD 1013.
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